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ASSESSMENT OF SUBFASCIAL PRESSURE CHANGES IN INJURED WITH POLYSTRUCTURAL GUNSHOT WOUNDS TO THE LOWER EXTREMITY

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The purpose of the study was to study the changes in subfascial pressure in wounded with gunshot wounds to the lower extremity during the first 24 hours after injury. Data of 137 measurements of subfascial pressure in osteofascial compartments of the damaged segment, obtained in 128 servicemen with gunshot wounds, were analyzed. In gunshot fractures of the lower extremities, the average level of subfascial pressure increases in the period from 6 to 12 hours after injury by 35.8 % (p=0.0111) with a total rise for the first 24 hours after injury from 29.9±11.4 to 47.2±8.8 mm Hg (p=0.0005), but remains statistically similar for the periods 6–12 and 12–24 hours after injury. In cases with soft tissue gunshot wounds to the lower extremity, the average value of subfascial pressure progressively increases (after 6–12 hours from injury by 22.9 %, after 12–24 hours – by another 39.4 %, p=0.0240 and p=0.0076, respectively). Isolated tangential soft tissue gunshot wounds to the lower extremity without fascia lesion do not have any statistically significant effect on the subfascial pressure levels.

Key words: compartment syndrome, osteofascial compartments, fasciotomy, "rescue fasciotomy time interval" after injury.

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ОЦІНКА ЗМІН ПІДФАСЦІАЛЬНОГО ТИСКУ У ПОСТРАЖДАЛИХ З ПОЛІСТРУКТУРНИМИ ВОГНЕПАЛЬНИМИ УШКОДЖЕННЯМИ НИЖНЬОЇ КІНЦІВКИ

Метою роботи було дослідження змін підфасціального тиску у поранених з вогнепальним ушкодженнями нижніх кінцівок впродовж перших 24 годин після поранення. Проаналізовано дані 137 вимірювань підфасціального тиску в кістково-фасціальних футлярах ушкодженого сегменту у 128 військовослужбовців з вогнепальними пораненнями. При вогнепальних переломах кісток нижніх кінцівок середня величина рівня підфасціального тиску в термін від 6 до 12 годин після поранення підвищується на 35,8 % (p=0,0111) із загальним зростанням за перші 24 години після поранення з 29.9±11,4 до 47,2±8,8 мм рт. ст. (p=0,0005), при цьому залишаючись статистично подібним для періодів 6–12 та 12–24 години після поранення. При вогнепальних пораненнях м'яких тканин нижніх кінцівок середня величина підфасціального тиску прогресуюче збільшується (через 6–12 годин після поранення на 22,9 %, через 12–24 години – ще на 39,4 %, p=0,0240 та p=0,0076 відповідно). Поодинокі дотикові вогнепальні поранення м'яких тканин нижніх кінцівок, які не супроводжувались дефектом фасції, статистично значимого впливу на рівень підфасціального тиску не справляють.

Ключові слова: компартмент-синдром, кістково-фасціальні футляри, фасціотомія, «інтервал часу рятувальної фасціотомії» після поранення.

The work is a fragment of research "Development of modern methods of physical and rehabilitation medicine for combat wounds and injuries", state registration No. 0121U109354.

One of the most severe pathological conditions underlying most complications of gunshot wounds to the lower extremity is compartment syndrome (CS), or local hypertensive ischemic syndrome [1]. Studies, conducted by Strafun et al. and devoted to the study of treatment errors that may result in development of CS, showed that the development of irreversible forms of CS in cases of lower extremity gunshot wounds was mostly associated with refusal to perform fasciotomy ($p<0.05$) or with technical errors during this intervention ($p<0.01$) [3].

In our opinion, such errors become possible due to the lack of awareness of surgeons and traumatologists about the pathogenesis of CS as a consequence of gunshot wounds to the lower extremity. The main reason that results in development of CS after injuries is an increase in subfascial pressure (SfP) [10]. Underestimation of the clinical situation severity leads to refusal performing fasciotomy and, thus, to the development of severe complications. However, the CS risk depending on the level of SfP in the early periods after a combat trauma has almost not been studied, whereas indications for fasciotomy depending on this indicator have not been developed.

