Int J Legal Med (2003) 117 : 102–105
DOI 10.1007/s00414-002-0357-0

ORIGINAL ARTICLE

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Heat-mediated changes to the hands and feet mimicking washerwoman's skin

Received: 30 August 2002 / Accepted: 19 November 2002 / Published online: 18 January 2003

Abstract If the palms of the hands and the soles of the feet of burnt bodies are not or only partially charred, whitish discoloration and wrinkled detachment of the epidermis is often observed. The findings are strongly reminiscent of the so-called washerwoman's skin, as seen after exposure to a moist environment for at least several hours. However, this is not to be expected after exposure to dry heat. What might be conceivable is a swelling of the skin due to the effect of the water used for fighting the fire. On the other hand this phenomenon is also observed in burnt bodies, which demonstrably have not come into contact with water, so that formation seems to be caused by a different mechanism. Moreover there are also histological differences between real washerwoman's skin and the pseudo-washerwoman's skin of fire victims. Whereas in genuine washerwoman's skin the stratum corneum is disaggregated and perinuclear vacuoles are found in the stratum germinativum, burnt bodies with pseudo-washerwoman's skin show detachment of the epidermis due to serum-filled blisters with elongation and palisade arrangement of the nuclei in the stratum basale. Consequently these changes agree with second-degree burns.

Keywords Burns · Pseudo-washerwoman's skin · Friction skin

Introduction

Skin reactions following heat exposure cover a broad spectrum. Differentiation between thermal and mechanical lesions can be just as difficult as distinguishing between intravital and postmortem heat damage. Although the usual staging of skin burns according to clinical signs (first, second, third or fourth degree) can also be used for burnt corpses, the findings are not always clear with regard to their vitality [2]. For example fourth degree burns are seen particularly often in burnt corpses, but these are usually of postmortem origin. In first and second degree burns an intravital origin of the thermal skin lesion is more probable. As a postmortem residue of a first degree burn a red margin may occasionally be observed after the reddening of the skin has faded due to hypostasis [9]. This phenomenon, which is difficult to detect even histologically may, however, also be due to postmortem effects of heat on the skin [2, 5, 8, 14]. The characteristic findings of a second-degree burn are fluid-filled blisters of the epidermis and, as a consequence, at least partial detachment of the epidermis. If the blister contains fibrin and leukocytes as a sign of an inflammatory reaction, it is usually assumed that it is a genuine burn blister of intravital origin [5, 11, 12].

A special form of heat-mediated alteration of the epidermis can be observed on the hands and feet both in burnt corpses and surviving burn victims [1, 13]. The epidermis is wrinkled, swollen and whitish discolored and in some cases there is a glove-like peeling of the whole epidermis. The findings are macroscopically similar to the so-called washerwoman's skin which develops after immersion in water for a prolonged period of time (Fig. 1). This finding is rarely mentioned in the literature, and if so, only as a marginal note [4, 15]. For this reason we have conducted systematic investigations on this phenomenon of burn-associated "pseudo-washerwoman's skin".

Material and methods

From January 1997 until June 2002 the burnt corpses on which judicial autopsies were performed at the Freiburg Institute of Legal Medicine were systematically examined with regard to the presence of skin changes on hands and feet similar to washerwoman's skin. Our study included a total number of 68 deaths due to fire, 42 males and 26 females. The age at the time of death ranged between 2 months and 92 years (median 53 years). The postmortem interval was 2 days on average and 6 days at the most.

In these cases the following parameters were recorded in addition to the skin changes of the hands and feet: extent of burn injury

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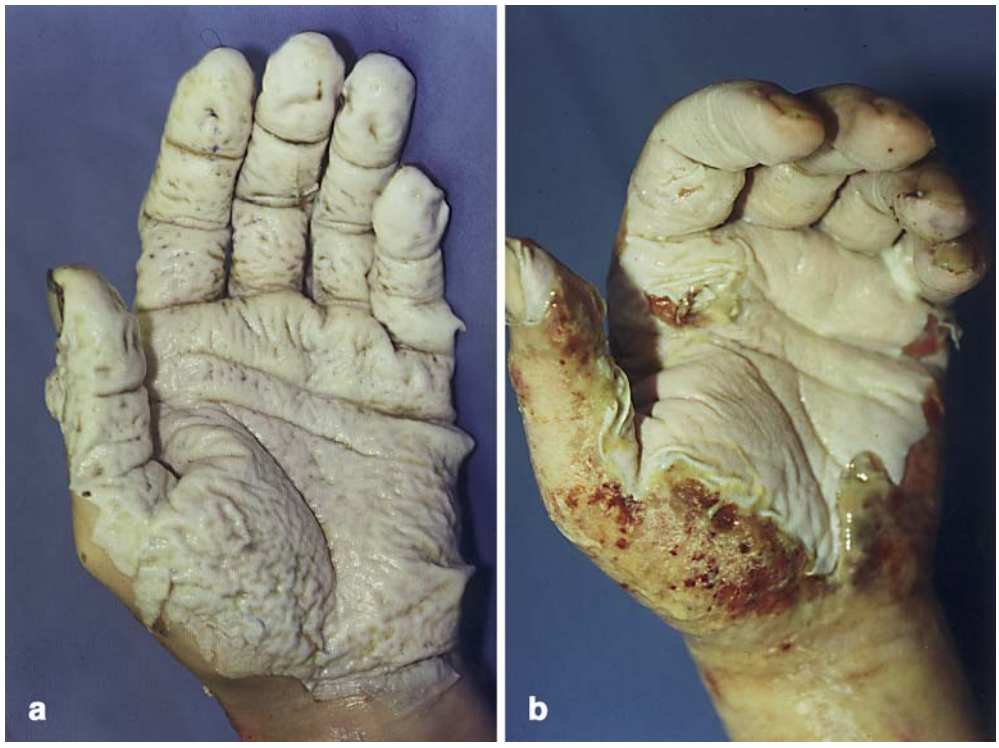

