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Skin blister formation together with patterned intradermal hematoma: A special type of tire mark injury in victims run over by a wheel

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ABSTRACT

A traffic accident victim run over by a vehicle may show a patterned skin hematoma reflecting the grooves of the tire's profile. Apart from this well-known type of imprint mark, the affected skin can also be blistered provided that the wheel exerts high pressure on the body for a prolonged period of time. The macro- and micromorphological findings as well as the protein composition of the blister fluid were investigated on the basis of a relevant autopsy case. Analogous to blisters associated with hanging marks, the transudation of serous fluid with consecutive detachment of the epidermis is interpreted as a pressure-related effect which cannot be regarded as a sign of vitality.

1. Introduction

Blunt trauma is defined as damage to the body due to mechanical force applied either by the impact of a moving blunt object or by the movement of the body against a hard surface, both mechanisms resulting in the transfer of kinetic energy high enough to produce an injury (mainly by compression, traction, torsion, and shear stress) [1]. In most instances, the external appearance does not allow drawing conclusions about the nature of the impacting object. Therefore, it is all the more important that patterned injuries, where present, are recognized and interpreted correctly.

On skin, a characteristic imprint may be caused either by (pressure) abrasion (depicting edges or protruding parts) or by bruises. Among the latter ones, intradermal hematomas are especially informative as they often reflect the surface configuration of the impacting object: The skin squeezed into the grooves will show intradermal bleeding, whereas the areas exposed to the elevated parts remain pale [2]. Patterned extravasations of this type can be seen as tire tread marks in victims run over by a wheel or in physically abused persons who suffered kicking or stamping with the ribbed sole of a shoe. The weaving structure of a garment may also generate a characteristic pattern of intradermal blood extravasations at the impact site.

In fatal traffic accidents, a forensic autopsy is not only performed for the purpose of determining the cause of death, but also to reconstruct the course of events. This includes the kind of the victim's involvement (e.g. pedestrian, car driver, front-seat passenger, cyclist, biker) and the type of collision (head-on, lateral or rear impact). Especially in fatally injured pedestrians, cyclists and bikers, it has to be clarified, whether the victim was run over by a motor vehicle when lying on the road.

Some morphological findings may suggest that at least one wheel has moved over the body: In typical cases, a so-called décollement (separation of the integument from the underlying fascia in combination with crush damage to the fatty tissue) indicates which parts of the body have been contused by compressive and shearing forces of the wheel. Due to additional traction exerted on the skin, superficial tears may occur at sites of predilection (e.g. inguinal regions) [3]. Nevertheless, tread marks on the clothes and/or on the skin are the most convincing proof that a person was run over.

A tread mark is either a positive imprint (produced by the projecting tread lugs providing the contact surface) or, more often, a negative one, which mirrors the groove pattern and usually consists of densely arranged intradermal bleedings. Recently, we had the opportunity to investigate an interesting modification of a

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groove pattern tread mark in that the geometrically shaped hematomas were accompanied by fluid-filled skin blisters. To the best of our knowledge, this variant form has not been published so far in the pertinent literature. It therefore seems justified to present the findings on the basis of a relevant autopsy case.

2. Case study

An articulated truck turned right from a road to a construction area. In doing so, the driver overlooked an 11-year-old girl cycling on a bike lane running parallel to the street. She was hit by the right frontal corner of the vehicle and fell to the ground where trunk and head were run over in prone position by the left three wheels of the fully laden trailer. When the truck came to a standstill, the third wheel rested on the body which remained impacted between the tread and the road surface until recovery (Fig. 1). The cycle helmet was completely disintegrated and the brain had partly exenterated from the burst skull.

The upper parts of the light-colored sweatshirt worn by the victim (hood, shoulder regions) were soaked with blood. On the back, the fabric was stained with greyish-black dirt (positive imprint of the tread lugs) with clean stripes in between (corresponding to the circumferential grooves). The location and course of the tire tread mark (Fig. 2) indicated that the girl had been run over in prone position approximately lengthwise from the legs to the head.