The purpose of the study was to examine subfascial pressure changes in injured with gunshot wounds to the lower extremity during the first 24 hours after injury and to justify performing a fasciotomy during initial surgical debridement.

Materials and methods. We analyzed the results of examination and treatment of 128 servicemen with injuries of the lower extremities (137 gunshot wounds), whom SfP measurements of osteofascial

compartments (OFC) of the injured limb segment were performed. Combined shrapnel wounds to the thigh and shin of different legs were presented in three cases, and wounds of both shins and thigh – in one case.

Inclusion of patients in the study was based on a study protocol developed according to the Helsinki Declaration and approved by the Ethics Committee of the National Military Medical Clinical Center "Main Military Clinical Hospital", all patients signed informed consent before enter the study.

All patients were male aged 20 to 59 years, mean age 43.8±2.1 years. We used the Shapovalov classification to determine the size of the soft tissue gunshot defect [4]. We used Strafun classification for clinical and instrumental assessment of the lower limb CS severity [3].

The first group included 41 cases with gunshot fractures of the lower extremity long bones. Exclusion criteria were: gunshot intra-articular fractures, gunshot fractures with injuries of the main vessels that required the use of a tourniquet, gunshot and ipsilateral fractures of the lower extremity, gunshot fractures with traumatic amputations. The second group included 58 cases with soft tissue injuries of the lower extremities. Exclusion criteria were: tangential and point (up to 0.5 cm) as well as large (more than 11 cm) polystructural damages with destruction of the limb segment; injuries with damage of the main vessels, which required reconstructive interventions; isolated and combined ipsilateral injuries with mutual encumbrance syndrome. The third group included 38 cases with tangential and point (up to 0.5 cm) soft tissue gunshot wounds to the lower extremity without fascia lesion, which did not require initial surgical debridement (ISD) of the wound. The exclusion criteria were: combination with damage, which can be classified as eligible for the first or second groups.

Moreover, the exclusion criteria for all groups were injured with any shock and/or prolonged hypotension.

After a comprehensive clinical and instrumental examination, the wounded were taken to the operating room for ISD of gunshot wounds to the lower extremity. At the stage of preoperative preparation in aseptic conditions, SfP measurements were performed using a serial device "Stryker" (Stryker, USA). All wounded received also medication, which included detoxification, antibacterial, anticoagulant, and anti-inflammatory therapy, directed to preventing the development of infectious and thromboembolic complications. To assess the reliability of the results obtained for each group, the mean value (M), standard deviation (SD) and variance (σ) were calculated and analyzed.

Checking the equality of the mean general population showed that the samples had a normal distribution (As and Ex<2), and the variances of the samples did not differ (unilateral pσ value>0.025). Therefore, we used parametric methods for samples with the same variances in the study. The statistical significance of the difference between the mean values in the groups was determined by the results of a two-sample t-test with the equal variances. We considered p-values <0.05 statistically significant.

Statistical data processing was performed using Microsoft Office Excel software.

Results of the study and their discussion. The time from the moment of injury to admission to the stage of providing qualified with elements of specialized medical care ranged from 2 to 24 hours. Depending on the time after injury and admission to the stage of providing qualified (with elements of specialized) medical care, each group was allocated to three subgroups: up to 6 hours, from 6 to 12 hours, and from 12 to 24 hours.

The average SfP values depending on the time and the severity of the injury are presented in Table 1.

Table 1

OFC SfP (M±SD) depending on the time after injury

Group	SfP level, mm Hg			p-value*
	Up to 6 hours	From 6 to 12 hours	From 12 to 24 hours	
I	29.9±11.4	40.6±7.6	47.2±8.8	p_1=0.0111 p_2=0.0740 p_3=0.0005
II	20.1±8.7	26.1±7.8	35.2±10.4	p_1=0.0240 p_2=0.0076 p_3=0.00005
III	9.2±1.8	10.4±2.4	10.3±2.5	p_1=0.1800 p_2=0.8000 p_3=0.2400

Note: *– significance between group parameters in dynamics; p_1 – significance between mean SfP levels in subgroups up to 6 hours and 6–12 hours after injury; p_2 – significance between mean SfP levels in subgroups 6–12 hours and 12–24 hours after injury; p_3 – significance between mean SfP levels in subgroups up to 6 hours and 12–24 hours after injury

Our results showed that SfP levels in Group I and Group II tend to increase and reach a level corresponding to mild or moderate CS during the first 24 hours after injury.