Fig. 1 **A** Genuine washerwoman's skin in a case of drowning. **b** Second degree burns of the hand of a 64-year-old burn victim mimicking washerwoman's skin

according to the Crow-Glassman Scale (CGS) [3], circumstances of the fire, of fighting the fire and recovering the body, scene of the fire, presence of so-called vitality signs (e.g. soot inhalation) as well as the manner and cause of death. Moreover any changes due to putrefaction were taken into account.

For histological investigations skin preparations obtained from the palms of the hands and the soles of the feet were embedded in paraffin after formalin fixation and stained with hematoxylin-eosin and a modified Mallory stain.

Results

Of the 68 victims 57 showed signs of intravital exposure to the fire, in the other 11 individuals burning had occurred postmortem. In 46 cases (68%) the manner of death was an accident, in 16 cases (24%) suicide, in 1 case each a natural death and a homicide. In 4 cases (6%) the manner of death could not be determined retrospectively. In 51 cases (75%) the fire played at least a contributory role in the cause of death. As regards the location of the fire, buildings ranked first with 39 cases (57%) followed by vehicles with 21 cases (31%) and only 8 victims (12%) burnt to death outdoors.

Changes similar to washerwoman's skin were found in 27 burnt bodies (40% of the study material) and the age and sex distribution was in line with the total number of burnt bodies. There was no correlation between appearance of the pseudo-washerwoman's skin and the manner of death or the location of the fire. The hands were affected in 13 cases, the feet in 14 cases and in most of these the shoes and socks were extensively or totally burnt. Only one corpse with pseudo-washerwoman's skin on the feet had nearly unburnt shoes and socks on (Fig. 2).

As far as the extent of the burn injuries was concerned, it was found that the cases with pseudo-washerwoman's skin showed lower CGS grades than the average total study material (Fig. 3) and of the 41 deceased without pseudo-washerwoman's skin only 9 showed no burns on the hands or feet, the other 32 showed severe burn injuries to the extremities ranging from the loss of skin with charring of the muscles to amputation.

The histological preparations of the palms and soles with changes resembling washerwoman's skin showed vesicular detachment of the epidermis within or below the stratum germinativum with the blisters being filled with homogenous eosin-stained fluid (Fig. 4a). No leukocytes were found in the blister content. The cells of the basal epidermal layers often showed nuclear elongation with a palisade arrangement in the vicinity of the fluid blisters. These findings were more or less pronounced, varying from case to case and partly even within one and the same preparation. Swelling of the epidermal cells with perinuclear vacuolization was not observed. In some cases heat condensation of the collagen fibers of the dermis and clumping of the erythrocytes in the capillaries as well as in the arterioles and venules was observed. Altogether the skin showed a strongly wrinkled surface with cone-like ridges containing small fluid blisters at the bases (Fig. 4b).

Discussion

In burnt corpses there are theoretically four different mechanisms which may be responsible for the wrinkling and