The autopsy findings are only reported briefly: body length 156 cm, body weight 43 kg; severe destruction of the cerebral and visceral cranium accompanied by partial exenteration and laceration of the brain; injuries to the thorax and abdomen (serial rib fractures, multiple ruptures of the inner organs and great vessels, displacement of the liver into the thoracic cavity and issue of bowels through a gaping tear of the abdominal wall; multiple fractures of the pelvic ring, the spinous processes of the vertebrae and the shoulder blades). In the dorsal and lumbar regions, the skin and subcutis were avulsed from the underlying muscles and bones (so-called décollement). Avulsions of the integument were also found on the right thigh and lower leg, both accompanied by vertical tears (open décollement).

The skin of the back showed wavy red lines running at an angle from the left shoulder to the right lumbar region (Fig. 3). The width of the lines and the distance between them corresponded to the circumferential grooves of the tire treads found on the trailer's wheels. Actually, two imprint patterns could be distinguished: One of them was rather faint and the other more prominent and shifted to the right. The second one was located on the right half of the back exactly in the area exposed to the continued pressure of the third wheel after the trailer had come to a standstill. Only this distinctive tread mark on the right lower back showed a combination of intradermal bruises and blistering.

Fig. 1. Scene of the traffic accident. The third wheel of the trailer is still resting on the body.

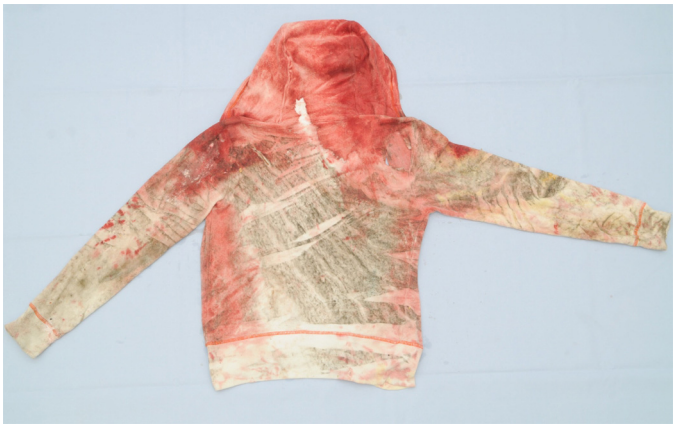

Fig. 2. Back of the sweatshirt worn by the victim with positive imprint of the tread lugs.

3. Methods

The scene of the accident, the articulated truck and the bicycle were investigated by the traffic police and by a technical expert, respectively. The garments worn by the victim remained on the body until autopsy, so that the clothes could be examined for accident-related damage and traces such as tread marks. After recording of all external findings and taking photographs, the body underwent a complete forensic autopsy.

Apart from specimens of the inner organs, pieces of skin from the back were fixed in buffered formalin (4%), embedded in paraffin, cut into thin slices (4 μm) and stained with hematoxylin-eosin and according to Mallory for histological investigations. Additionally, the skin was subjected to cryosection and stained with sudan red 7B.

Large skin blisters were punctured with a disposable syringe in order to aspirate the yellowish fluid content. The total protein concentration and the main protein fractions (albumin, alpha-1-globulin, alpha-2-globulin, beta globulin, gamma globulin) were determined using routine laboratory methods (Roche Diagnostics Cobas™ analyzer and Sebia's Capillarys™ 2 system, respectively). Based on the relative proportions of the protein fractions, the albumin–globulin ratio was calculated and compared with literature data concerning the fluids of different blister types.

4. Results

The tire tread mark on the victim's sweatshirt is shown in Fig. 2: Its pattern portrayed the form, size and arrangement of the tread lugs and therefore constituted a positive imprint representing the elevated parts. In contrast, the imprint on the skin was a negative one in which the parallel lines corresponded to the grooves between the lugs (Fig. 3).

According to the external appearance, the tire mark on the back consisted of wavy parallel lines. They were sharply defined and had a carmine-red hue as it is typical of blood extravasations in the upper corium layers [4]. When looked at with a magnifying glass, the red skin discolorations were composed of individual or confluent petechial bleedings located closely together. On the right lower back, where the intradermal hemorrhages were especially pronounced, the skin was also blistered in congruence with the red-colored stripes. The blisters were strictly confined to