We used Strafun classification for clinical and instrumental assessment of the lower limb CS severity:

I degree – the distal segment is warm, the pulse is preserved, paresthesia or hypoesthesia of the toes, active and passive movements in the joints of the toes are preserved, painless. SfP 30–40 mm Hg below diastolic pressure.

II degree – the temperature of the distal segment is reduced, the pulse is weakened, hypoesthesia and anesthesia of the toes, active movements in the joints of the toes are sharply limited, passive painless. SfP within diastolic one level.

III degree – no pulse, anesthesia of the toes, active movements in the joints of the toes are absent, passive movements are sharply painful. SfP is greater than diastolic one.

In Group I, clinical signs of CS were observed in 15 of 41 cases (36.6 %). In the first 6 hours after injury, the average SfP level remained within 30 mm Hg, which corresponds to the CS of a mild degree. However, at the end of the first day of the gunshot injury with lower extremity fracture, mean SfP level increased up to 47.2±8.8 mm Hg, which is critically close to the CS of medium severity.

In Group II, signs of mild or moderate CS were diagnosed in 18 cases of 58 (31.0 %). The levels of SfP at the end of the first day after injury gradually increased from 20.1±8.7 to 35.2±10.4 mm Hg. In Group III, mean SfP level slightly exceeded the upper limit of normal (from 5 to 9 mm Hg) regardless of the time after injury, and ranged from 9.2±1.8 to 10.3±2.5 mm Hg.

The results of a two-sample t-test with the equal variances confirmed the different dynamics of the SfP levels for different nature wounds in different periods after injury. The parameter of SfP is not a constant value, after injury its level increases over time.

The average SfP value in Group I within the first 6 hours after injury was 29.9±11.4 mm Hg, during next 6 hours increased by 10.7 mm Hg (by 35.8 %) and reached 40.6±7.6 mm Hg (p=0.0111), and, finally, in the period from 12 to 24 hours after injury SfP level increased compared to the initial data by 17.3 mm Hg (by 57.9 %), and reached the level of 47.2±8.8 mm Hg (p=0.0005), but did not change significantly compared with the indicator in the second (6–12 hours after injury) time period. That is, in patients with lower extremity gunshot fractures, OFC SfP levels significantly increased compared with the first hours at the time period 6–12 hours after injury, and then remained statistically unchanged for up to 24 hours after injury.

In Group II, the average SfP level within the period up to 6 hours after injury was 20.1±8.7 mm Hg, within the period from 6 to 12 hours after injury it increased by 6.0 mm Hg (22.9 %) and reached 26.1±7.8 mm Hg (p=0.0240), and, finally, for the period 12–24 hours after injury it reached the value of 35.2±10.4 mm Hg with increasing by 15.1 mm Hg (75.1 %) compared with the initial level (p=0.00005), and 9.1 mm Hg (34.9 %) compared with the period 6–12 hours after injury (p=0.0076). These data indicate that the OFC SfP level increased progressively in the affected soft tissues of the lower extremities during the first 24 hours after injury.

In Group III, the mean SfP value slightly exceeded the normal one at baseline and did not change during 24 hours of observation after injury, indicating the absence of significant impact of gunshot damage eligible for this group (without fascia lesion) on SfP levels, thus, the risk of CS development was minimal.

The results obtained largely determined the treatment tactics and organization of treatment of the victims. Surgical debridement for gunshot wounds was performed in accordance with its basic principles: extensive wound dissection, excision of non-viable tissues, revision of vascular and nervous structures and fasciotomy of all OFC throughout the affected segment [5, 7].

