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Clinical study

A quantitative analysis of microcirculation in sore-prone pressure areas on conventional and pressure relief hospital mattresses using laser Doppler flowmetry and tissue spectrophotometry

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KEYWORDS
Laser Doppler flowmetrie;
Pressure sore;
Tissue spectrophotometry;
Pressure relief mattress

Abstract *Background:* Pressure ulcers are associated with severe impairment for the patients and high economic load. With this study we wanted to gain more insight to the skin perfusion dynamics due to external loading. Furthermore, we evaluated the effect of different types of pressure relief mattresses.
Methods: A total of 25 healthy volunteers were enrolled in the study. Perfusion dynamics of the sacral and the heel area were assessed using the O2C-device, which combines a laser light, to determine blood flow, and white light to determine the relative amount of hemoglobin. Three mattresses were evaluated compared to a hard surface: a standard hospital foam mattress bed, a visco-elastic foam mattress, and an air-fluidized bed.

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Results: In the heel area, only the air-fluidized bed was able to maintain the blood circulation (mean blood flow of 13.6 ± 6 versus 3.9 ± 3 AU and mean relative amount of hemoglobin of 44.0 ± 14 versus 32.7 ± 12 AU.) In the sacral area, all used mattresses revealed an improvement of blood circulation compared to the hard surface.
Conclusion: The results of this study form a more precise pattern of perfusion changes due to external loading on various pressure relief mattresses. This knowledge may reduce the incidence of pressure ulcers and may be an influencing factor in pressure relief mattress selection.

Background

Up to one third of hospitalized patients and up to one fifth of nursing home residents are reported to develop pressure ulcers [1]. For the affected patients this represents a severe impairment, as pressure ulcers are known to cause pain, as well as infections and lead to prolonged hospital stays [2,3]. They even are a marker of a poor overall prognosis and may lead to a premature death in some cases [4,5].

But not only patients are affected, as pressure ulcers pose an enormous financial impact on health care costs. A Dutch study even found out, that the treatment of pressure ulcers is the third most expensive, after the treatment of cancer and vascular diseases [6].

Although the etiology of pressure ulcers is multifactorial, tissue ischemia is widely accepted as the primary factor [7]. The ischemia is caused by unrelieved pressure or friction of the skin, which leads to compromised capillary blood flow resulting in reduced oxygen delivery in the affected tissue [8,9]. Due to this pathomechanism, sites over bony prominences such as the heel, the sacrum or the trochanter are often affected, because in a supine lying person, the small amount of soft tissue between the bone and the surface is often insufficient to support the local pressures [10]. Heel interface pressures usually exceed arterial diastolic pressure and often are close to or greater than arterial systolic blood pressure [11]. In the past, the depth at which pressure ulcer formation starts was controversially debated in the literature [12]. It is now agreed the largest majority start in the skin tissues and may develop downwards, while a few are initiated in the muscle layer and progress to the skin surface.

Reduced mobility, higher age, vascular disease, diabetes, poor skin condition, as well as a bad nutritional state were hypothesized as important risk factors for developing such pressure ulcers [13—15].

Because of the mechanisms, which lead to the formation of pressure ulcers the best form of prophylaxis is to reduce the immobilization of patients to a minimum. If this is not possible, for example with patients needing mechanical ventilation or patients suffering from paralysis, the repositioning of the patient by the nursing staff every few hours, as well as the use of pressure relief mattresses are common ways of pressure ulcer prophylaxis [16,17]. With this study we wanted to gain more insight to the skin perfusion dynamics due to external loading by measuring the blood flow and the relative amount of hemoglobin on particularly vulnerable sites of the test person's body while lying on different surfaces and thereby evaluating the effect of different types of pressure relief mattresses.

Methods

Healthy volunteers were recruited from the hospital staff (physicians, nurses, and students). Before participation into the study, a detailed informed consent was obtained. A total of 25 were enrolled in the study: 13 males (mean mass 81.5 kg, range 71—101 kg; mean age 34 years, range 19—48 years) and 12 females (mean mass 62.8 kg, range 40—82 kg; mean age 31 years, range 21—52 years). Exclusion criteria were: smoking, vascular diseases, diabetes mellitus, arterial hypertension, and perfusion altering medication.

For each healthy subject the probe was sequentially attached with double sided adhesive tape over two sore-prone pressure areas: over the sacral area in the middle of an imaginary line between the inferior posterior iliac spines and over the heel in projection onto the calcaneal tuber. All volunteers were asked to lie in the supine position