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Polytrauma: Definition of the Problem and Management Strategy (Review)

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Политравма: определение термина и тактики ведения больных (обзор)

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Summary

Polytrauma is a highly relevant problem from both scientific and clinical perspectives due to its high mortality rate (>20% in young and middle-aged individuals and >45% in the elderly). The lack of consensus in the definition of polytrauma complicates data collection and comparison of available datasets. In addition, selection of the most appropriate management strategy determining the quality of medical care and magnitude of invested resources can be challenging.

Aim of the review. To revisit the current definition of polytrauma and define the perspective directions for the diagnosis and management of patients with polytrauma.

Material and methods. Based on the data of 93 selected publications, we studied the mortality trends in the trauma and main causes of lethal outcomes, analyzed the polytrauma severity scales and determined their potential flaws, examined the guidelines for choosing the orthosurgical strategy according to the severity of the patient's condition.

Results. The pattern of mortality trends in trauma directly depends on the adequacy of severity assessment and the quality of medical care. The Berlin definition of polytrauma in combination with a mCGS/PTGS scale most accurately classifies polytrauma into four severity groups. For the «stable» patients, the use of primary definitive osteosynthesis with internal fixation (early total care, or ETC) is the gold standard of treatment. For the «borderline» and «unstable» groups, no definitive unified strategy has been adopted. Meanwhile, in «critical» patients, priority is given to general stabilization followed by delayed major surgery (damage control orthopaedics, or DCO), which increases survival.

Conclusion. The use of artificial intelligence and machine learning, which have been employed for more specific goals (predicting mortality and several common complications), seems reasonable for planning the management strategy in the «controversial» groups. The use of a clinical decision support system based on a unified patient registry could improve the quality of care for polytrauma, even by less experienced physicians.

Keywords: polytrauma, Berlin definition of polytrauma; orthosurgical strategy; trauma registry; machine learning

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Introduction

Despite all the measures taken to reduce trauma incidence over the past 30 years, the mortality rate has decreased only modestly by 1.8% [1, 2]. In the tertiary trauma care centers, about 20–25% of patients under 60 years of age die [3–5], and with

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increasing age the mortality rate increases to 45–60% [6, 7]. Urbanization and industrialization have a direct impact on the incidence of trauma owing to an increased number of personal vehicles in the population and more frequent road traffic accidents (RTAs), as well as industrial emergencies, fires, domestic traumas, and military conflicts. In cities and large settlements, the majority of patients with polytrauma arrive at the emergency room in the evening, during off-hours and weekends [8]. Brinck et al. link this fact with the recreational use of alcohol and other drugs [9], which are the dominant causes of road and domestic accidents [10]. According to the World Health Organization (WHO) report on «Global Road Safety», about 1.35 million people are killed each year in traffic accidents, and up to 50 million suffer nonfatal injuries. Road traffic injuries are the eighth leading cause of death in all age groups, and the first in the 5 to 29 age group. Over 90% of all deaths occur in low- and middle-income countries (27.5 and 14.4 cases per 100,000 population, respectively), while high-income countries have much lower death rates (9.3 cases per 100,000 population) [11]. In 50–80% of cases, the injured patient is a man of young/middle age [10, 12, 13]. More than half of polytrauma survivors subsequently have a significant reduction in quality of life or disability [14, 15]. According to the WHO forecast, by 2030 trauma will become one of the five leading causes of death. For example, in the People's Republic of China, where over 400,000 people die annually (23% of them due to road traffic injuries), polytrauma mortality is already in fifth place [10].

According to the Federal State Statistics Service of the Russian Federation, in 2020, out of 2.1 million deaths in the Russian Federation, more than 60,000 deaths were directly related to injuries, of which 17,000 were transport accidents [16]. In the Republic of Kazakhstan, the situation is summarized in the report of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms. It presents summary data on mortality «from accidents, poisonings and injuries», based on which road traffic injuries rank 7th among all causes of death in Kazakhstan (14.7 cases [the 10-year average is 16.9] per 100,000 population per year) [17].

