

Literature review

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Current state of treating patients with extensive degloving injuries of integumentary soft tissues (literature review)

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The authors analyzed the scientific publications that deal with the problems of treating injured persons with extensive degloving injuries to integumentary tissues. The majority of literature sources available for the last 10 years were published abroad. They particularly discuss the use of not only anamnesis and clinical methods for the diagnosis of open and closed degloving injuries of integumentary tissues but also a great variety of instrumental and radiological techniques. Their treatment is optimized by participation of different specialists, including plastic surgeons. It enables not only to avoid pyo-septic complications but also to achieve the best possible aesthetic outcomes in most cases. The Russian literature on the problems of diagnosis, treatment and rehabilitation of injured persons with extensive degloving injuries of integumentary tissues is extremely scarce. Upon summarizing the data of foreign and Russian literature, we conclude that there is no consensus on an optimal choice of the terminology, no classification and, as a consequence, there are no unified approaches to treatment. The above points prove the fact that management of extensive degloving injuries to integumentary tissues remains the topic of further studies.

Keywords: degloving injury of soft tissues, Morel-Lavallée lesion, treatment with vacuum-assisted devices, results

The skin is a protective outer covering of the body that is susceptible to numerous external mechanical impacts. If the impact force is great and exceeds the resistance and elasticity reserve of the skin and other underlying tissues, it injures the connective tissue dermal elements and subcutaneous tissues. The magnitude of injury may be very great and affects large body surface areas [1].

Traumatic skin avulsions are a consequence of rough mechanical impacts of different moving mechanisms and were first described by a French surgeon Morel Lavalée in 1863 (cited according to John F. Carroll, 2010) [2]). Since then, the reports on this topic were not available in the medical literature for a long time. In 1889, R. Keller described the mechanisms of such injuries and touched their treatment issues (cited according to V.K. Krasovtsov, 1947) [1].

The first report about *decollement de la peau* in the national literature appeared in 1930 and was described by V.V. Alekseev [3]. The first journal article was written by S.M. Rubashev in 1936 [4]. Later on, the major works were published in the last century [5, 6, 7]. It should be noted that the topic of integumentary tissue detachments has not been included or has been described incompletely in the national manuals or textbooks [8, 9].

The majority of available literature sources on this issue were written in the English language. They present

several synonyms to term this pathology such as post-traumatic soft tissue cysts, pseudocysts, Morel Lavalée hemorrhage, Morel Lavalée hematoma, Morel Lavalée effusion [10]. In its essence, these synonyms describe different phases of the condition after a direct traumatic impact. Therefore, it can be concluded about the specific stages of the Morel Lavalée syndrome development though not a single study focuses on the phasing of the condition.

Epidemiology of traumatic integumentary tissue detachment

The opinions of the scientists on the issue of epidemiology differ. In Russia, due to the scarcity of the information on the topic, one can state that the pathology is either rare or does not attract the researchers.

I.G. Belenkii et al. [11] state that extensive integumentary detachments can be encountered in 1.07 to 1.6% of cases from the total of trauma patients. The authors point to the fact that their treatment is difficult and has no final solutions yet.

V.A. Sokolov [12] observed traumatic skin and subcutaneous tissue detachments in 1.5 to 3.8% of the injured persons with multiple or associated trauma. In isolated trauma, such injuries occur as occasional cases. The author understands under the detachments a separation of the skin and subcutaneous tissue from the underlying fascia on the extension of more than 1% of the body surface. In the period from 1998 to 2003, the author and his

colleagues from the Moscow N.V. Sklifasovsky Research Institute of Emergency Care treated 54 patients with closed traumatic skin degloving.

I.E. Mikusev and co-authors (2013) [8] report on the analysis of management of 53 patients. Traumatic skin degloving occurred in 18 of them due to a bus, trolley bus, truck, or car wheel motion over the body parts.

According to foreign literature, degloving injuries are rather common. In particular, E. Letournel and R. Judet (1993) [13] observed closed degloving of the integumentary tissues in 8.3% of the injured persons with fractures in the acetabular area that was due to the impact into the greater trochanter region. They reported on the Morel Lavallee syndrome in 23 injured persons out of 275 cases of pelvic fractures.

