Dorsal Skin Reactions to Sunlight and Artificial Ultraviolet Light in Hairless Descendants of Mexican Hairless Dogs

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Abstract: Dorsal skin reactions to irradiation with two different types of ultraviolet (UV) light sources (sunlight and artificial UV light) were investigated in hairless descendants of Mexican hairless dogs. The total energy dose of solar UV exposure and artificial UV irradiation was 90 kJ/m² and 40 kJ/m², respectively. Histological examinations were done up to 7 days after UV irradiation (7 DAI). At 1 DAI, the solar UV-exposed skin did not show marked changes, while artificial UV irradiated skin exhibited a visible erythematous reaction and prominent histological alterations such as epidermal thickening, appearance of sunburn cells and deformation elastic fibers. At 4 DAI of solar UV-exposure, the skin color became moderately dark and noticeable pigmentation developed in the epidermis. In contrast, at 4 DAI of artificial UV irradiation, there still remained moderate degeneration in the epidermis and dermis, and delayed tanning was weak. At 7 DAI of solar exposure, delayed suntan reactions became more prominent. Histologically, there were heavy pigmentation of melanin granules mainly in the stratum basale. On the other hand, artificial UV irradiated skin showed less pigmentation. Thus, solar exposure provoked remarkable pigmentation while artificial UV irradiation brought about severe sunburn reactions in the dorsal skin of hairless dogs.

Key words: hairless dogs, sunlight, artificial ultraviolet, sunburn, suntan

Introduction

Hairless descendants of Mexican hairless dogs have abundant melanocytes in the epidermis and their skin is sensitive to solar ultraviolet (UV) irradiation [5]. These hairless dogs are therefore considered to be useful for the investigation of the protective effects of sunscreens on sunburn and suntan reactions in the skin [7]. However, UV-induced reactions of the skin are complicated by a large number of experimental variables such as the spectral irradiance, absolute UV dose, size of the irradiated area and environmental factors. In particular, the difference in the source of UV light seriously affects the results of photodermatological studies. For example, Pathak [13] reported that none of the sunscreen products that were effective against artificial UV...
light had sun protection factor (SPF) values of more than 12 when tested outdoors. The purpose of the study was to clarify skin reactions histologically in hairless dogs exposed to the two different types of UV light sources (sunlight and artificial UV light).

**Materials and Methods**

*Dogs:* Three 3-year-old N₂ hairless hybrids (male N₂ hairless hybrids × female Beagles) and three 2-year-old N₂ hairless hybrids (male N₂ hairless hybrids × female Beagles) were used. The dogs were individually housed in stainless steel cages (90 × 90 × 90 cm) in an animal room controlled at 25 ± 2°C and 50 ± 10% relative humidity with 10 to 15 exchanges of 100% fresh air/h and a 12-hr light (7AM to 7PM), 12-hr dark (7PM to 7AM) cycle. They were fed a commercial dry dog food (Labo D Standard, Nihon Nosen Kogyo Co., Ltd.) and water ad libitum.

*Irradiation regimen:* During solar irradiation, 3 dogs (2 male N₂ hairless hybrids and 1 female N₂ hairless hybrid) were kept outdoors and exposed to sunlight. Solar irradiation was conducted for 1 hour (1PM to 2PM), yielding a total dose of 90 kJ/m².

The remaining 3 dogs (1 female N₂ hairless hybrid and 2 male N₂ hairless hybrids) were irradiated with artificial ultraviolet light (UVA + B) (Toshiba Co. Ltd., Tokyo, UVB: 290 to 320 nm, UVA: 320 to 400 nm). The irradiation doses of UVA and UVB were 35 kJ/m² and 5 kJ/m², respectively. During these procedures, each dog was placed in a wire cage (85 × 95 × 75 cm) with 2 cm mesh. The irradiated sites (10 × 10 cm) were confined to the skin over the dorsum of each dog.

*Histology:* Tissue specimens were obtained from the irradiated sites with a 6-mm biopsy punch (Nagatoishi Co., Ltd., Tokyo) under local anesthesia with 0.5% procaine at 1 day before and at 1, 4 and 7 days after irradiation (DAI). Skin specimens were fixed in 10% neutral buffered formalin, and 4-μm paraffin sections were stained with hematoxylin and eosin (HE) and toluidine blue (TB), and by van Gieson’s and Weigert’s staining, and Fontana-Masson’s method (FM).