The aim of the review: to update the definition of «polytrauma» term and outline promising directions in diagnosis and management of patients with polytrauma.

Material and Methods

The literature review was based on available publications that included data on patients with severe polytrauma. Sources were retrieved from the PubMed/Medline database and limited to English language. No depth of search limitations were used. For the epidemiology section of the review, the following MeSH terms in various combinations were used: «multiple trauma», «polytrauma», «epidemiology», «mortality», «complications», and «causes of death». For the section on clinical course and severity of polytrauma, keywords such as «trauma assessment», «triage», «injury assessment scale», «trauma process», and «death tirade» were used. Also, for the Discussion section on the use of neural networks, artificial intelligence, and machine learning in emergency medicine and trauma, we searched for «clinical decision support systems», «artificial intelligence», «neural networks», «decision tree», and «machine learning» MeSH terms in combination with «multiple trauma» / «polytrauma» terms. Some of the material missed in the initial search was taken from citations in the retrieved publications and used for further detailed analysis. When selecting the publications for the review, we used the following criteria:

- Original full-text publications focusing on the main subject of the review.
- Papers published in international peer-reviewed journals with a study design of at least C level of evidence.
- Sources dealing with physiological and pathophysiological aspects were not time-limited

The publications that did not contain information on predicting patient condition based on physiological parameters were excluded, except for their sections covering artificial intelligence.

A total of 216 publications were reviewed, of which 93, containing relevant information, were selected. Using the selected sources, we studied the mortality patterns in trauma and its main causes, analyzed polytrauma severity scales and identified their potential flaws, examined guidelines for selecting orthosurgical strategies based on the severity of disease.

Definition of Polytrauma

In the second half of the 20th century, after the adoption of the term «polytrauma» and many refinements of its definition, Oestern et al. proposed the most comprehensive one, which is «polytrauma is a traumatic injury to two body regions, of which one or combination of all the existing injuries is life-threatening» [18]. This term is widely used in the Eurasian continent, especially in post-Soviet countries. In U.S. literature, the terms «multiple trauma» or «major trauma», with the added distinction of its life-threatening character, are more common [19].

An in-depth examination of the trauma pathophysiology produced an understanding of the need to assess not only anatomical lesions [20], but also physiological factors and parameters. In order to identify such parameters, which are associated with mortality exceeding 10% in patients with polytrauma, in 2012 the International Working Group on Polytrauma was established, including organizations most actively involved in studying trauma care (American Association for the Surgery of Trauma (AAST), European Society for Trauma and Emergency Surgery (ESTES), German Trauma Society (DGU), British Trauma Society (BTS), New Zealand Association for the Surgery of Trauma (ANZAST)) [21]. They coined the «Berlin definition» (BD), according to which polytrauma is an injury to two or more body regions with an AIS score ⩾3 and one or more of the following values: systolic blood pressure (SBP) ⩽90 mmHg; Glasgow coma scale (GCS) score ⩽8; base excess (BE) ⩽6.0 mmol/l; international normalized ratio (INR) ⩾1.4 or activated partial thromboplastin time ⩾40 seconds; age ⩾70 years [21].

In 2017, Rau C. et al. conducted a retrospective study (n=1629) aimed at testing the validity of these criteria. Two groups of patients similar in medical and anatomical condition were defined, one of which had the physiological criteria from the BD. Mortality in the polytrauma group was significantly higher (OR 17.5; 95%; CI 4.21–72.76; P<0.001). Also these patients were more likely to be admitted to the intensive care unit (ICU) (84.1% vs 74.1; P=0.013) with a longer stay (10.3 days vs 7.5 days; P=0.003). In addition, the treatment of polytrauma was generally more costly for the hospital (by 31.5%) with increased spending on tests (by 33.1%), surgical interventions (by 40.6%), and medication treatment (by 53.9%) [22]. In the Driessen et al. study, the BD was applied to the Dutch national trauma registry (300,649 cases included in the study). The authors concluded that adding physiological parameters to the anatomical scale improved the sensitivity in estimating the likelihood of an adverse outcome. Thus, in patients classified as «polytrauma» according to the BD (n=4,264), the mortality was 27.2%, and the need for admission to an ICU was 71.2% [23].