After performing decompression fasciotomy, we had conducted revision of the wound canal with excision of devitalized tissues. Stabilization of fragments by the device of external fixing was carried out in cases of fractures of long tubular bones. The wounds were not sutured, we covered them with napkins with aseptic solutions (decamethoxine, octenidine dihydrochloride / phenoxyethanol, povidone-iodine).

In cases of risk of OFC CS development, we performed a preventive closed fasciotomy with usage of a fasciotom on the adjacent segment.

Muscles usually prolapse into the fasciotomy wound if SfP is increased. Muscle excitability and bleeding are signs of its viability. Drains were placed in the wounds; aseptic dressings were applied. In case of bleeding from damaged subcutaneous veins, fasciotomy wounds were tamponaded with turundas with hydrogen peroxide. Sutures were not applied to fasciotomy wounds to let the possibility assess the viability of the muscles in the future. Primary delayed sutures were applied during repeated surgical debridement at this or the next stage of medical care in the absence of signs of progression to CS.

We believe that such patients need special attention, because the total time required for evacuation between stages, examination of the wounded by the surgeon and determining the order of medical care may exceed the “rescue fasciotomy time interval”.

This approach is especially important in patients with complications in assessing the clinical manifestations of CS. For example, in case of direct nerve damage, which can make it impossible proper

assessment of several clinical symptoms and signs such as hyperpathy, hypoesthesia, skin anesthesia, muscle weakness, etc.

The data obtained demonstrate a statistically confirmed dependence of SfP changes on the time after injury and its severity. The absence of clinical signs of CS among wounded within the first hours after injury cannot be a reason to refuse a fasciotomy. Such refuse can lead to the development of CS with risk of irreversible ischemic changes [2]. This approach is especially important in treatment patients with injuries of the extremities, accompanied by traumatic damage to peripheral nerves [4]. The absence of afferent impulses from the damaged segment smooths out the bright clinical manifestation of CS, which complicates its timely diagnosis [6]. In such cases, timely performed fasciotomy allows to reduce the risk of complications [8]. In cases with absence of direct gunshot nerve damage, clinical manifestations of CS, such as hyperpathy and hypoesthesia, skin anesthesia, and muscle weakness, could be used to diagnose CS severity and assess CS dynamics.

It is generally accepted that CS is a clinical diagnosis and its diagnostics does not require a mandatory measurement of SfP levels in the OFC of the affected segment [9]. According to our data, all victims with injuries of the lower extremities have an increase in the level of SfP of various degrees. While further increase in SfP levels is unlikely in injured with lower extremity gunshot wounds of the subcutaneous adipose tissue without fascia lesion, such an increase is likely in the cases of soft tissue gunshot injuries of the lower extremities, and its probability depends a lot from the damage size and the presence of gunshot fractures. It should be noted that SfP levels will significantly increase within 6–12 hours after injury in the presence of lower extremity fractures, and that SfP levels will progressively increase up to 24 hours after soft tissue injury of the lower extremities. These data encourage changes in the approach to fasciotomy in injured with gunshot fractures or soft tissue lesions of the lower extremities.

Thus, according to our data, the decision to perform a fasciotomy in injured with gunshot fractures should be made within the first 12 hours after injury, and, in cases of soft tissue gunshot wounds – till the end of the first day. Given the fact that in field medical care there is a concept of “golden hour” [1], we consider it possible to introduce the concept of ”rescue fasciotomy time interval“ after the injury, during which a decision should be made to perform a fasciotomy. Performing a fasciotomy at a later time will no longer be effective, and ischemic changes in the muscles of the injured limb will be irreversible.

By reducing the medical assistance volume in conditions of large number of wounded admitted, injured may be transferred to a higher level of medical care without performing ISD [7]. In such cases, according to the principle of “damage control orthopedics”, a full surgical treatment with adequate fasciotomy should be performed [7].

Particular attention should be paid to the patients with combined injuries of the torso and extremities with the risk of delayed fasciotomy because of the priority of operations on vital organs. It is necessary to remember that after completion of urgent operation surgeon should consider the possibility of surgical treatment of limb wounds and assess indications for fasciotomy [7].

