Water-filtered infrared-A (wIRA) can act as a penetration enhancer for topically applied substances

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GMS German Medical Science 2008, Vol. 6, ISSN 1612-3174

Abstract

Background: Water-filtered infrared-A (wIRA) irradiation has been shown to enhance penetration of clinically used topically applied substances in humans through investigation of functional effects of penetrated substances like vasoconstriction by cortisone.
Aim of the study: Investigation of the influence of wIRA irradiation on the dermatopharmacokinetics of topically applied substances by use of optical methods, especially to localize penetrating substances, in a prospective randomised controlled study in humans.
Methods: The penetration profiles of the hydrophilic dye fluorescein and the lipophilic dye curcumin in separate standard water-in-oil emulsions were determined on the inner forearm of test persons by tape stripping in combination with spectroscopic measurements. Additionally, the penetration was investigated *in vivo* by laser scanning microscopy. Transepidermal water loss, hydration of the epidermis, and surface temperature were determined. Three different procedures (modes A, B, C) were used in a randomised order on three separate days of Physiology, investigation in each of 12 test persons. In mode A, the two dyes were applied on different skin areas without water-filtered infrared-A (wIRA) irradiation. In mode B, the skin surface was irradiated with wIRA over 30 min before application of the two dyes (Hydrosun® radiator type 501, Germany 10 mm water cuvette, orange filter OG590, water-filtered spectrum: 590–1400 nm with dominant amount of wIRA). In mode C, the two dyes were applied and immediately afterwards the skin was irradiated with wIRA over 30 min. In all modes, tape stripping started 30 min after application of the formulations. Main variable of interest was the ratio of the amount of the dye in the deeper (second) 10% of the stratum corneum to the amount of the dye in the upper 10% of the stratum corneum.
Results: The penetration profiles of the hydrophilic fluorescein showed in case of pretreatment or treatment with wIRA (modes B and C) an increased penetration depth compared to the non-irradiated skin (mode A): The ratio of the amount of the dye in the deeper (second) 10% of the stratum corneum to the amount of the dye in the upper 10% of the stratum corneum showed medians and interquartile ranges for mode A of 0.017 (0.007/0.050), for mode B of 0.084 (0.021/0.106), for mode C of 0.104 (0.069/0.192) (difference between modes: $p=0.0112$, significant; comparison mode A with mode C: $p<0.01$, significant). In contrast to fluorescein, the lipophilic curcumin showed no differences in the penetration kinetics, in reference to whether the skin was irradiated with wIRA or not. These effects were confirmed by laser scanning

microscopy. Water-filtered infrared-A irradiation increased the hydration of the stratum corneum: transepidermal water loss rose from approximately 8.8 g m-2 h-1 before wIRA irradiation to 14.2 g m-2 h-1 after wIRA irradiation and skin hydration rose from 67 to 87 relative units. Skin surface temperature increased from 32.8°C before wIRA to 36.4°C after wIRA irradiation.

Discussion: The better penetration of the hydrophilic dye fluorescein after or during skin irradiation (modes B and C) can be explained by increased hydration of the stratum corneum by irradiation with wIRA. Conclusions: As most topically applied substances for the treatment of patients are mainly hydrophilic, wIRA can be used to improve the penetration of substances before or after application of substances – in the first case even of thermolabile substances – with a broad clinical relevance as a contact free alternative to an occlusive dressing.