Patterns of Mortality Distribution

Assessment of polytrauma severity and further management strategy are directly related to the risk of adverse outcomes. In 1980, Baker et al. conducted one of the key studies [24] in the epidemiology of mortality among polytrauma patients. A tri-modal mortality distribution was revealed [25], which later was studied in more detail [13, 26–29]. Three mortality peaks were identified: within the first hour after the injury, during the first 24 hours of hospital stay, and «late death» (within several days or weeks). However, in high-income countries with advanced emergency medical services, this tri-modality is not always evident [1, 2, 12]. Here, the patient after receiving the minimal efficient care in the prehospital period, including fracture stabilization, can be transported from the scene to a tertiary trauma center within the first 30 minutes after the trauma team activation [30, 31]. This approach is associated with a unimodal or bimodal distribution of fatalities, due to the superposition of the first peak on the second [8].

Regardless of the modality of fatality distribution, the main causes of death remain the same [28]. Looking at the tri-modality, which is more characteristic of middle- and low-income countries, the researchers found that about half of all fatal cases occurred during the first peak due to severe fatal injuries. Of these, craniocerebral trauma (skull base fracture, intracranial hemorrhages, cerebral edema, cerebral necrosis) accounts for up to 70% of cases. From 25 to 80% of deaths are associated with the consequences of bleeding and/or coagulation disorders. In addition, mortality is high in acute multiple organ failure (MOF) or systemic inflammatory response (SIR). During the second peak, the causes are similar, but their clinical progression is not so dramatic, and usually no fatal outcome during the first hour of injury occurs. During the third peak, death is due to septic complications, slowly progressing MOF, and comorbidities (coronary heart disease, chronic heart failure, and chronic pulmonary conditions) [1, 13]. Often, delayed mortality is due to a longer stay in the ICU with the underlying brain damage and associated respiratory complications (damage of brain respiratory center, ventilator-associated pneumonia, acute respiratory distress syndrome) [32].

Assessment of Polytrauma Severity and Orthosurgical Approach

One of the best approaches to medical care for trauma patients involves a trauma team in the emergency department, operating according to a standard algorithm [33, 34]. The scope of their activities should include correct assessment of the disease severity, performing cardiopulmonary resuscitation (CPR), and determining the necessary surgical strategy [35, 36]. An early involvement of such team can significantly reduce the incidence of complications and adverse outcomes [10], but in practice, this occurs in only half of all cases [37]. This is due to the lack of training of emergency department staff in the algorithms and criteria for involvement [38]. In addition, non-specialized hospitals often lack a trauma team, and all care is provided by general anesthesiologists, intensive care specialists and trauma surgeons [39]. The quality of care remains a matter of medical experience and competence, the low level of which inevitably leads to inaccurate assessment of risks and likely outcomes in every particular case of polytrauma [40]. The assessment of patient severity is an obligatory skill for every physician, but the variability of polytrauma injuries complicates such assessment and requires special training and licensing [41]. Internationally, a trained intensivist, anesthesiologist, or orthosurgeon is responsible for assessing the status of a polytrauma patient [34, 42].

All scales used can be divided into three groups: anatomical, physiological, and combined. Internationally, the basic anatomical scale describing traumatic injuries is the Abbreviated Injury Scale (AIS), which characterizes three aspects of injury such as body region, type of anatomical structure, and severity of injury [41]. This scale characterizes each injury separately and does not allow evaluating patients with multiple fractures as a whole. The Injury Severity Score (ISS) was developed to describe polytrauma, based on the AIS injury assessment. The scale principle is based on calculating the sum of the squares of the three maximally injured body regions. At the end of the last century, clinicians used to define an injury as «severe» if mortality exceeded 20%, corresponding to an ISS score ⩾16 [23]. However, with the development of the trauma care service, mortality began to decrease, which led to disagreement concerning the minimum ISS threshold, which now varies from 15 to 26 points [19].