In our opinion, the above explains the importance of timely fasciotomy during ISD. Performing a fasciotomy is not a recommendation, but a mandatory element of ISD.

Conclusions

1. In cases of gunshot fractures of the lower extremities, the average SfP level increases in the period from 6 to 12 hours after injury by 35.8 % (p=0.0111) with total rise for the first 24 hours after injury from 29.9±11.4 to 47.2±8.8 mm Hg (p=0.0005), but remains statistically similar for the periods 6–12 and 12–24 hours after injury.

2. In cases of soft tissue gunshot wounds to the lower extremity, the average SfP level progressively increases (for the period 6–12 hours from injury by 22.9 %, 12–24 hours – by another 39.4 %, p=0.0240 and p=0.0076, respectively).

3. Single tangential soft tissue gunshot wounds to the lower extremities without fascia lesion do not have a statistically significant effect on the SfP levels.

4. The decision to perform a fasciotomy in injured with gunshot lower limb fractures should be made within the first 12 hours after the injury, and in the cases of soft tissue gunshot wounds to the lower extremity – till the end of the first day, which we consider as “rescue fasciotomy time interval”. Performing a fasciotomy later will no longer be effective, and ischemic changes in the muscles of the injured limb will be irreversible.

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BIOCHEMICAL INDICATORS IN THE ORAL FLUID IN CHILDREN WITH CARIES AND GINGIVITIS ON THE BACKGROUND OF EXCESS BODY WEIGHT

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The study is devoted to the research of biochemical indices of oral fluid of 15–18-year-old children with major dental diseases against the background of excess body weight. 88 children aged 15 to 18 participated in clinical examinations, and were divided into 3 groups (the main group – 48 children with main dental diseases and excess body weight, the comparison group – 20 children with main dental diseases and somatically healthy, and the control group – 20 children who were dentally and somatically healthy). Biochemical indices of oral fluid were studied in children. The conducted studies showed that in all children with major dental diseases, a decrease in local non-specific resistance, a weakening of antioxidant protection, an increase in inflammatory processes, a dysbiotic shift, and a violation of functional reactions in the oral cavity were observed.

Key words: dental indices, biochemical markers, children, excessive body weight, preventive complex.

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БІОХІМІЧНІ ПОКАЗНИКИ РОТОВОЇ РІДИНИ У ДІТЕЙ З КАРІЄСОМ ТА ГІНГІВІТОМ НА ТЛІ НАДМІРНОЇ МАСИ ТІЛА

Дослідження присвячене вивченню біохімічний показників ротової рідини діти віком 15–18 років з основними стоматологічними захворюваннями на тлі надмірної маси тіла. У клінічних обстеженнях брало участь 88 дітей віком від 15 до 18 років, які були розподілені на 3 групи (основна група – 48 дітей з основними стоматологічними захворюваннями та надмірною масою тіла, група порівняння – 20 дітей з основними стоматологічними зазворюваннями та соматично здорові, та група контролю – 20 дітей, які були стоматологічно і соматично здорові). У дітей вивчали біохімічні показники ротової рідини. Проведені дослідження показали, що у всіх дітей з основними стоматологічними захворюваннями спостерігалося зниження місцевої неспецифічної резистентності, послаблення антиоксидантного захисту, посилення запальних процесів, дисбіотичний зсув, порушення функціональних реакцій в порожнині рота

Ключові слова: стоматологічні показники, біохімічні маркери, діти, надмірна маса тіла, профілактичний комплекс.

The work is a fragment of the research project "Correction of pathogenetic mechanisms of disorders of carbohydrate and lipid metabolism in the body and tissues of the oral cavity in patients depending on environmental and nutritional factors affecting carbohydrate and lipid metabolism", state registration No. 0118U006966.

Development and implementation of methods and means of prevention of major dental diseases (MDD) in children is an important problem of public health in Ukraine [7]. Therefore, the study of the development trends and features of the course of caries, periodontal tissue disease and deterioration of oral hygiene in children, especially on the background of combined somatic pathology or excess body weight (EBW) and obesity is extremely relevant [4, 8].