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Basic research

Remote effects of extracorporeal shock wave therapy on cutaneous microcirculation

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Remote ESWT;
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Abstract *Background:* Extracorporeal shock wave treatment (ESWT) has proven its clinical benefits in different fields of medicine. Tissue regeneration and healing is improved after shock wave treatment. Even in the case of burn wounds angiogenesis and re-epithelialization is accelerated, but ESWT in extensive burn wounds is impracticable.
Hypothesis: High energy ESWT influences cutaneous microcirculation at body regions remote from application site.
Methods: Eighteen Sprague Dawley rats were randomly assigned to two groups and received either high energy ESWT (Group A: total 1000 impulses, 10 J) or placebo shock wave treatment (Group B: 0 impulses, 0 J), applied to the dorsal lower leg of the hind limb. Ten minutes later microcirculatory effects were assessed at the contralateral lower leg of the hind limb (remote body region) by combined Laser-Doppler-Imaging and Photospectrometry.
Results: In Group A cutaneous capillary blood velocity was significantly increased by 152.8% vs. placebo ESWT at the remote body location ($p = 0.01$). Postcapillary venous filling pressure remained statistically unchanged ($p > 0.05$), while cutaneous tissue oxygen saturation increased by 12.7% in Group A ($p = 0.220$).

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Conclusion: High energy ESWT affects cutaneous hemodynamics in body regions remote from application site in a standard rat model. The results of this preliminary study indicate that ESWT might be beneficial even in disseminated and extensive burn wounds by remote shock wave effects and should therefore be subject to further scientific evaluation.

1. Introduction

Extracorporeal shock wave therapy (ESWT) denotes the use of high energy acoustic waves generated by electropneumatic, electrohydraulic, electromagnetic or piezoelectric methods [1]. It is a non-invasive and inexpensive procedure to affect different tissues. Originally used for urologic lithotripsy, ESWT has proven its benefits in limb and myocardial ischemia [2,3], osteonecrosis and bone healing [4,5], acute and chronic wounds [6,7], burn scars [8] and even in ischemia reperfusion injury [9]. Moreover, it has been shown to increase topical blood perfusion in skin flaps [10], striated skin muscle [11] and other flaps [1,12].

Different shock wave parameters have been used in the literature concerning energy flux density per shock, number of shocks per treatment and number of ESWT sessions [13]. There is no consensus which parameters should be used for the best effects. Therefore, we recently compared the effects of high and low energy ESWT on cutaneous hemodynamics in a rat model. We were able to demonstrate that cutaneous blood flow, tissue oxygen saturation and venous filling pressure were dependent on the chosen energy flux density as a dose—response relationship, while number of shocks was constant in a single session treatment [14].

In a prospective randomized trial the use of low energy ESWT significantly accelerated re-epithelialization in second-degree burn wounds [15], indicating that ESWT might be a therapeutic option to reduce the number of necessary skin grafts. But the treatment of each single burn wound can be a time-consuming challenge, since most burn wounds are spread over the body surface. Contact burns may involve both hands (e.g. in little children), scald wounds are often localized on different extremities; burn injuries occurring after explosions may involve face and hands. Moreover, direct manipulation involves the risk of wound contamination. Therefore, new therapeutic strategies have to be found to minimize direct manipulation of damaged tissue and affect tissues located in distant body regions by effects remote from the application site.

Recently, we showed that remote ischemic preconditioning (RIPC) can have systemic effects on skin microcirculation after topical application by humoral mediator release [16]. ESWT enhances the expression of nitric oxidase (NO) and vascular endothelial growth factor (VEGF) as systemically effective mediators, too, indicating that similar effects to RIPC might occur [17]. Nevertheless, there still remains a lack of scientific data on the remote response of ESWT.

Therefore, the aim of this study was to examine the effects of ESWT on cutaneous microcirculation in the hind limb of the rat remote from the application site.

2. Methods

2.1. Animal model and experimental protocol

Eighteen Sprague Dawley rats (Charles River Laboratories, Sulzfeld, Germany), weighing 250—350 g, were used in this study. Animals were kept at 21 °C in a room with 12 h day/night cycle. Two rats were housed per cage. They received water and food ad libitum. The experimental procedures were conducted in accordance with the German legislation on protection of animals and the National Institutes of Health Guide for the Care and Use of Laboratory Animals (Institute of Laboratory Animal Resources, National Research Council).

During the experiments, the rats were under pentobarbital sodium anesthesia (55 mg/kg bw ip; Narcoren, Merial, Hallbergmoos, Germany) monitored by stable heart rate and breathing frequency in order to minimize microcirculatory affection, due to pain reaction. Body temperature was maintained at 36—37 °C using a heating pad. Before ESWT application and microcirculatory analysis were started, the whole hair was removed from the hind limb with an electrical shaver. Rats were fixated with tape on a platform. The ESWT