The ISS scale was modified in respect to the final score calculation for improving sensitivity [43]. Thus, in the New ISS modification (NISS), the final score consists of the sum of squares of the three maximum AIS scores with the possibility of repeated inclusion of body regions [44]. This modification increased sensitivity concerning the necessity of tracheal intubation and mechanical lung ventilation. Unfortunately, evaluation of trauma with true anatomic scales is not flawless. The most frequent problems are discrepancies between anatomical and physiological severity and inherent inconsistency, where cases of the same injury severity score in different regions have dramatically different outcomes [37, 45]. In addition, the complexity of correct coding and mathematical calculation is the reason for the low inter-researcher reproducibility of the polytrauma definition compared to the BD (Cohen's kappa coefficient for ISS ⩾ 16 = 0.521; ISS ⩾ 16 = 0.521; BOP = 0.781) [46].

Physiological scales are mostly used in the ICU setting, where assessment of severity correlates closely with mortality. The most common scales that can be used in polytrauma are the Sequential Organ Failure Assessment (SOFA) [47–49] and the Acute Physiology and Chronic Health Evaluation II (APACHE-II) [50–52]. Both scales are based on the assessment of vital and biochemical parameters and aimed at predicting the risk of septic complications and MOF which are the most common causes of death in ICU [53, 54]. The SOFA scale assesses functional changes in respiratory, cardiovascular, coagulation and nervous systems, as well as indirectly evaluates liver and renal function. In turn, the APACHE-II is aimed at assessing both the current and preclinical physiological state of the patient. A limitation of the use of intensive care scales is the need for rapid laboratory testing, as well as the intricate scoring principles. If the scales are simplified by excluding laboratory parameters, most surrogate points, such as mortality and the need for intubation [55], are still available, but with a significant sacrifice in specificity.

Among trauma physiological scales, the Revised Trauma Score (RTS) is widely used, which assesses neurological status using GCS, respiratory rate and systolic BP, multiplying them by special coefficients and then adding the products [56]. In the emergency room setting, the RTS is sufficient to assess adverse outcomes, but not the injury severity [45]. The RTS, like other scales based on fixed coefficients, has been criticized over time and requires adjustment of coefficients [57–59].

Among combined scales, Trauma Injury Severity Score (TRISS) [60] and its simplified modification, A Severity Characterization of Trauma (ASCOT), remain the most used. The scale is based on ISS, RTS and age of the patient multiplied by coefficients whose exact values are also debated [61, 62] due to medical progress and increasing experience with polytrauma patients [45]. Given the modality and causes of death, there is a need to assess the patient's severity in terms of nervous system injuries and coagulation disorders. In pediatric practice, the BIG scale is used for this purpose, and has also shown satisfactory results in adults [59]. BIG is an abbreviation of BE, INR (both indicating hemorrhagic shock severity) and GCS . The lack of assessment of skeletal injuries makes it narrowly focused and not applicable when no traumatic brain injury is present.

All of the above physiological scales are aimed more at determining the risk of death relative to the baseline condition, rather than at actually categorizing patients. In addition, some researchers, due to unclear reasons, fabricate novel scales from those already available by adding several nominally new clinical variables [10, 48, 68, 50, 55, 59, 63–67].

As of the time of writing this paper, the authors had not found any generally accepted criteria for differentiating patients with polytrauma in relation to the severity of their condition. However, the problem of categorizing patients was addressed by German researchers, led by Pape H. C. [69]. After a series of studies the authors came to the conclusion that in addition to the classical «deadly triad» (BE<–6 mmol/l, pH <7.2, t<35°C) [70–72], the extent of soft tissue injuries directly influences the trauma outcome. Based on this finding, the Clinical Grading System (CGS), an anatomical and physiological scale for assessing the severity of polytrauma with classification of patients into «stable», «borderline», «unstable» and «critical» groups was proposed. The original version contained several flaws such as the presence of little-known anatomical scales, expensive laboratory tests, and poor internal consistency of the criteria. For the latter reason, the groups of borderline and unstable patients are the most controversial with respect to the selection of surgical treatment strategy. Later, the authors revisited the data to expand the patient sample and developed Polytrauma Grading Score (PTGS) based on CGS (Table 1) [63]. This version did not contain the doubtful variables while maintaining the ability to differentiate between patients.

