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S.O. Korol, A.L. Chelishvili<sup>1</sup>, I.P. Palii, O.Ya. Musenko, N.V. Svystak  
Ukrainian Military Medical Academy, Kyiv  
<sup>1</sup>Poltava State Medical University, Poltava

## CLINICAL AND PATHOPHYSIOLOGICAL SUBSTANTIATION OF THE MUTUAL AGGRAVATION SYNDROME IN COMBINED COMBAT THERMOMECHANICAL INJURY

e-mail: sergej.korol72@gmail.com

There was a comparative integrated clinical examination of 93 persons with combined combat thermomechanical injuries, 87 persons with isolated extremity injuries involving bone fractures and 65 persons with isolated burn injuries. The said examination covered the recording of integral body rheography, study of coagulation tests results, biochemical, immunological blood indicators at admission on 1–3 and 5–7 days after the injury. The authors believe that only persons with extremely severe combined combat thermomechanical injuries, when there are two or more isolated injuries (wounds and burns), experience severe homeostasis disorders, which is demonstrated by the mutual aggravation syndrome with central hemodynamics as the leading link in its pathogenesis.

**Key words:** mutual aggravation syndrome, combined combat thermomechanical injuries, shock.

С.О. Король, А.Л. Челішвілі, І.П. Палій, О.Я. Мусенко, Н.В. Свистак

## КЛІНІКО-ПАТОФІЗІОЛОГІЧНЕ ОБҐРУНТУВАННЯ СИНДРОМУ ВЗАЄМНОГО ОБТЯЖЕННЯ ПРИ КОМБІНОВАНІЙ БОЙОВІЙ ТЕРМОМЕХАНІЧНІЙ ТРАВМІ

У 93 постраждалого з комбінованою термомеханічною бойовою травмою, у 87 – із ізольованим пораненням кінцівок з переломом кісток та у 65 – із ізольованою опіковою травмою проведено порівняльне комплексне клінічне обстеження, що включає реєстрацію інтегральної реографії тіла, вивчення коагулограми, біохімічних, імунологічних показників крові на час вступу, на 1–3, 5–7 добу після травми. Автори вважають, що тільки у постраждалих з вкрай тяжкою комбінованою термомеханічною бойовою травмою, коли є два і більше ізольовані ушкодження (поранення та опіковий компонент) розвиваються виражені порушення гомеостазу, що знаходить відображення у «синдромі взаємного обтяження» в патогенезі якого, провідною ланкою є центральна гемодинаміка.

**Ключові слова:** синдром взаємного обтяження, комбінована бойова термомеханічна травма, шок.

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There was a comparative integrated clinical examination of 93 persons with combined combat thermomechanical injuries, 87 persons with isolated extremity injuries involving bone fractures and 65 persons with isolated burn injuries. The said examination covered the recording of integral body rheography, study of coagulation tests results, biochemical, immunological blood indicators at admission on 1–3 and 5–7 days after the injury.

The authors believe that only persons with extremely severe combined combat thermomechanical injuries, when there are two or more isolated injuries (wounds and burns), experience severe homeostasis disorders, which is demonstrated by the mutual aggravation syndrome with central hemodynamics as the leading link in its pathogenesis.

Based on the statistical analysis, an anatomical and functional index of the severity and prognosis of wound and burn shock were developed. The authors believe that the Allgower shock index can be used only for a preliminary assessment of the severity of wound shock, and an individual approach is needed to determine the prognosis of wound and burn shock and to choose the optimal tactics of intensive care and surgical treatment, taking into account the severity, periods and phases of shock. Moreover, when there are two or more isolated injuries, severe homeostasis disorders occur, which is demonstrated by the mutual aggravation syndrome with central hemodynamics as the leading link in its pathogenesis.

Initially, the term “mutual aggravation syndrome” was used to describe the clinical progression of combined radiation injuries caused by two different causative factors – radiation and mechanical ones.

At the same time, the term “mutual aggravation syndrome” (MAS) is used in the contemporary literature to define features of the clinical progression of combined thermomechanical injuries, which is also aggravated under the influence of two different causative factors [1].

Thus, based on the study of mortality in various types of combined injuries, it was found that in mild combined injuries (MCI), when there are two minor injuries, the mortality rate is 4.9 %; in severe combined injuries (SCI), when there are a severe isolated injury and minor isolated burns – 30.6 %; in extremely severe combined injuries (ESCI), when there are two or more severe injuries – 61.3 % and 84.4 %, respectively [2].

This means that persons suffering from SCI and ESCI face the most serious clinical issue characterizing a brand-new pathological condition that can be defined as a shock (critical) condition with high mortality.

A distinctive feature of the critical condition in combined injury is an increase in the share of the functional component of the global assessment of the injury's shock potential, which is determined by the MAS of the injury [3].

It is quite obvious that the quantitative identification of SCI and ESCI as forms of critical condition based on the severity of vital function disorders is a complex task.