P. Tornetta and S. Tseng (2006) [14] summarized the experience of treating 90 cases with an acute Morel Lavallee syndrome encountered between 1994 and 2004 and chosen from medical records of 1100 patients with pelvic fractures. Twenty patients out of those with integumentary tissues degloving sustained pelvic fractures, seven had fractures in the acetabulum, and two had fractured ribs. The severity of trauma was impaired by pulmonary contusion in three patients, two had injured spleens, and one had a ruptured liver.

D.A. Milcheski et al. (2010) [15] report on the results of 21 patients treated over the period of four years. Among them, there were 11 (52.4%) patients that had work-related injuries, and 10 sustained injuries while riding a motor-cycle.

P. Wójcicki, W. Wojtkiewicz and P. Drozd [16] described three severe cases over the period of three years. K.A. Kudsk et al. (1981) [17] published the findings about 21 patients for 9 years of observations, and S. Dawre et al. (2012) [10] described 19 cases of the Morel Lavallee syndrome.

D.A. Hudson (1995) [18] reported on seven injured individuals (one male and six females) encountered over the period of five years that sustained a traumatic degloving of the integumentary tissues. Their mean age was 26.6 years. Six of them were pedestrians and one was a passenger in a car. Degloving was associated with fractures in three of them (clavicle, humerus, and metacarpal bone).

A number of authors [19, 20, 21, 22] state that sport activities (football, wrestling) can also result in the Morel Lavallee syndrome. Though such injuries are referred to a low energy trauma, the tangential effect of the force can result in the rupture of the connections between the subcutaneous fat and superficial fascia.

Mechanisms of integumentary tissue detachment

As for the mechanisms of detachment injuries, we could not find disagreement between Russian and foreign authors. The mechanism of degloving is a high-

energy injury which can be caused by [12, 23]:

- Pulling along an asphalted road surface when a vehicle (car, bus, train) captures person's clothes or arm and then drags him/her along the road surface or platform;
- Capturing the limb, mainly the upper one, into a moving mechanism (industrial machine, snow machine, etc);
- Ripping off the skin and subcutaneous tissue with broken vehicle parts in road accidents or with metallic and other objects at explosions;
- Car or train wheel riding over the person's body or its parts.

As far as the muscles envelope the bone in a closed fascial sack, a tear of separate muscle fibers and vessels of muscles or fascia can occur. At the same time, muscles serve as shock absorbers by the injuries. If the bone is enveloped with muscles from all sides (femur), the periosteum is rarely injured.

The following figure presents the mechanism of traumatic detachment of integumentary soft tissues (Fig. 1).

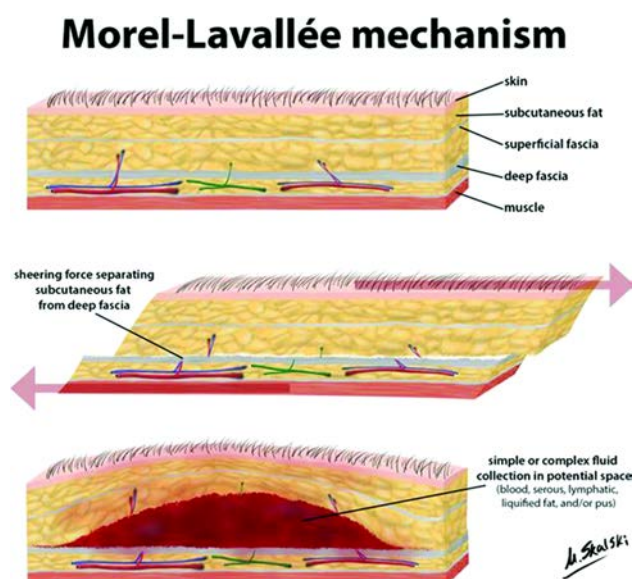


Fig. 1 Mechanism of Morel Lavallee lesion development [24]

Under the mechanical force impact, the tear of vessels, subcutaneous fat, and collagen fibers of the skin dermis and of separate fat portions may occur with the skin integrity intact. The subcutaneous fat is separated from the fascia at this or that extension. The fascia ruptures only in case of a considerable force impact but commonly remains intact. The action of the force is transferred to the muscles located under the fascia.