In parallel with Pape H. C., Nahm et al. modified the original CGS by simplifying and adapting it to real clinical setting and proposed the the mCGS (Table 2) [39].

Recently, Halvachizadeh et al. [74] conducted a large comparative analysis (n=3368) of CGS [69], mCGS [39], PTGS [63] and Early Appropriate Care (EAC) protocol [75] for sensitivity in determining the risk of early (death in the first 72 hours from traumatic brain injury and/or blood loss) and late (MOF, acute respiratory distress syndrome (ARDS), pneumonia, sepsis and death after 72 hours) complications in patients with polytrauma. According to mCGS, the change in transfusion volume estimation during the first 24 hours significantly affected the accuracy of determining the «stability» of the patient's clinical condition. The «borderline» patients had a higher mortality rate (50%) when categorized using the PTGS scale than similar groups based on CGS (35.9%) or mCGS (37.8%). Overall, the study showed that the proposed scales are effective in categorizing patients by severity of condition into groups and can be improved in terms of the criteria used.

The adequacy of severity assessment using physiological scales is closely related to the pathophysiology of trauma [69]. Any tissue damage is known to result in changes in immune status. Initially, hyperinflammation develops, followed by counter-regulatory anti-inflammatory response.

Table 1. The Polytrauma Grading Score (PTGS).

Parameter	Value	Points
Systolic blood pressure, mm Hg	76–90	1
	⩽75	2
BE, mmol/l	–(8–10)	2
	<–10	4
INR	1.4–2,0	1
	>2.0	3
NISS assessment	35–49	3
	50–75	4
The volume of hemotransfusion, units	3–14	2
	⩾15	5
Platelet count, ×10^9/l	<150	2

Note. BE — base excess; INR — international normalized ratio; NISS — New Injury Severity Score. Interpretation. Less than 6 points, stable (mortality up to 5%); 6–11 points, borderline (mortality up to 15%); more than 11 баллов, unstable (mortality up to 40%).

In the literature, this stage is called the «first hit», and its severity is directly related to the extent of injury. Thus, in monotrauma, the above-described immune response changes are not crucial for the patient, while in polytrauma, surgical intervention together with complications (coagulation disorder, bleeding and hypothermia) enhance the body's response to tissue damage and can lead to the «second hit», which involves systemic hyperimmune response [42]. Depending on the predisposing factors, the «second hit» in blunt extensive soft tissue trauma causes subacute complications such as ARDS, SIRS or MOF [76].

Based on the pathophysiology of trauma and the decision making regarding the risks in the patient, one of two orthosurgical approaches is commonly used in developed countries: primary definitive osteosynthesis with internal fixation (Early Total Care, ETC) and temporary external fixation followed by secondary definitive osteosynthesis with internal fixation (Damage Control Orthopedics, DCO). ETC is the «gold standard» [69] in terms of orthosurgery, as it allows early patient mobilization and has a lower incidence of late complications,

Table 2. The Modified Clinical Grading System (mCGS).