Therefore, one of the criterion methods for the rational division of such a complex process may be the identification of a “dominant” injury in a shock-producing combined injury, i.e., the identification of one of the most severe and dangerous injuries at the moment that requires urgent care [4].

In severe combined injury, where the role of the leading pathogenetic factor is taken on by a pathological component in the form of multiple organ failure, the MAS is not a common additional component in the form of functional failure of individual organs and systems, but is an interrelated single shock – producing process [4].

In such a case, the following question naturally arises: how justified is the identification of the MAS in the complex terminological chain of concept definitions: severity of combined injury, severity of condition, severity of wound and burn shock, as well as wound and burn disease. Isn't this an attempt to make another problem within the framework of the generally recognized concepts of wound shock, burn shock, wound and burn disease?

**The purpose** of the study was to objectify the mutual aggravation syndrome based on the anatomical and functional model for assessing the severity of combined combat thermomechanical injury in 93 persons with combined thermomechanical combat injury, 87 persons with isolated gunshot bone fracture and 65 persons with isolated burn injury within the comparative clinical examination.

**Materials and methods.** 41 of the 93 wounded with combined combat thermomechanical injury (CCTMI) had severe combined injuries, where a severe component (gunshot extremity injuries involving gunshot bone fractures) was combined with a non-severe extraskelatal component (burns), the remaining 34 persons had extremely severe combined injuries, where there were two severe isolated injuries (wounds and burns), and the other 18 deceased persons had extremely severe combined injuries, where there were two extremely severe injuries.

Among the 87 injured with isolated gunshot extremity injuries involving gunshot bone fractures, 10 persons had open gunshot femur fractures, 22 persons had gunshot isolated tibia fractures, 18 persons had gunshot humerus fractures, 20 persons had gunshot forearm fractures and 17 persons had gunshot hand and foot fractures. Among the 65 injured with isolated burn injuries, 36 persons had upper extremity burns and 29 persons had lower extremity burns. There were 245 injured examined in total.

**Results of the study and their discussion.** Homeostasis disorders in severe CCTMI (according to the PTS, Hannover – 12.2 0.41 points) compared with severe extraskelatal injuries (according to the PTS, Hannover – 11.2 0.53 points) had identical statistically insignificant changes ( $>0.05$ ) with a slight decrease in one-time cardiac efficiency (SVI – 44.2 4.33 ml/m<sup>2</sup>). Despite the above, the cardiac output increased by 20 % due to tachycardia compared with the proper CO (CI – 4.3 0.25 l/min/m<sup>2</sup>, RR – 1.5 0.09 units). There was also a significant tension in the hemodynamic component of external respiration against the background of increased inspiration and expiration stroke volume and tachypnea (RCF – 1.47 0.04; RTI – 30.5 2.8). Peripheral vascular tone was characterized by mild hypotension and normal heart rate (ITF – 78.9 0.62 units, PVT – 1.09 0.008). Generally, respiratory and circulatory systems interaction indicated an adequate compensatory response of the central and peripheral hemodynamics (RCDSI – 6.6 1.05; PHR – 1.12 0.07 RU). Integrated comparative anatomical and functional assessment corresponded to severe injuries with a favorable prognosis (AFA – 545.8 11.2 points; MVA – 0.19 0.07 points). These findings gave us the reason to merge these two groups into a group of persons with burn injuries (n=77). All-over index was increased by 2.5 times compared to the control group, and characterized severe CCTMI in groups 1 and 2 (1.30±0.03 units) ( $p<0.05$ ). The index did not differ between the comparison groups on the 1st–3rd day after the injury ( $p>0.05$ ) [7].

Compared to isolated extremity injuries involving gunshot bone fracture (PTS – 11.7 0.43 points), injured with CCTMI (PTS – 18.9 0.75 points) experienced unidirectional and statistically significant equivalent changes in homeostasis indices ( $P>0.05$ ), which resulted in a decrease in one-time cardiac efficiency (SVI – 32.9 1.42 ml/m<sup>2</sup>). Peripheral vascular tone was characterized by moderate hypotension and normal heart rate (ITF – 76.1 0.5; PVT – 1.09 0.007). The hemodynamic component of external respiration was characterized by a moderate increase in inspiration and expiration stroke volume and tachypnea (RCF – 1.55 0.07; RTI – 33.08 2.27). Generally, respiratory and circulatory systems interaction indicated subnormal functioning of the central and peripheral hemodynamics (RCDSI – 3.16 0.79; PHR – 0.78 0.04). Integrated anatomical and functional assessment of injured with CCTMI corresponded to severe injuries with a favorable prognosis (AFA – 589.7 16.6 points; MVA – 0.33 0.09 points) and did not statistically differ from the integrated anatomical and functional assessment of persons with isolated extremity injuries involving gunshot bone fractures, which gave us the reason to conclude that there is no aggravation of homeostasis parameters in severe CCTMI, i.e., there is no MAS. Moderate centralization of blood circulation against the background of hypotension was noted in the injured with severe CCTMI in the groups 5–7 days after the injury (coefficient of integral tonicity 79.77±1.91 um. units; systolic blood pressure 82.75±1.71 mm. Hg and coefficient of integral tonicity 80.14±2.03 mmHg; systolic blood pressure 83.70±1.82 mmHg, respectively) [8].

