Review

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Modern View on the Problem of Treatment of Traumatic Soft Tissue Detachments

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ABSTRACT The treatment of traumatic soft tissue detachments is an urgent problem for a first-level trauma hospital. This paper provides an analysis of the literature sources of the PubMed database, which are devoted to the classification, diagnosis and treatment of traumatic skin detachments. It was revealed that most of the works are publications of 1–2 clinical cases, only a few works are retrospective studies of patient groups. Currently, there is no generally accepted classification of traumatic detachment of soft tissues, due to the complexity and mosaic nature of pathoanatomical signs. According to the tactics of treatment, there is a difference in approaches for low-energy trauma (sports injury) and high-energy impact (traffic accidents, falls from a height). In the first case, the treatment methods are compression therapy, physiotherapy, and in rare cases, puncture. In the second case, puncture and drainage are the main method of treatment, and in persistent recurrent cases, chemical ablation or open surgery to excise the capsule in combination with vacuum drainage are the methods of treatment. Methods of endoscopic treatment of the walls of the detachment, ligation of the lymphatic vessels around the detachment, and the use of blockable sutures for obliteration of the detachment cavity are currently new methods of treatment, which effectiveness requires further study.

Keywords: Morel-Lavalle syndrome, traumatic soft tissue detachments

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RTA - road traffic accident
MRI - magnetic resonance imaging
EOC - electron-optical converter

INTRODUCTION

Traumatic detachment of soft tissues, or Morel-Lavallee lesion, occurs due to the shift and detachment of the hypodermis [1] from the underlying fascia with the formation of a dead space in which blood decay products and necrotic tissues accumulate, which can potentially lead to the formation of phlegmon, osteomyelitis [2], but in most cases this condition manifests itself in the form of long-term non-healing seroma [3], causing pain and visible deformation of the body contour [4]. Another complication of traumatic soft tissue detachments is damage to the vascular plexuses that feed the skin, which disrupts blood supply and can lead to the death of large areas [3].

MECHANISMS OF INJURY AND DIAGNOSIS

Many authors note that traumatic detachments of soft tissues are a relatively little-studied disease, so accurate statistics on its detection are absent in the literature. A keyword search in the *PubMed database* revealed approximately 54 papers, of which 13 were retrospective studies of small groups of patients, 23 were papers containing 1–2 clinical observations, and 18 were literature reviews.

Tejwani S.G. et al. (2017) notes that one of the mechanisms of injury is shearing of the skin during a fall while playing football. As a rule, the victims in such cases are young professional athletes [5]. The most common area of damage in such observations is the knee joints [6].

Another mechanism of injury is road traffic accidents involving a person being dragged along the road. After such trauma, skin detachments are located in the projection of the greater trochanter, in the pelvis, thigh, anterior abdominal wall, and knee joint [2]. As a rule, in such observations, detachments of integumentary tissues are accompanied by combined damage to bones and internal organs [7].

Most often, soft tissue detachments resulting from road traffic accidents are combined with fractures of the pelvis and acetabulum, according to *Steiner CL et al.* [7]. The presence of traumatic detachment creates problems when performing surgical approaches during surgical treatment of injuries of the pelvic bones and increases the risk of purulent complications [8].

A clinical sign of traumatic detachment of soft tissues is a visible deformation of the patient's body contour and the presence of a skin area in which the presence of a fluctuating cavity is determined upon palpation [8]. Additional diagnostic methods in complex cases include ultrasound scanning and magnetic resonance imaging (MRI) [1]. Diagnostic methods also include puncture of the contents of the detachment followed by histological and microbiological examination of the punctate.

