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THE SYSTEMS OF PREVENTION OF COMPLICATIONS AT PATIENTS OF HIGH RISK

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Preventing complications in patients with a high risk of critical condition developing and fatal outcome is one of the most poignant problems of modern health care. The main cause of death in the world is the diseases like infection, trauma and various nutritional disorders. The article presents a survey of literature offering various solutions that prevent the development of life-threatening conditions. It was proved that signs of clinical deterioration of patient's condition appear more than eight hours before the development of a critical condition, which allows the necessary correction of therapy to be provided on time. According to the data provided, the most effective preventive measures are the system of checklists and early recognition of patients' clinical deterioration. When using a checklist system, it is worth using mnemonic rules that reflect sequences of diagnostic search or therapy. When introducing early prevention systems into clinical practice, thorough attention should be paid to vital signs and behavioral disorders assessment. The most specific and sensitive signs that might indicate a high risk of developing a critical condition are heart rate and respiratory rate. The key element for effective use of early prevention systems is not only timely identification of clinical deterioration signs, but also a standardization of actions of healthcare personnel in case of complications, which was represented by the SBAR system (Situation – Background – Assessment – Recommendation).

Keywords: complication; life-threatening states; patient of high risk; check-list; early warning of clinical deterioration.

СИСТЕМЫ ПРЕДОТВРАЩЕНИЯ ОСЛОЖНЕНИЙ У ПАЦИЕНТОВ ВЫСОКОГО РИСКА

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Предотвращение осложнений у пациентов с высоким риском развития критических состояний и летального исхода представляет собой одну из наиболее актуальных проблем современного здравоохранения. Основной причиной летальных исходов в мире служат такие заболевания, как инфекция, травма и различные расстройства питания. В статье представлен обзор литературы, предлагающей различные варианты решения, позволяющие предотвратить развитие жизнеугрожающих состояний. Доказано, что признаки клинического ухудшения состояния пациента возникают более чем за восемь часов до развития критического состояния, что дает возможность провести необходимую коррекцию терапии. Согласно представленным данным наиболее эффективными мерами профилактики являются системы чек-листов и раннего распознавания клинического ухудшения состояния пациентов. При использовании системы чек-листов целесообразно придерживаться мнемонических правил, отражающих последовательность диагностического поиска или терапии. При внедрении в клиническую практику систем раннего предупреждения клинического ухудшения особое внимание должно быть уделено оценке показателей витальных функций и расстройств поведения. Наиболее специфичные и чувствительные признаки, свидетель-

ствующие о высоком риске развития критического состояния, — это частота сердечных сокращений и частота дыхания. Ключевой элемент эффективности применения систем раннего предупреждения заключается не только в своевременном выявлении признаков клинического ухудшения, но и в стандартизации действий медицинского персонала в случае развития осложнений, которая реализована в системе SBAR (ситуация – фон – оценка – рекомендация).

Ключевые слова: осложнение; жизнеугрожающее состояние; пациент высокого риска; чек-лист; раннее предупреждение клинического ухудшения.

Infectious and somatic diseases, most commonly the lower respiratory tract infections, gastrointestinal tract disorders accompanied by diarrhea, meningitis, and nutrition disorders are responsible for a majority of deaths worldwide [14, 17].

The first 24 hours after hospitalization are the most critical, as the patient's condition can clinically deteriorate and adverse events may occur. This completely corresponds with the concept of the "golden hour," which was proposed in the last century by R.A. Cowley, a leading expert in the field of emergency medical care. The lack of resources in the healthcare system and lack of an efficient system for the dynamic assessment of the severity of a patient's condition may lead to a delay in diagnostic or therapeutic interventions during those 24 hours. Such a delay is a major risk factor for mortality in nearly one-third of pediatric patients [27].

Humans have a natural inclination to make errors and mistakes, which play a significant role in the development of an unfavorable outcome. As Seneca Sr. said: "Errare humanum est, stultum est in errore perseverare" ("Err is human, but it is stupid to persist in your mistakes").

In nearly all cases, mistakes committed by healthcare workers are not deliberate, and are generally associated with fatigue, high workload, and individual characteristics of the patient's disease course [43]. It was previously reported that one in every ten hospitalized patients suffered from complications associated with the conduct of diagnostic and therapeutic interventions in the hospital. This has been described in detail in a concept known as the "double strike," proposed by the founder of Russian resuscitation science, Professor A.P. Zilber [7].