Factor	Parameter	Stable (grade I)	Borderline (grade II)	Unstable (grade III)	In extremis (grade IV)
Shock	SBP, mm Hg	⩾100	⩾80 – <100	⩾60–<80	<60
	BE, mmol/l	⩾–2.3	<–2.3–⩾–4.5	<–4.5–⩾–6.0	<–6.0
	Lactate, mmol/l	0,5–⩽2.2	>2.2–⩽2.5	>2.5–⩽4.0	>4.0
	PRBC transfusion (on day of injury), units	⩽2	3–8	9–15	⩾16
Coagulation	Platelets, ×10^3/µl	>110	>90–⩽110	>70–⩽90	⩽70
Temperature	°C	>34	>33–⩽34	>30–⩽33	⩽30
Soft tissue injury	Chest injury AIS	⩽2	3	4	⩾5
	Moore OIS [73]	⩽2	3	4	⩾5
	Pelvic injury (AO/OTA)	нет	A	B	C or crush
	Extremities AIS	⩽2	3	4	5 or crush

Note. SBP — systolic blood pressure; BE — base excess; AIS — Abbreviated Injury Scale; PRBC — packs of red blood cells; OIS — organ injury severity; AO/OTA — AO Foundation and Orthopaedic Trauma Association. A patient can be classified into a specific group if three of the four factor criteria are met.

but often leads to the development of «second hit». Early final fixation in unstable and critical patients can cause fat embolism, which enhances lung damage associated with their contusion or rib fractures [36]. In turn, DCO allows resuscitation and stabilization of injuries of the long tubular bones and pelvis, thus stopping massive bleeding, followed by transferring the patient to ICU for further correction of vital signs. This approach increases the total length of stay in the ICU and the hospital, is not cost-effective and associates with a significantly higher incidence of late thrombotic and septic complications due to delayed major surgery [35]. In a systematic review conducted by P. Lichte et al. [42], numerous evidence has been found that DCO dramatically reduces blood loss in patients in comparison with ETC (up to four times) and the duration of surgical intervention (over three times). The sparing and protective approach of DCO has a positive effect on the patient's immune status, which was confirmed in a high-quality study by Pape H. C. et al. [77]. Meanwhile, the review presents contradictory results on the relationship between the categorization of patients («stable», «borderline», «unstable», «critical») and the use of DCO for stable and borderline patients. This could be due to the lack of universal tools and criteria for accurate triage, which can improve survival rate [10, 36]. Despite attempts to classify patients into severity groups to determine orthosurgical strategies aimed at minimizing complications, there are many nuances in each individual patient's body that affect approach and outcome (e. g., need for general anesthesia, presence of initial hemorrhagic shock, changes in blood buffer capacity and anatomical regions of injury) [78–82]. The available studies comparing DCO and ETC are mostly retrospective and based on a small sample of patients with polytrauma, but their results provide background for the development of additional criteria to define borderline patients [83].

Clinical Decision Support Systems

Clinical decision support systems (CDSS) based on artificial intelligence (AI) are being widely implemented to improve approaches to the diagnosis and treatment of various diseases. The main objective of such a system is to analyze the information collected by a physician and produce a certain result. Algorithms that perform this kind of activity are commonly referred to as «models». Linear and logistic regression, neural networks, decision trees, and the Rotation Forest method serve as examples of such models [84]. Unlike statistical packages, an AI-based model is in most cases capable of continuous self-learning, thus improving its performance.

The issue of using a computer in the management of severe trauma patients emerged at the end of the twentieth century. At that time, medicine was already using simple CDSSs based on rigid «If — Then» conditions. The «algorithm» for assessment, in fact, being a set of conditions, was based on the treatment protocols of that time and compared the patient's condition with already described variants of trauma manifestations [85]. With the development of information technology, the science of machine learning, and big data analysis, simple systems began to evolve into more powerful tools. Recently, a niche in the field of trauma patient management has been actively filled by various AI solutions. For example, in order to describe injuries more accurately on different types of images, models have already been developed that show superiority over physicians [86]. In addition, there are two models that allow to suspect with high accuracy the development of acute traumatic coagulopathy [87]. Other studies have attempted to use AI to predict the incidence of trauma admissions relative to weather conditions, day of the week, and time [88].

