Does neuromuscular thermography record nothing else but an infrared sympathetic skin response?

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A recent submission to this journal proposed to re-name Neuromuscular Thermography to Infrared Sympathetic Skin Response Studies. The reasoning for this proposal was the following:

When abnormalities due to vasomotor/ sudomotor dysfunction occur there are associated changes in skin galvanic impedance and skin temperature. Skin galvanic impedance changes map closely with skin temperature. In physics this is explained by the fractal nature of infrared waves and their relationship to resistance and conductivity.

This statement raises the old question what physiological change is imaged by infrared thermography. There have been an number of answers to this question in the past including pain [1], radiculopathy [2], disc herniation [3], and of course, the level of activity of the sympathetic nerve system [4].

All these statements suffer from the fact that they confuse cause and effect. It is out of debate, that infrared thermal imaging is technique for mapping the infrared emission from an object, encoded as temperature values. It is also well accepted that the superficial blood vessels play a major role in the heat exchange of a living body,.

Temperature regulation system

Infrared radiation is one of the mechanisms of heat exchange of the human body In principle, a constant temperature gradient exists between the core temperature, the shell temperature and the environment. Most of the time, the environmental temperature is below the core temperature. In a system dependent on heat gain from the environment, the mean challenge of temperature regulation would be to defend the body against heat loss. But homoiothermic beings, achieve their heat balance by the net sum of heat generation and heat exchange with the environment. Due to endogenous heat generation, particularly through muscle work., the mechanisms of heat loss predominate the mechanisms of heat preservation.

The heat from the temperature core travels by conduction through tissues and by convection along blood vessels to the surface and is dissipated in 70% percent by infrared radiation. Additional heat loss occurs by conduction with respect to contact areas or convection dependent on moving air at the body surface.

The vascular network in the subepidermal skin layer was identified as the anatomical structure that is both the source of infrared radiation and the active vascular bed where thermoregulation takes place within the thermoneutral zone. The thermoneutral zone is defined as the temperature range, where disturbances in the thermal balance are equalised by variation in the width of the vascular bed [5] Increase of the vessel diameter is called vasodilation and is followed by increase of blood flow leading to bigger surface area of warm blood, from which infrared radiation will occur. Narrowing the vascular bed or vasoconstriction reduces the surface for heat dissipation and is therefore a mechanism for heat preservation. Both vasoconstriction and vasodilation in the vascular bed dedicated to temperature regulation are under the control of sympathetic nerve fibres [6, 7].

Temperature regulation is not the only influence on the width of vessels. External chemical compounds such as nicotinic acid, mustard oil or CO_2 , endogenous NO_2 or mediators of inflammation such as bradykinin, histamine, substance P or calcitonin gene related peptide may force vasodilation without involving the temperature regulation system. Ergotamine, norepinephrine or endothelin will cause vasoconstriction similar as cold environment. Inflammation, reactions to mechanical or chemical stimuli or permanent occlusion of vessels can lead to changes of the skin temperature without or only minor involvement of the sympathetic nerve system.

Nerve system and skin temperature

20 years ago, Ash et al. questioned the ability of thermography to image sensory dermatomes [8]. They came to the following conclusion:

1. Thermographic imaging of the sensory dermatome is not plausible.

2. There are no predictable sympathetic dermatomes.

Although the involvement of sensory and sympathetic nerve fibres in thermal regulation is nowadays much better understood as previously [9-11], the conclusion of Ash et al. is a still valid statement.

The clinical value of the electrical sympathetic skin response (SSR) was critically reviewed [12]. The authors stated that current procedures for the elicitation of SSR are not sufficiently reliable for diagnostic purposes, and show imperfect correlations both with clinical features and other measurements of autonomic, in particular, sudomotor dysfunction. The SSR can be provoked by a number of non specific stimuli including inspiratory gasp, a cough, a loud noise, an electrical shock, or a stroke of the skin. Typically, a single electric square pulse, 0.1–0.2ms in duration, de-

livered randomly and at a minimal interstimulus interval >30 seconds is applied. Nevertheless, the SSR must be provoked and is not a continuous reaction to an ongoing pathological process. Simultaneous recording of SSR and skin temperature is not published yet, although transient skin temperature changes have been reported in the vicinity of the site of applied mild, non specific stimuli [13] and during needling of acupuncture points [14].Successful sympathetic nerve blocks have been evaluated by the absence of SSR [15] and by infrared thermography [16].

Whilst the relationship between a sweat film on the skin and electrical skin conductivity and resistance is well established, the proposed relationship between infrared emission and electrical skin resistance needs further explanation. Profuse sweating may lead to binding of water molecules in the keratine layers of the skin similar as the immersion in water for 15 minutes or more [17]. Such a water film may act as filter against infrared radiation and may also result in prolonged evaporative cooling. Transient deprivation of sympathetic nerve supply of sweat glands by anaesthetic nerve block will lead to an increase of skin temperature as long as the temperature regulation occurs within the thermoneutral zone [5] and the mean skin temperature is above a level of 33°C.

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