The mechanical force does not act in a straight manner but is tangential and contributes to the detachment of the skin and subcutaneous fat from the fascia. The cavity formed by a closed detachment may collect up to three liters of poured blood. If the detachments is not diagnosed, that happens very frequently if it locates in

the gluteal region, spine and posterior surface of thighs, it may result in an “unexplained hypotonia and anemia.”

As stated by several authors [1, 12], there are differences in the clinical manifestations in females and males due to the anatomical features of their skin and subcutaneous fat. In females, the detachment is 4- or 5-fold more frequent as far the connective tissue intersections that fix the subcutaneous fat to the underlying fascia are less marked and strong than in males.

Classification of extensive traumatic soft-tissue degloving

Since the time of Morel-Lavallee, all skin detachments are commonly divided into three groups: small, middle and large. However, the measurements of the injured area size have not been specified by this division.

Degloving is either open or closed. In an open detachment, there is a wound that communicates with the cavity at the detachment site. In a closed degloving type, the skin is not completely damaged though there may be extensive scratches but the underlying cavity does not communicate with them.

Classification of extensive traumatic soft tissue detachments was proposed by Russian authors V.K. Kravosovtov (1947) [1] and was extended by I.E. Mikusev with co-authors (2013) [8]. These authors distinguish three main types of traumatic skin degloving. **In the first type**, crushing of the subcutaneous fat prevails in the area of detachment that is separated into portions connected with the skin while the remaining part is connected with the fascia. **In the second type** of degloving injury, the rupture of the subcutaneous fat takes place which is not accompanied by a severe damage to it or to the tissues that lie deeper. However, the major part of the subcutaneous fat is detached along with the skin. **In the third type**, the crushed portions of the subcutaneous fat interchange with the portions where some part of the subcutaneous fat with the skin is preserved like a sheet (mixed combined closed skin detachment).

A.A. Proshakov and co-authors [25] divided all patients into three groups according to the type, area of degloving and treatment tactics. Group 1 is characterized by a traumatic skin detachment with the area of up to 200 cm², increase in limb volume, and fluctuation. Group 2 features a damaged area of 200–400 cm², pain in the region of the injured segment, limb function disorders, increase in limb volume, decreased pulsation in the distal parts in the presence of expressed swelling of the limb, undulation symptom, and skin folding (Keller symptom). Group 3 is characterized by the detachment area exceeding 400 cm², and in the majority of cases the pathological process extends beyond one segment.

By direct trauma, the subcutaneous fat acts as an absorber but blood and lymphatic vessels are less resistant

when damaged by a mechanical force and form a cavity that is called a “pocket” and fills with lymph and blood. The notion was introduced by G.P. Istomin [26]. Moreover, lymphatic vessels suffer to a greater degree. The damage to predominantly lymphatic vessels is explained by the fact that they are less resistant to trauma than blood vessels and are more frequently torn [5, 26]. Lymph is accumulated predominantly under the skin and resembles a hematoma. The collected content of the “pocket” in extensive degloving may reach 1.5 to 2 litres [27].

Foreign practitioners use the classification proposed by Z.M. Arnez, U. Khan and M.P. Tyler in 2009 [28]. Four types of injuries are distinguished according to this classification:

- 1) limited superficial abrasion/avulsion with tissue loss due to an abrasive force;
- 2) Non-circumferential degloving. Integumentary tissues are either absent or present as flaps. The area of injury is limited by one layer (commonly between the deep fascia and subcutaneous fat).
- 3) Circumferential single plane degloving;
- 4) Circumferential multi-plane degloving that involves damage to muscles, periosteum, and bones.