CLASSIFICATION OF TRAUMATIC DETACHMENTS

A generally accepted classification of traumatic detachments has not currently been developed. In clinical studies, only the location of traumatic detachment is mentioned. The work of radiologists *Mellado* and *Jenny* attempted to classify these lesions based on MRI findings. The classic picture of detachment is damage in the perifascial layers of subcutaneous tissue in the area of the greater trochanter and the anterolateral surface of the thigh. There is a pattern of additional mass in this zone. Type I is a detachment along the surface of the deep fascia; the contents of the detachment are homogeneous and serous. It can be either with or without a capsule. Type II is a subacute hematoma in the layers of subcutaneous tissue adjacent to the deep fascia. The contents of the detachment are inhomogeneous, methemoglobin is determined, and there are signs of damaged and crushed subcutaneous tissue. As a rule, there is a thin capsule. Type III is a chronic hematoma, which is characterized by the accumulation of hemosiderin, the development of granulation tissue, the presence of necrotic tissue, fibrin and blood clots. Type IV is detachment of soft tissues within the fascial layers with transition to the thickness of the subcutaneous tissue, that is, there is a closed wound of the subcutaneous fatty tissue. Type V is the so-called nodal form. It is characterized by the presence in the perifascial layers of damage of a rounded shape, which contents are heterogeneous, inclusions from damaged and torn off subcutaneous fatty tissue can be determined. Type VI is an infected soft tissue detachment, which is characterized by the presence of damage to the perifascial layers of the subcutaneous tissue, a thin capsule, a breakthrough of the contents into the thickness of the subcutaneous fatty tissue, and the presence of fistulas connecting the cavity with the external environment [9].

Another attempt to classify traumatic soft tissue detachments was made by Mikusev I.E. et al. (2013) [10]. The authors distinguish type I detachments when the destruction of subcutaneous fat prevails, that is, the layer is divided into tissue adjacent to the fascia and tissue adjacent to the skin. In this case, the vessels passing in the subcutaneous fatty tissue and feeding the skin are injured, and this leads to a high probability of necrosis. In Type II detachment a layer of skin and subcutaneous fat exfoliates from the fascia. The skin and subcutaneous fat make up a single thick layer containing supply vessels, therefore, disturbed blood supply to the skin in type II detachment is less likely. Type III is the most common type of detachment, in which areas characteristic of types I and II alternate. As a diagnostic measure, these authors recommend multiple incisions of 1 cm and a digital examination of the thickness of the flap to detect crushed areas of subcutaneous fat.

Some authors classify soft tissue detachments into closed, without violating the integrity of the integument, and open, associated with skin wounds [10]. However, in most studies, open detachments of soft tissues are referred to as scalped wounds [2].

TREATMENT METHODS

Many authors are of the opinion that the key method of treating traumatic soft tissue detachments is puncture. Thus, *Doelen T.V.* and *Manis A.* (2019) described the observation of effective treatment of post-traumatic detachment in the knee joint area using puncture supplemented with massage, shock wave therapy and physiotherapy exercises [6].

However, *Tejwani S.G.* (2007) showed on a group of 27 detachments in the knee joint of professional football players that in approximately 50% of cases treatment was successful without puncture, using a compression bandage, cryotherapy and exercises [5].

According to some authors, the ineffectiveness of three punctures of the contents of the detachment of integumentary tissues is an indication for performing chemical sclerodesis [11]. Data are given on the use of talc, tetracycline antibiotics, ethanol, plidocanol, endidromycin, fibrin glue, and povidone iodide for this purpose.

Luria S. et al. (2006) using the example of 4 patients with soft tissue detachments in the hip and gluteal region showed the effectiveness of talc. The detachment cavity was treated with talc under the control of an electron-optical converter (EOC), Redon drainage after treatment of the cavity was left for an average of 12 days. This method is simple and fast, as opposed to invasive surgical treatment (excision of the detachment capsule) [12].

Bansal A. et al. (2013) present a group of 16 clinical observations of patients with long-term (from 2 months) soft tissue detachments, predominantly in the trochanteric region. In all patients, attempts at treatment with punctures were unsuccessful. The authors performed puncture of the detachment, removal of fluid, administration of the sclerosant doxycycline, and wearing of a compression bandage. This method of treatment was successful in 15 patients. The authors attribute the failure in one observation to the low compliance of the patient who arbitrarily canceled the compression bandage. After repeated treatment, this patient showed healing of the detachment [1].

Currently, various types of drainage of the detachment cavity are actively used [12–14]. Only a few authors cite clinical cases of cure using only this technology. Thus, *Zhong B. et al*. (2014) published 8 observations of patients with soft tissue detachments, in whom the diagnosis was established with a delay of 7 days [15]. In all patients, with the help of percutaneous drainage, it was possible to achieve healing of the detachment. A variation of detachment drainage is the installation of a sponge into the cavity instead of the drainage tube with the establishment of a system for vacuum aspiration [2]. These authors report an observation of extensive post-traumatic soft tissue detachment in the lumbar region in a 48-year-old patient who applied 1 month after the injury. The patient underwent a two-centimeter incision and 900 ml of serous fluid was removed. After rinsing with 0.9% betadine, a vacuum therapy sponge was placed. The vacuum was removed after a few days. Healing of the detachment cavity and incision without inflammation was noted. During the study of long-term treatment results, the absence of relapse was noted.