Further comparative examinations showed that the survivors with extremely severe CCTMI (PTS – 33.05 1.49 points), where there was a combination of two severe anatomical injuries compared to severe extremity injuries involving gunshot bone fractures (PTS – 11.7 0.43 points), had greater statistically significant disorders of homeostasis indices ( $P<0.05$ ), resulting in a sharp decrease in one-time cardiac efficiency (SVI – 30.08 1.27 ml/m<sup>2</sup>). Due to the inadequate tachycardia, the CO was maintained at a subnormal level and was increased by only 10 % compared to the proper CO (CI – 3.01 0.14 l/min/m<sup>2</sup>; RR – 1.1 0.05). Peripheral vascular tone was characterized by severe hypotension (ITF – 75.8 0.87) and normal heart rate (PVT – 1.09 0.007). The hemodynamic component of external respiration was characterized by significant tension due to a significant increase in inspiration and expiration stroke volume and tachypnea (RCF – 1.55 0.004; RTI – 35.7 2.26). Severe respiratory and circulatory disorders were observed in the comparison groups (index of severity of respiratory and circulatory disorders 5.36±0.27 units in group 1, 4.89±1.03 units in group 2, 3.12±1.09 units in group 3). A peculiarity was the tendency to increase the indicated indicator in group 1 due to changes in the one-time and minute productivity of the heart in dynamics (pulse index=38.73±1.87 ml/m<sup>2</sup>, cardiac index=3.96±0.12 l/min/m<sup>2</sup>). Despite the above, respiratory and circulatory systems interaction was inefficient and characterized as decompensated–reversible (PHR – 0.68 0.04; RCDSI – 2.44 0.22). Integrated anatomical and functional assessment indicated extremely severe injuries and poor prognosis (AFA – 625.8 12.5 points; MVA – 0.9 0.12 points) and had a statistically significant difference with the integrated assessment of severity and prognosis of severe isolated extremity injuries with gunshot bone fractures, which gave us the reason to conclude that there is an aggravation of homeostasis indicators in extremely severe CCTMI (the phenomenon of mutual aggravation) [9].

A comparative analysis of homeostasis indices between injured with isolated extremity gunshot injuries involving gunshot bone fractures and deceased with extremely severe CCTMI (PTS – 35.7 2.96

points) showed that all types of homeostasis were suppressed in deceased with extremely severe CCTMI, which were expressed by extremely severe respiratory and circulatory disorders due to a three – quarter decrease in one – time cardiac efficiency and 15 % decrease in CO compared to the proper CO (CI – 2.74 0.36 l/min/m<sup>2</sup>; RR – 0.97 0.11). All over index normalized in group 1, was significantly increased in group 2 (0.72±0.03 um.unit). A feature was a significant decrease in the All over index by 21.25 % in groups 1 and 2 – by 17.24 %, in comparison with admission 5–7 days after the injury. The All over index in group 3 exceeded the value of the control group in the survivors by 1.5 times and in the deceased by 2.5 times (0.91±0.07 um.units and 1.40±0.09 um.units, respectively ) (p<0.01). Hemodynamic stress in the respiratory function was ineffective (RCF – 1.94 0.15; RTI – 41.38 5.29), and was characterized by a decrease in hemodynamic support of the organism by 49 % compared to the proper one (PHR – 0.51 0.08). Severe vascular hypotension associated with heart rhythm disorder (ITF – 74.1 2.21; 1.11 0.01) and a quarter increase in the total volume of extracellular fluid compared to the proper volume of extracellular fluid (BI – 1.21 0.1) also showed irreversible decompensated homeostasis disorders. Integrated anatomical and functional assessment showed extremely severe CCTMI with poor prognosis (AFA – 661.9 23.4 points; MVA – 1.55 0.39 points) [10].

### Conclusions

1. Mutual aggravation syndrome is a pathophysiological definition of the vital functions disorders crisis, which in case of severe injuries of anatomical and functional areas due to various causative factors, namely gunshot injuries and burns, are clinically demonstrated as a shock (critical) condition.
2. Central hemodynamics is the leading link in the pathogenesis of shock.
3. All injured with CCTMI, regardless of the severity of their condition, have a decrease in one–time cardiac efficiency, increased heart rate, and decreased total peripheral vascular resistance, which keeps the cardiac output at normal and subnormal levels.
4. Significant decrease in the parameters of central hemodynamics, especially CI associated with severe hypotension, heart rhythm disorders and increased total extracellular fluid volume were observed only in injured in a terminal phase.

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