A.L. Akopov et al. (2016) reported that 60% of medical errors can be corrected with relative ease, 33% are repeated with varying degrees of regularity, and 7% are fatal [1].

The checklist system and early warning (EW) card system for clinical deterioration are the two important systems that are currently in place for the prevention and early detection of complications.

The first attempts to prevent adverse events in medicine were made using risk-free systems for actions, such as piloting aircrafts, handling ships and trains, or designing high-rise buildings, during which an error can cost one to more than hundreds of human lives.

The checklist system, which enables the point-by-point implementation of simple actions with their mandatory documentation, was found to be the most effective. Careful implementation of this system virtually eliminates the possibility of any incorrect execution of the performer's actions and avoids failure. In addition, strict and regular adherence to the checklist leads to a clear structuring of the performer's actions, significantly reducing the possibility of an error [5, 6, 21].

When compiling checklists, it is advisable to use mnemonic rules related to all the components of the patient's condition [42]. An example would be the acronym STABLE, which is used as a mnemonic for the set of procedures that should be followed to stabilize the condition of a newborn before transportation to the ICU and includes the following components: S (sugar, glucose) refers to the controlling of the concentration of blood glucose to maintain euglycemia; T (temperature, temperature) refers to the monitoring and maintenance of normothermia; A (artificial ventilation, artificial/assisted breathing) refers to ensuring adequate gas exchange and blood oxygenation; B (blood pressure) refers to the maintenance of optimal cardiac output; L (lab work) refers to the normalizing of vital biochemical constants; and finally E (emotional support) refers to the emotional support that should be provided to the parents [2, 15].

The second variant of the system to prevent complications is the implementation of EW systems for clinical deterioration in the patient's condition. This system enables healthcare workers to recognize the critical signs of an unfavorable pathological course. The threat-metric system for the comprehensive monitoring of patient condition by regular evaluation of vital signs and recording indicators in observation cards is considered to be most efficient. Periodic analysis of the observation card enables the timely

identification of pathological changes, determination and appropriate correction of therapy, and prevention of complications.

As a rule of the system, the observation card is regularly filled by the nursing staff monitoring the patient. B.L. McKelvie et al. (2016) reported that the accuracy in filling of the observation card in the resuscitation and intensive care unit (ICU) of a multidisciplinary hospital was 89.2%, and is independent of the diagnosis, severity of the condition, day of week, and profile of the ICU. In addition, they noted that the efficiency of the observation card for making a decision on changing the patient surveillance was only 52.6% [26].

Furthermore, it has been reported that maintenance of observation cards in pediatric ICUs significantly improves treatment outcomes and reduces the likelihood of deaths [36].

EW systems for clinical deterioration are widely employed in hospitals [9, 24, 39]. Attempts are presently being made to apply such systems to neonatal ICUs [29].

There are various modifications of the EW system for clinical deterioration in adults (EWS, RRS, etc.) and in children (PEW, Brighton PEWS, etc.) all over the world [13, 16, 20, 23, 28, 30].

It should be noted that these tools, which enable clinicians to quickly identify patients at high risk of clinical deterioration and prevent the development of complications, are of relevant use in ICUs as well as in specialized departments [11]. Clinical deterioration if not detected in time, can lead to respiratory failure, circulatory insufficiency, or shock, which can ultimately cause an emergency transfer of the patient to the ICU or death under unfavorable conditions [45].

It should be noted that the signs of clinical deterioration in the condition of adult patients do not appear suddenly. They occur gradually over a period of several hours before the patient is transferred to the ICU. This provides the clinicians with an opportunity to conduct appropriate diagnostic and therapeutic interventions [22].

It has been reported that in children, the deviation of vital signs from reference values is observed 11.5 hours before clinical deterioration [9].

A study conducted by E. Zimlichman et al. (2012) is noteworthy, as it is dedicated to the prediction of complications in adult patients in specialized departments prior to ICU admission, where only two vital signs are assessed: heart rate (HR) and respiratory rate (RR) [45]. The authors highlight the high sensitivity and specificity of these signs, namely an HR <40 and >115 bpm (sensitivity, 82%; specificity, 67%), an RR <8 and >40 (sensitivity, 64%; specificity, 81%), and the combination of these changes in HR and RR (sensitivity, 55%; specificity, 94%).