Many authors are of the opinion that treatment of the detachment capsule is necessary for successful treatment and provide various methods for performing this procedure [16, 17]. The original method was proposed by *Tseng*, *Tornetta* (2006): the detachment cavity was treated with a brush through 2 incisions of 2 cm, one in the most distal part of the detachment, the second in its most posterior or anterior part [13]. After brushing, a pulse lavage system was applied. The surgical intervention was completed by installing drainage through the entire injury.

Liposuction is another proposed method for treating the detachment wall. *Kalaria S.S. et al.* (2020) used this method of treating the cavity and wall of seroma in a 33-year-old patient 3 weeks after injury. Postoperative treatment consisted of drainage, compression stockings, and intramuscular antibiotics [14].

Kim S. et al. (2016) published a clinical observation in which the contents of the detachment and capsule were removed endoscopically [18]. The authors note that endoscopic surgical treatment makes it possible to achieve the goals of open surgery without causing major surgical trauma. *Walls A. et al*. (2017) presented a case of treatment of traumatic detachment in a 44-year-old man. The detachment was diagnosed 2 days after the injury. Surgical treatment of the detachment was performed endoscopically, which led to rapid improvement and complete healing [19]. *Koc B.B. et al*. (2017) publish an observation of the treatment of traumatic soft tissue detachment in a professional football player. It was noted that conservative treatment did not bring results, and the victim underwent endoscopic surgical treatment of the detachment cavity and introduced fibrin glue. The authors note that the treatment was successful and there was no relapse [20].

Despite the popularity of minimally invasive methods of treatment, many authors consider open debridement with excision of non-viable tissues and the capsule as the "gold standard" of care for victims with traumatic soft tissue detachments [16, 21]. The tactics of surgical treatment, according to the above authors, are as follows: a longitudinal incision was made in the central part of the detachment to the hematoma, tissue dissection along the entire length of the detachment, removal of areas of non-viable tissue, skin and fascia, resection of the detachment capsule, hemostasis.

Authors have different opinions regarding the final stage of the operation. So, *Köhler D.* and *Pohlemann T* . (2010) on the example of 9 patients, they believe that after surgery it is necessary to apply a vacuum system for an average of 8.5 days, which allows you to control the wound and reduce bacterial colonization [21]. The wound is then closed with secondary sutures or, in the presence of skin defects, with a split skin graft. *Reid D.B.C. et al.* (2019) sutured the cavity was sutured using transmyofascial stiches, 2 drains were installed in the cavity, and the incision was sutured [17]. The vacuum treatment of the area of postoperative sutures was carried out for 6 days, aspiration from the drains for 13 days. In this observation, the authors managed to achieve complete healing of the detachment.

Jones R.M. and *Hart A.M.* (2012) published a case of treatment of a patient with skin detachment along the medial surface of the thigh and lower leg. After surgical treatment and excision of the detachment capsule, staining and ligation of the lymphatic vessels feeding the detachment were performed. The cavity was closed with suturing and fibrin glue. The authors note that the treatment was successful, and the patient returned to her previous lifestyle. Within 6 months, no recurrence was noted [16].

Boudreault D.J. et al. (2016) suggested, using the example of two clinical observations, the use of sutures with a special blocked "barbed" thread for suturing detachments. These sutures were used to secure detached skin and subcutaneous tissue to the underlying fascia after debridement. In both cases, vacuum therapy was used in the postoperative period. Skin defects were replaced with split skin-fascial grafts [22].

CHOICE OF TREATMENT METHOD

Most of the clinical works devoted to traumatic detachments of integumentary tissues are an analysis of 1–2 clinical cases, so the problem of choosing a treatment method depending on the nature of the injury is little discussed. There are only a few papers that publish the results of treatment groups. Authors *Tejwani S.G. et al*. (2007), analyzing the course and results of treatment in 24 football players, came to the conclusion that if fluid accumulates in the detachment cavity during conservative treatment, then punctures are necessary, and in the absence of the effect of punctures, sclerodesis with doxycycline is a safe method [5].