Diagnosis of extensive integumentary tissues degloving

Currently, the diagnosis of traumatic integumentary tissues degloving is established with clinical, sonographic, radiographic, radiological and microbiological methods of study. Thereby, the examination of patients with closed or open type of degloving has a number of specific features as far as clinical manifestations of closed detachments do not always coincide with the results of instrumentation diagnostic methods [21]. The expressiveness of symptoms may increase within several hours or days since the injury.

Clinical manifestations are divided into general and local. When the area of the injury is examined, one should pay attention to the presence of edema and wounds, protrusions, change in the body contours, change in local temperature, skin color, non-uniformity of soft tissues consistency, fluctuation, pathological mobility of the skin relative to the underlying tissues, disorders in joint functions, deformities and limb shortening, possible sensitivity and blood circulation disorders distally from the injury zone [21].

Radiography is not a specific method used for integumentary tissues degloving but it enables to assess the condition of bone tissue in the region of injury [21].

According to many authors [21, 29], ultrasound is the method to diagnose the size and severity of soft tissue lesions (**Fig. 2**). Hyperechogenic (hematoma) and hypoechogenic (discharged lymph, serous fluid) formations are significant findings. Acute and subacute

syndromes (less than one month since the injury) are characterized by variability in cavity sizes and contours, according to the authors. Detachments that are 18 months or older have permanent shapes, smoothness of cavity walls, and uniform contents.

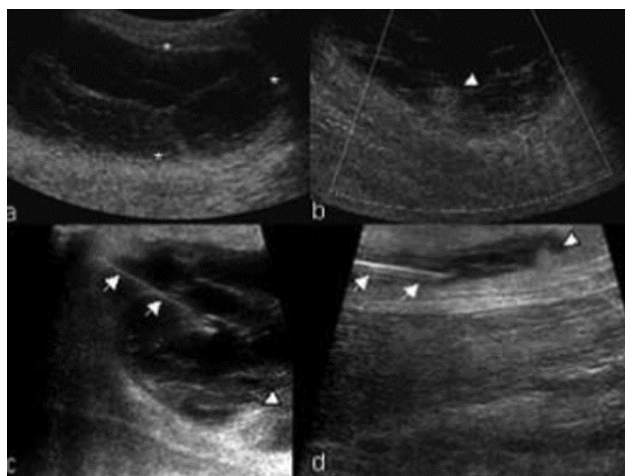


Fig. 2 Ultrasound image of the right femur in a patient after a bicycle accident shows a large cavity with separations and fluid in deep subcutaneous tissues (stars) that corresponds to Morel-Lavallée lesion (a). Doppler study showed the absence of internal blood flow (b). A spinal needle 20-caliber catheter was introduced into the cavity under the US control, 85 cm³ of serous hemorrhagic fluid was removed (c). Captured portions of the fat tissue look like bright hyperechogenic nodes in the injury area (arrows) (c and d). Presented by Chokshi F.H. et al., 2010, pages 252-263 [29]

CT and MRI methods are the means of a good visualization of encapsulated and non-capsulated fluid accumulations (**Fig. 3**). If available, the authors prefer MRI as the most informative method of diagnosis [21, 22, 24, 30, 31, 32, 33].

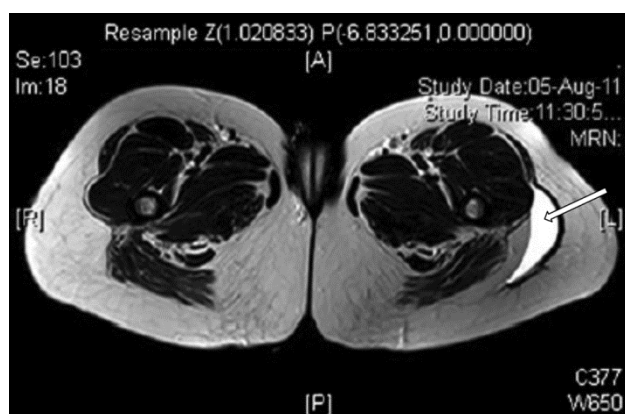


Fig. 3 MRI image. On the right, the arrow shows an area of closed integument tissue degloving. Presented by Gupta K. et al., 2012, pages 489-494 [10]

Basing on their experience, J.M. Mellado et al. (2004) [27], C.G. Borrero and J.M. Moriarty (2011) [34] divided the MRI picture of the Morel-Lavallée syndrome into six types according to the content in the cavities, shapes and structure of the capsule walls if it is present.