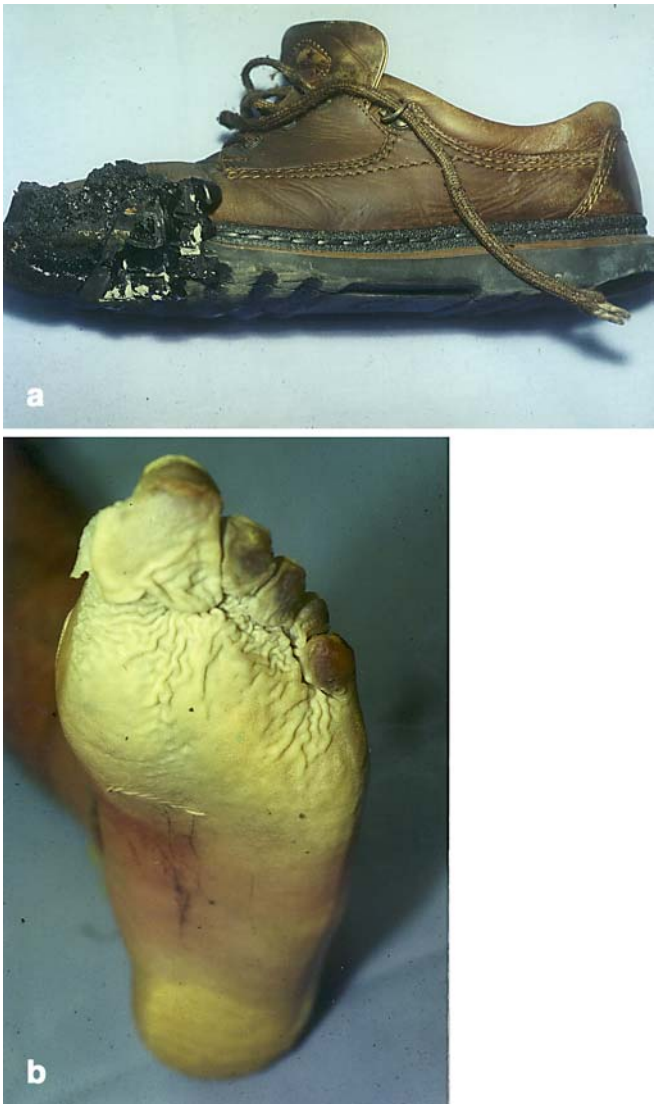

Fig. 2 Left shoe and foot of a 64-year-old male with postmortem heat exposure; self-extinguishing of the fire

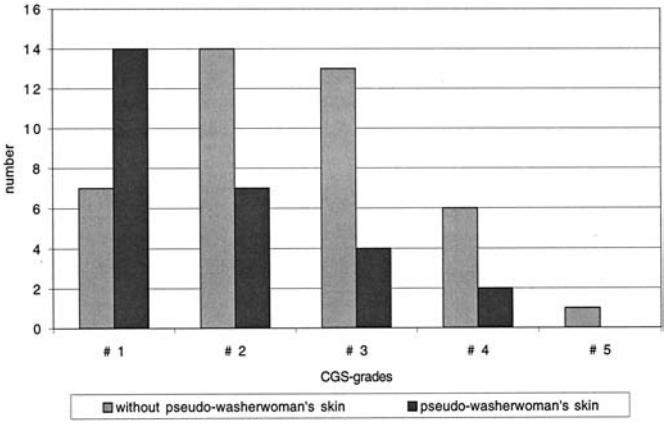

Fig. 3 Frequency of pseudo-washerwoman's skin in burnt corpses broken down according to the degree of destruction by the fire as defined in the Crow-Glassman-Scale (CGS)