*Grading of histological changes:* The total severity of epidermal and dermal changes including pigmentation was graded from − (negligible) to +++ (marked).

**Results**

The severity of histological changes in the dorsal skin is shown in Table 1.

Before UV irradiation, the epidermis of hairless dogs was flat and consisted of 2- to 3- cell layers (Fig. 1), and the epidermis had some melanin deposits (Fig. 2). Melanin granules were mainly distributed among the the *stratum spinosum* and *basale.*

At 1 DAI of solar exposure, the epidermis showed slight thickening with mild vesicular degeneration of component cells (Fig. 3). No marked changes were found in the dermis. The sunburn reaction faded by the following day when solar exposure-induced erythema was seen. In contrast, at 1 DAI of after UVA+B irradiation, a visible erythematous reaction was observed in the irradiated sites, and the epidermis became thickened with disarrangement of component cells that represented severe cellular and intracellular edema (Fig. 4). In addition, a few epidermal cells with pyknotic nucleus and eosinophilic cytoplasm known as sunburn cells were observed mainly in the *stratum basale* (Fig. 5). In the dermis beneath the affected epidermis, changes in collagen and elastic fibers, and vasodilatation were also found (Fig. 6). Degenerative elastic fibers were abnormally thick and contained twisted bundles.

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<tr>
<th>Table 1. Severity of histological changes in the skin after sunlight and artificial UV irradiation (UVA+B)</th>
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<tbody>
<tr>
<td><strong>Changes</strong></td>
</tr>
<tr>
<td><strong>Sunlight</strong></td>
</tr>
<tr>
<td>Epidermis</td>
</tr>
<tr>
<td>Dermis</td>
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<td>Pigmentation</td>
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The degree of the severity of histological changes: − (negligible) to + + + (marked). There were no apparent variations in histological changes in any animals in the corresponding group.
Fig. 1. Dorsal skin of a hairless dog before UV irradiation. HE stain, × 350.

Fig. 2. Dorsal skin of a hairless dog before UV irradiation. Some melanin granules are seen mainly in the stratum basale. FM stain, × 350.

Fig. 3. Dorsal skin of a hairless dog at 1 DAI of solar exposure. Slight epidermal thickening. HE stain, × 350.

Fig. 4. Dorsal skin of a hairless dog at 1 DAI of UVA+B irradiation. Marked epidermal thickening. Marked cellular and intracellular edema are seen. HE stain, × 350.
of elastotic materials. Neither irradiation procedure had any effect on the number of dermal mast cells and their degradation.

At 4 DAI of solar exposure, the epidermis showed signs of recovery from damage, while the skin color became moderately dark and delayed suntan reactions began to develop. That is, large numbers of epidermal cells in the entire layer of the stratum basale and in the lower layer of the stratum spinosum were markedly pigmented with melanin granules (Fig. 7). In contrast, at 4 DAI of UVA+B irradiation, there still remained moderate degeneration in the epidermis and dermis (Fig. 8). Although UVA+B irradiation provoked delayed tanning, it was weaker than that provoked by solar exposure.

At 7 DAI of solar exposure, the skin color became darker and delayed suntan reactions were evident. Histologically, there was a heavy pigmentation of melanin granules mainly in the stratum basale of the solar-exposed skin (Fig. 9). On the other hand, the UVA+B irradiated skin showed less melanin granule pigmentation than the solar-exposed skin. Additionally, in the

Fig. 5. Dorsal skin of a hairless dog at 1 DAI of UVA+B irradiation. Some sunburn cells (arrowheads) are seen mainly in the stratum basale. HE stain, × 350.

Fig. 6. Dorsal skin of a hairless dog at 1 DAI of UVA+B irradiation. Severe dermal degeneration. Vasodilation, and altered collagen and elastic fibers are seen. Left: van Gieson’s stain, × 350, Right: Weigert’s stain, × 90.
Fig. 7. Dorsal skin of a hairless dog at 4 DAI of solar exposure. Marked melanin pigmentation in the epidermis. FM stain, × 350.