Use of intravenous contrasting of the subcutaneous

veins with the aids of fluorescence according to S. Wai-kakul (1997) [35] is the best method of an early detection of the demarcation line between the viable and nonviable skin.

Treatment of traumatic skin detachment and degloving

Treatment of patients with traumatic skin detachments presents a number of difficulties. There is no patterned approaches that have been described by both Russian and foreign literature sources [21, 36, 37].

K. Gupta, L. Shashank, H. Sreekar (2012) [10] formulated optimal algorithms of organizing the treatment process in acute and chronic Morel-Lavallée lesions upon summarizing their experience. In the foreign literature, there are numerous statements that the work requires several specialists at different stages of treatment in such patients [15, 24]. L. Rijal and co-authors (2012) [38] point to the necessity of participation of emergency care doctors, general surgeons, trauma and orthopaedic surgeons, and microsurgeons if required.

Currently, there are several strategies of treatment used for traumatic integumentary tissues degloving that can be divided into the conservative and surgical ones. The first ones are compression bandages, percutaneous aspiration and draining as well as sclerosant injections into the cavities [39, 40, 41, 42, 43]. Use of non-steroid anti-inflammatory drugs (NSAID medication), physiotherapy and stable immobilization of limbs are indicated by small detachments that are not accompanied by fractures in the region.

Surgical methods are of special significance in a complex treatment of patients with traumatic tissue detachments. It was believed that timing of a surgical intervention is of great importance. Type of surgical treatment according to other authors depends upon the type, area and deepness of degloving, tissue infection, and associated fractures.

Surgical interventions are complete primary debridement of the wound with revision of “pockets” that may include an endoscopic revision, treatment of the detached skin according to V.K. Krasovtsov and primary wound plasty with skin flaps and wound plasty with vascularized tissue complexes [44, 45, 46, 47, 48, 49]. It is proposed to fix the limbs with the injured integumentary tissues with external fixators, the Orthofix fixator being the most commonly used [14].

Foreign authors offer to use vacuum-assisted closure devices, various types of wound cleaning with ultrasound apparatuses and chemical means of treating the cavities [50].

Negative pressure wound treatment (NPWT) is one of the contemporary techniques for treating the wound of various etiology, including the wounds that are formed due to a traumatic injury to the integumentary system [50].

This method is especially relevant for infection arrest in the wound. Negative pressure provides a continuous evacuation of the exudates and efficiently cleans the wound surface, stimulates granulation tissue proliferation. A lot of authors that used the vacuum-assisted technique did not report on any complications specific for this method.

Extensive lesions to the tissues and their infection, problems of the wound surface that persist for long time are the predispositions for the development of a number

of complications [51]. However, the discussion of these issues is scarce both in the national and foreign literature. D. F. Mello and co-authors from Brazil [44] observed complications in 29 (62 %) out of 47 patients treated over eight years and had two deaths (4.2 %) on days 15 and 25 after admission. Kudsk K.A. [17] reported on amputations in five persons and two deaths in a group of 21 patients.

CONCLUSION

Soft tissue degloving is a group of severe and potentially devastating lesions. They should be early diagnosed. High degree of suspicion is a decisive factor in treatment of closed degloving injuries. Multi-disciplinary actions should be used and a multi-organizational work is needed.

National literature is scarce on the topic of traumatic degloving of the integumentary system tissues. Both

foreign and national literature does not discuss the issues of patient's transportation. There are no recommendations for the cases that feature extensive crushing of not only the integument tissues but also in association with crushed fasciae and muscles. Publications that deal with different and not rare complications such as suppuration, sepsis, extensive and deep defects of soft tissues are not available.

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