One of the most extensive studies (79 patients) on traumatic detachments of skin tissues was published in 2014 [3]. The authors noted that the recurrence rate with compression therapy alone was 19%, with puncture treatment it was 56%, and with surgical treatment it was 15%. Surgical treatment in this study in the presence of skin necrosis consisted of full surgical debridement followed by vacuum therapy and closure with secondary sutures or skin grafting. In the absence of skin necrosis, surgical treatment consisted of making a 2 cm incision, washing the detachment cavity and installing a drain, followed by connecting the drain to active aspiration. In the group in which the punctures were performed, a significantly higher frequency of relapses was noted when receiving more than 50 ml of punctate.

Based on these data, the authors offer the following algorithm for choosing a method of treating detachment. In their opinion, the presence of a large (without specifying the area) detachment, deformation of the body contour, pain in the area of detachment are contraindications to compression treatment. In this case, if the skin is viable, it is necessary to puncture the contents of the detachment and completely remove the liquid from the cavity. If the fluid volume is less than 50 ml, then compression therapy and observation are necessary. With repeated accumulation of fluid, a puncture is necessary. The authors consider a volume of more than 50 ml of fluid obtained during puncture to be an indication for making a 2 cm long incision, washing the detachment cavity and draining it. Non-viability of the skin is an indication for full surgical treatment and application of a vacuum system. Subsequently, after the detachment is closed, secondary sutures can be applied or the skin defect can be closed using autodermoplasty.

Mikusev I.E. et al. (2013), suggest the following algorithm for choosing a treatment method in the first hours after injury, based on the classification of detachments according to the level of damage. In case of detachment type II, when the layer of subcutaneous fatty tissue associated with the skin is preserved, and the blood vessels supplying the skin are preserved, it is necessary to drain the detachment through several incisions of 1 cm each. Areas of subcutaneous adipose tissue and skin treatment according to Krasovitov and fixation of the treated skin to the wound surface in order to use it as an autograft [10].

SURGICAL TREATMENT OF COMBINED INJURIES OF THE PELVIC BONES IN PATIENTS WITH TRAUMATIC SOFT TISSUE DETACHMENTS

Kohler D. and *Pohlemann* T. (2010) note that combinations of traumatic detachments with pelvic bone fractures are quite common. Thus, out of 9 patients with integumentary tissue detachments, 5 had unstable injuries to the pelvic ring, which were fixed upon admission [21]. *Tseng S.* and *Tornetta P.* (2006) performed percutaneous fixation of the posterior pelvic ring with screws simultaneously with surgical treatment of detachment in 7 patients. If an open operation for bone osteosynthesis is necessary, these authors note that it is important to achieve healing of the detachment. According to the authors, osteosynthesis of the pelvic ring is possible not less than 24 hours after removal of the drainage from the detachment cavity. The authors conclude that such a strategy for surgical treatment of soft tissue detachments minimizes the risk of deep wound infection [13].

DISCUSSION AND ANALYSIS

The characteristics of clinical observations are given in the table.

Table

Features of clinical observations

Author and year	Number of patients	Most Injury Mechanism patients	Treatment method	Relapse/ complications
Doelen, *Manis* (2019)	1	sport	conservative	No
Koc et al. (2017)	1	sport	conservative	relapse
			endoscopic: debridement + fibrin glue	No
Zhong et al. (2014)	8	accident, falls from a height	drainage	No
Dodwad et al. (2015)	4	car accident	debridement, drainage, vacuum treatment	No
Walls et al. (2017)	1	fall	endoscopic debridement	No
Reid et al. (2019)	1	–	debridement, transmyofascial sutures, drainage	No
Kohler, *Pohlemann* (2010)	9	fall, accident	surgical treatment, vacuum system	No
Bansal et al. (2013)	16	falling from a height	puncture, injection of doxycycline, application of a compression bandage	1
Kalaria et al. (2020)	1	sport	liposuction, drainage, compression bandage	No

Kim (2016)	1	car accident	endoscopic debridement	
Jones Hart (2012)	1	car accident	surgical debridement, excision of the capsule, ligation of lymphatic vessels, fibrin glue, suturing, compression bandage	No
Mooney (2020)	1	fall	2 cm incision, fluid removal, cavity lavage with betadine solution, vacuum therapy	No
Li et al. (2020)	1		incision 2 cm, drainage	No
Tseng, *Tornetta* (2006)	19	fall, accident	incision 2 cm, plastic brushing, draining	No
Luria et al. (2006)	4		incision 2 cm, treatment of the cavity with talcum powder, drainage	No
Steiner et al. (2007)	20	falls from a height, accidents, sports	debridement, vacuum therapy	no / 9 patients - prolonged wound healing, 1 patient - death during surgery
Tejwani et al. (2007)	14	sport	conservative treatment	No
	13	sport	punctures	3
	3	sport	administration of doxycycline	No
Boudreault et al. (2016)	2	car accident	surgical treatment, suturing with a special “barbed” thread	No
Mikusev et al. (2013)	1	car accident	drainage through several 2 cm incisions	No
	1	road traffic accident	treatment of skin deprived of blood supply, autotransplantation of scrap skin	No
Terry et al. (2014)	21	accident, falls from a height	conservative treatment	4
	25		punctures	14
	41		drainage, surgical treatment if necessary	6