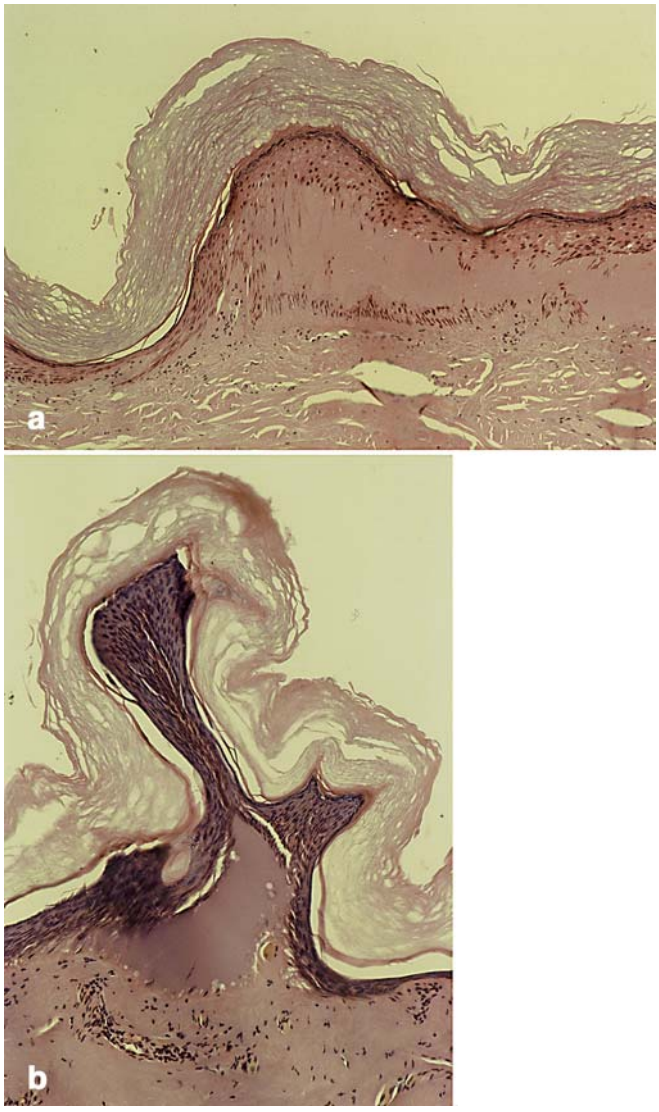

Fig. 4 Pseudo-washerwoman's skin. **a** Vesicular detachment of the epidermis in the stratum germinativum with blisters filled with homogenous eosin-stained fluid (HE, ×200). **b** Wrinkled surface with cone-like ridges containing small fluid blisters at their base (HE, ×300)

vesicular detachment of the epidermis on the palms of the hands and soles of the feet called pseudo-washerwoman's skin by us. These could be:

- Genuine washerwoman's skin as a result of the effects of the water used to extinguish the fire
- Putrefactive detachment of the epidermis
- The result of a heat-related fluid loss in the corium
- A morphology of skin burns dependent on the localization.

For all these theories the special anatomy of the skin on the palms of the hands and the soles of the feet, so-called friction skin has to be taken into account. As is well known, this is characterized by a particularly thick stratum corneum of the epidermis, a dense interlock of the epidermis with the high papillae arranged in rows in the corium and a

tight attachment of the stratum reticulare to an underlying aponeurosis.

The formation of genuine washerwoman's skin in burnt corpses would require prolonged exposure of the palms of the hands and soles of the feet to a moist environment. As is well known, the wrinkling and whitish discoloration of the genuine washerwoman's skin is due to swelling of the epidermis as a consequence of the intake of fluid from the environment. In warm water the first changes on the fingertips develop even after a few minutes, whereas in cold water it may take several hours before the swelling of the skin spreads to the entire palmar or plantar skin [7]. Histologically, formation of vacuoles and fraying of the horny lamellae is seen. Gradually the cell boundaries of the epidermis become less defined and finally vacuoles develop also in the stratum germinativum and partial detachment of the epidermis follows [6]. The histological findings do not correspond to those found by us in burnt corpses, which would argue against a genuine washerwoman's skin. Moreover another fact contradictory to this theory of genuine washerwoman's skin is that the phenomenon was mostly found in bodies, which definitely had not been in contact with the water used for extinguishing the fire (Fig. 2). In most cases with pseudo-washerwomans's skin on the feet, the shoes and socks were extensively or totally burnt so that direct exposure of the skin to the heat can be assumed.

Against the second theory of a putrefactive cause there is the argument that the bodies of our study material showed neither external nor internal signs of putrefaction. For an advanced decomposition restricted to hands or feet only there would be no explanation. Moreover putrefactive blisters on the palms of the hands and soles of the feet as well as in other body regions have a dome-like shape. The histological findings are also hardly consistent with a putrefaction characterized by the loss of the cell and nuclear boundaries as well as complete detachment of the epidermis from the corium [5].

The third theory that the phenomenon might be the result of a heat-related fluid loss of the corium is also not very plausible. In this case one would rather expect a stiff, leathery skin analogous to mummification than a wrinkled, whitish, soft epidermis. Although wrinkling of the skin, especially on the fingertips and toes, is occasionally also seen in mummified extremities, the entire thickness of the skin is involved in those cases and there is no detachment of the epidermis [10].

The histological picture of pseudo-washerwoman's skin, fluid-filled blisters in the stratum germinativum, elongation, hyperchromasia and palisade arrangement of the basal cell's nuclei, clumping of the erythrocytes fulfills the criteria of second degree burns of the skin [5, 16]. Therefore it is to be assumed that pseudo-washerwoman's skin is a morphological variation of the second degree skin burn due to the special anatomy of friction skin, which is characterized by a particularly thick stratum corneum of the epidermis, a dense interlock of the epidermis with the high papillae arranged in rows in the corium and a tight attachment of the stratum reticulare to an underlying aponeurosis.

In burnt corpses pseudo-washerwoman's skin should be regarded as a vital sign only in those cases where, as generally demanded for burn blisters, fibrin and leukocytes are found in the blister content. However, this requires a certain survival time which did not occur in our study material. In addition pseudo-washerwoman's skin was also found in 5 cases (7%), in which there were only postmortem effects of heat on the body and in these cases formation is probably due to heat-related shifts of fluid within the soft tissues. That fluid-filled blisters on the skin can also be caused by postmortem effects of heat has repeatedly already been reported in the older literature (for summary and references see von Hofmann and Haberda [4]).

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