Accordingly, a sufficiently high predictive ability of deviations in these indicators from reference limits was established, namely HR ≥20 per min (sensitivity, 78%; specificity, 90%), RR ≥5 per min (sensitivity, 100%; specificity, 64%), and the combination of deviations in HR and RR indicators (sensitivity, 78%; specificity, 94%).

Early detection of clinical deterioration and prompt initiation or correction of the treatment course allows for the significant improvement in the treatment outcome, especially in the case of sepsis, myocardial infarction, and acute cerebral circulation disorder in adults [19, 37, 44].

A multicenter study including 23 major medical centers in Australia and 16 wards of intensive care at major medical centers in the UK, demonstrated that the implementation of an EW system allowed for a significant reduction in mortality in the UK medical centers. However, the treatment outcomes in the Australian medical centers were not significantly affected [25].

A number of authors conducted a meta-analysis of randomized controlled studies on the implementation of EW systems for clinical deterioration in adults questioning the efficiency of implementing such systems into practice. However, the authors pointed out that a large, multicenter study is required to obtain an accurate result [10].

In particular, a multicenter EPOCH study conducted in 21 medical centers across 7 (Belgium, Canada, Great Britain, Ireland, Italy, New Zealand, the Netherlands) with a sample size of 1,44,539 patients aged from 0 to 18 years indicated that the use of the Bedside PEW scale, a modification of PEW, was found to have no significant effect on mortality compared to the traditional observation system; however, it has been reported that the mortality rate is relatively low with the implementation of any monitoring system [31].

D.R. Prytherch et al. reported regarding the high prognostic ability of the modified EWS-ViEWS scale and its significant role in reducing mortality [34].

It should be noted that the effectiveness of early detection of clinical deterioration predictors is influenced by the quality of the filling of the EW card by healthcare workers as well as by the prompt and appropriate identification of the signs of clinical deterioration by the staff. A study by J.A. Petersen (2018) conducted in large Danish

medical centers for adults, showed that of a total of 144 cases included in the study, strict compliance with the EW card system was observed in only 8% cases. The regular frequency of monitoring was not observed in 81% cases, whereas the on-duty or senior physicians were not informed about changes in the patient's condition by nursing staff in 52% cases. The improper maintenance of EW cards is most commonly due to lack of staff and time. There were no statistically significant intergroup differences in hospital stay duration, hospitalization rate in the ICU, increased mortality, the frequency of subsequent deterioration after the period of 48 hours, and the incidence of asystole depending on the correctness of filling the EW cards. However, strict adherence to the principles of EWS enabled the quick control of clinical deterioration in patient condition by the staff, including by young specialists. This ultimately led to the prevention of fatal outcomes with a high probability [33]. In a similar study, no benefit was obtained by reducing the observation interval from every 12 hours to 8 hours [32].

Despite various evaluations of the efficacy of EW systems for clinical deterioration, it is evident that implementation of such systems can lead to a significant reduction in mortality in countries with sufficient resources compared to those with limited healthcare resources. Obviously, other factors can also affect the difference in hospital mortality rate. Particularly, the local regulations and policies of countries with sufficient healthcare resources include clear indications for hospitalization in pediatric ICUs.

In addition, the quality of medical care in the ICU is also significantly affected by the professional characteristics of medical personnel. Teams of specialists working in the ICU differ in quantitative composition depending on the type of clinic. However, as a rule, they are represented by doctors, nurses, and support staff [3, 4]. In countries with limited healthcare resources, there are significant problems in the ICU due to the lack of local regulatory documents, lack of adequate medical and nursing staff, or insufficiently qualified personnel [4, 41].

It has been previously reported that the generally accepted prognostic scales (PRISM, PELOD, PIM 2) in countries with limited healthcare resources operate well under conditions of third-level medical organizations. For example, India and Pakistan have low efficiency in lower-level health organizations due to the limitations in capabilities of the latter [35, 38]. Nevertheless, even with limited resources, strict adherence to the principles of ABC assessment of vital function can improve treatment outcomes [41].