Ehrlich et al. noted that AI-based systems are necessary in the emergency room setting to quickly provide quality triage of patients and determine further treatment strategies [89]. Almost all used scales of patient assessment try to assign the severity of the condition to a number, which should give the physician a clear understanding of the clinical situation and determine what decision will be taken. With a large quality database, it is possible to create a computer model that performs these procedures automatically with high reliability [90, 91]. However, any assessment scale consists of two parts which are a set of variables and a rule defining the principle of calculating the final score for interpretation. Despite all the computational power, a computer is not capable of presenting every physiological aspect of a patient as a set of variables. This necessitates the analytical determination of a minimum set of input parameters that more accurately reflect the clinical condition and course of trauma. Wide variability and multiple inputs often require different modeling approaches. For these reasons, the currently available solutions are narrowly focused. The use of AI in the field of medicine is one of the priority areas and requires additional research [89].

Limitations

The selection of material for the review was difficult because of the heterogeneity of the literature and the lack of a unified definition of polytrauma. This was due to the heterogeneity of publications in levels of evidence (I–II) and grades of recommendation (A–C), as well as the lack of a unified definition of polytrauma. After analyzing the original material, the authors achieved most of their aims by drawing additional conclusions.

The largest percentage of people die from craniocerebral trauma, which is mostly incompatible with life, as well as from the sequelae of massive bleeding. In emergency care, timely control of bleeding improves the survival rate of patients during the «golden hour», as well as is directly related to the development of late complications [92, 93]. Improvement of the medical care and management organization could help significantly reduce mortality and avoid its trigger-modal distribution [1].

The authors agree with the international opinion about the best accuracy and adequacy of the Berlin definition of polytrauma, which has shown high interobserver reproducibility.

The authors failed to identify generally accepted criteria or scales for classifying patients into groups with respect to the severity. The most used scales, such as AIS, ISS, TRISS, SOFA, have various limitations and are not helpful in patient classification [37, 45, 49, 62]. The large choice of scales obliges a clinician to spend time studying their characteristics and choosing the best one. For this reason, there is a need to develop international criteria for categorizing patients with polytrauma in respect to the severity of their initial condition.

German researchers focusing on polytrauma have developed several scales (CGS, mCGS, PTGS) categorizing patients according to the severity of diseases based on a large database of clinical cases [39, 63, 69]. Obviously, there is a need for additional exploration of the experience of German colleagues in local populations with adaptation of the scales to the existing medical capacities.

The issue of optimal timing of definitive osteosynthesis with internal fixation also remains controversial [10, 36]. The algorithm-guided patient management is known to increase the likelihood of a favorable outcome [34, 35]. Currently, several guidelines indicate the need for ETC in «stable» patients and DCO in «critical» patients. However, for the «borderline» and «unstable» patients, there are no clear recommendations for a specific orthosurgical approach due to inconsistent research results [36, 42, 80]. Analyzing the physiological status of an individual patient and predicting the risks of complications in an emergency setting is a great challenge for the physician. Information technologies can be successfully implemented in the polytrauma management practice, as well as in other areas of medicine [89]. With a well-trained computer model, even physicians with minimal experience with polytrauma are able to perform high-quality assessment and categorization of patients [87]. In addition, clinical decision support systems can predict risks and determine the best tactics for a specific patient.

There is an obvious need for a registry of polytrauma patients accessible to all clinics providing orthosurgical care. Participation in such a registry facilitates access to information and enables researchers to conduct clinical studies with the development of treatment and diagnostic protocols, especially in regions with limited exposure to these data [90]. Unification of the database record format allows to construct big databases and improves the quality of statistical analysis. An excellent example of such registers is the Trauma Register of the German Trauma Society (TraumaRegister DGU®), which requires mandatory participation of all clinics in Germany and also provides the possibility of free participation to clinics from other countries. Since its introduction in 1993 and with more than 700 clinics, it has been able to collect a database of over 450,000 patients in 28 years.

Conclusion

A possible solution to the issue of defining an optimal management strategy for «vulnerable» groups of patients is the use of artificial intelligence and machine learning, which are already applicable to more specific problems (predicting mortality and the development of some common complications based on initial patient assessment). The use of a clinical decision support system based on a unified patient registry will improve the quality of polytrauma care, even by less experienced specialists.

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