Fig. 8. Dorsal skin of a hairless dog at 4 DAI of UVA+B irradiation. Degeneration in the epidermis and dermis is unchanged. Moderate pigmentation in the epidermis is also seen. FM stain, × 350.

Fig. 9. Dorsal skin of a hairless dog at 7 DAI of solar exposure. Heavy pigmentation of melanin granules is seen in the stratum basale. FM stain, × 350.

Fig. 10. Dorsal skin of a hairless dog at 7 DAI of UVA+B irradiation. Note the distribution of melanin granules in the entire epidermis. FM stain, × 350.
UVA+B irradiated skin, melanin granules were sporadically distributed throughout the entire epidermis including the stratum basale (Fig. 10).

**Discussion**

The skin effects of UV irradiation are directly related both to the wavelength and to the total dose of UV irradiation. Accordingly, the photobiological effects are also influenced by the intensity and the duration of UV irradiation. The solar spectrum includes wavelengths of about 290 to 3,000 nm, and the natural light source (sunlight) is ideal for the investigation of photodermatology. Nevertheless, depending on the location and season, sunlight produces a different UV irradiation dose between 2 and 5 mW/cm². Thus, artificial UV light sources are generally employed for testing the effects of UV irradiation on the skin.

Histologically, as reported previously [6], the dermatological characteristics of hairless dogs are obviously different from those of nude mice and other hairless animals [8, 14, 15]. In particular, these hairless animals, except for hairless dogs, have no melanocytes which produce melanin granules, and therefore it may be difficult to employ these hairless animals for the study of skin pigmentation.

In this study, there were no significant individual differences in the skin reaction among the irradiated dogs in the same experimental group. In addition, there were no apparent differences depending on the sex or age of the hairless dogs. The data for these hairless dogs were therefore combined as solar UV and artificial UV irradiated groups.

At 1 DAI of solar exposure, epidermal changes in hairless dogs were similar to those reported in our previous study [5]. In the areas exposed to UVA+B light, sunburn reactions characterized by epidermal thickening and development of sunburn cells were more prominent. Gilchrest et al. [1] reported histological findings on human skin exposed to the Hanovia lamp. Major histologic alterations in the epidermis included dyskeratotic and vacuolated keratinocytes (sunburn cells). The dermal changes were vascular dilatation, involving both the superficial and deep venularplexuses. These severe forms of dermatological damage in humans following irradiation with artificial UV sources were closely akin to acute sunburn reactions seen in the skin of hairless dogs in the present study.

In human beings, hyperplasia of elastic fibers is the earliest indicator of actinic damage. In laboratory animals, Kligman et al. [8, 9, 10] reported that the dermis of hairless mice showed a great increase in elastic tissues after UV irradiation. Unlike in human beings, solar elastosis is a very rare manifestation of UV-induced skin damage in dogs [2, 3, 11, 12], but after single UVA+B irradiation, altered elastic fibers were demonstrated in the dermis of hairless dogs.

It has previously been pointed out that artificial tanning and suntan salons have many risks [13]. As shown in the present study, habits of tanning parlors should refrain from excess UV irradiation. In general, the presumably more relevant outdoor SPF values tend to be somewhat lower than indoor solar simulator-derived SPF values [13]. Our results may give support to this finding.

As we reported in a previous study [5], the time of onset of pigmentation (delayed suntan reaction) in hairless dogs was similar to that in human beings. Macroscopically and histologically, pigmentation in hairless dogs was similar to that observed in human beings exposed to UV irradiation. In a laboratory test with brownish guinea pigs, daily exposure of the skin to UVB irradiation induced visible black pigmentation [4]. The sections of the skin prepared on the 15th day of UVB irradiation showed a large number of melanocytes with heavily pigmented granules. The skin of hairless dogs sensitively manifested suntan reaction to artificial UV irradiation, corresponding to the changes that occurred in the pigmented skin of these guinea pigs.

In conclusion, it was clarified in the present study that the degree of severity of dermatological changes in hairless dogs depended on the kind of UV light source. That is, solar exposure provoked remarkable pigmentation while artificial UV irradiation brought about severe sunburn reaction in the skin of hairless dogs.

**References**