The problem of traumatic detachments of tissues is still poorly understood. Treatment options range from compression bandaging and exercise therapy to extensive debridement and excision of the detachment capsule. In order to select the optimal method of treating detachment, attempts are being made to classify these injuries, but in most clinical studies only the localization of the detachment and approximate dimensions are noted, which suggests that the existing classifications are cumbersome and difficult to apply in clinical practice.

When analyzing the works, we found that for injuries sustained during low-energy trauma, for example, while playing football or when falling from a small height, most authors use either conservative treatment or punctures. If punctures do not bring results, then the “reserve” method in such works is chemical sclerodesis of the cavity. The need for one or another surgical treatment of detachment is indicated only by the authors who treat injuries resulting from a high-energy mechanism of injury.

One of the main goals of debridement is to remove necrotic tissue, and we hypothesize that with low-energy trauma there is no significant destruction or necrosis of tissue in the area of detachment, which makes debridement unnecessary in most cases, since tissue viability is preserved.

The classification of Mikusev I.E. et al. (2013) reflects this division, when type I is accompanied by crushing of the tissue, which leads to impaired blood supply to skin areas, and type II is characterized by the preservation of a single layer of skin and subcutaneous fat. However, the difficulty of the clinical application of this classification lies in the fact that, as the authors point out, most lesions are of a mixed, "mosaic" nature and areas in which the structure of the subcutaneous tissue and skin is preserved alternate with areas where the normal tissue architectonics is destroyed. Another difficulty in applying the classification according to the level of damage is that it is necessary to perform multiple diagnostic incisions and a digital examination of the fiber, and this is far from always indicated in the severe condition of the victim and the presence of associated injuries [10]. It is possible that an MRI study performed in the first hours after an injury could eliminate the need for a diagnostic incision, but there are no works on the use of this research method in the first hours after an injury.

Most authors evaluate only the consequences of trauma to the subcutaneous fatty tissue: necrosis of skin areas. The presence of necrotic tissue requires full surgical debridement, followed by wound management using vacuum therapy and closure using secondary sutures or skin autotransplantation.

The most common associated pathology in patients with traumatic detachments is pelvic bone fractures. This creates difficulties both in the surgical treatment of skeletal trauma and in creating conditions for healing of the detachment. Most authors who have studied this problem have accepted that pelvic stabilization using minimally invasive methods should be performed before or simultaneously with surgical treatment of abruption. Extensive internal osteosynthesis operations should be postponed until the detachment has healed. However, this tactic is just an expert opinion, confirmed only by an uncontrolled retrospective study of a small group of patients.

CONCLUSION

Morel-Lavallee injuries or traumatic detachments of integumentary tissues occur as a result of sports injuries, when the victim is dragged across the football field, as a result of falls from a height and traffic accidents. In high-energy injuries, Morel-Lavallee injuries are often associated with pelvic fractures.

Based on an analysis of clinical work, we came to the conclusion that the application of a compression bandage and various types of physical therapy are most often used for low-energy injury mechanisms. If the volume of fluid remains in the detachment cavity, puncture is indicated, and if necessary, repeated puncture. If after several punctures the fluid persists, then sclerodesis with talc or doxycycline is successfully used.

The high-energy mechanism of trauma in the victim, according to many authors, leads to the frequent development of skin necrosis, which requires complete surgical treatment, removal of necrotic tissues and the capsule, wound management with a vacuum system and closure with secondary sutures or autodermoplasty.

In the absence of skin necrosis and receiving more than 50 ml of fluid during detachment puncture in patients with high-energy trauma, washing of the detachment cavity through a two-centimeter incision and drainage is indicated.

Along with traditional methods, there are reports in the literature on the successful use of endoscopic surgical treatment of the detachment cavity, fibrin glue for gluing the walls, and suturing the walls with a special "barbed" thread. However, these reports are rare and such methods require further study.

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