The primary purpose of using different options for the EW system for clinical deterioration in pediatrics is the identification of high-risk children. Timely intervention in such children can enable the prevention of further deterioration. Furthermore, more frequent monitoring, close attention of the nursing staff including the organization of an individual nursing unit, more frequent evaluations by a medical, and transfer to higher level of medical care or to ICU from the specialized department can be provided for such cases of high-risk children.

The team approach is also important when all team members use the same tools, methods of assessment, and therapy adjustment in response to a change in the patient's condition [30]. An additional benefit of implementing the EW system is the improved consistency between team members [40].

Despite the proven efficiency of the EW system, it has a number of disadvantages which warrant discussion. One disadvantage is associated with the different modifications adapted for local needs, which has resulted in an increase in the number of indicators (from 5 to 36). This volume of input significantly increases the filling time ultimately complicating the implementation of the system.

The advantage of the implementation of an EW system into practice is the early detection of signs of clinical deterioration and improved treatment outcomes in pediatrics. In the implementation of an EW system, possible ambiguous reaction of nurses should be taken into consideration. The key to successful implementation of the EW system is timely, regular, and comprehensive training of medical personnel in this field. However, disorganized use and completion of cards are serious obstacles to proper implementation of the system [30].

The scale of EW monitoring is presented in main sections, describing the state of vital functions such as blood circulation, respiration, and behavior. Additional sections include the effectiveness of nebulizer therapy and vomiting. These five sections form the basis of the scale. If necessary, the scale can be supplemented with additional sections to meet the needs of a particular hospital or department.

The EW card varies depending on age, namely 0–3 months, 4–11 months, 1–3 years, 4–6 years, 7–11 years, 12 years and older. This differentiation is associated with the different age reference intervals of vital sign indicators.

The "Blood Circulation" section includes HR, systolic and diastolic blood pressure, capillary filling time, and skin color.

The "Breathing" section includes RR, oxygen therapy (with an indication of the amount of oxygen flow), transcutaneous oxygen saturation of hemoglobin, and the presence of respiratory distress (respiratory failure), and its degree of severity.

The "Behavior" section notes the impairments in consciousness, stratified by somnolentia, agitation, dormancy (lethargy), and lack of response to pain. Vomiting is noted after surgical intervention and nebulizer therapy in cases which require it every 15 minutes.

Each of the first three sections is scored at a maximum of 3 points. A high score is associated with a higher risk of clinical deterioration. The points are added, and patient management is determined based on the total score.

The EW system enables clinicians and staff to conduct an effective assessment of the state of vital function and allows for the timely recognition of the signs of clinical deterioration, particularly under conditions of minimum resources. One of the main stages of the system is the standardization of actions of medical personnel in diagnosing a potential deterioration.

The action plan (standardization of communication of medical personnel) is implemented in the SBAR system (Situation – Background (anamnesis) – Assessment – Recommendation). This represents a diagram that includes a summary: S) of the situation; B) nearest history; A) opinion of the situation and R) proposed actions (Table 1).

A clear structuring of the SBAR decision-making system enables healthcare staff to timely identify the problem, understand its causes, and devise a clear plan of action. Medical aid efficiency can improve with the use of structuring and algorithms, which has been demonstrated by P.G. Shnyakin et al. (2017) in the optimization of diagnosis and treatment of adult patients with acute cerebrovascular incidents [8]. These optimization results can also be extrapolated to the field of urgent pediatrics.

Therefore, the implementation of the checklist system and EW system for clinical deterioration in routine practice, with an aim to regularly assess and monitor the vital functions of patients in all specialized departments of the hospital, will allow for the

Table 1 / Таблица 1

Instrument of communication of SBAR
Инструмент коммуникации SBAR

System element / Элемент системы	Version of a formulation of a problem / Варианты формулировки проблемы
S (Situation)	— I am (name), a nurse on ward ... / Я [Ф. И. О], палатная медсестра палаты […] — I am calling about .../ Я хочу доложить об инциденте с пациентом […] — I am calling because I am concerned that … (e.g. blood pressure is low/high, pulse is ... temperature is ..., Early Warning Score is ...) / Я сообщаю потому, что я обеспокоена [снижением ЧСС, увеличением АД, появлением… и пр., оценкой по шкале PEW… баллов]
B (Background)	— Child (...) was admitted on (... date) with (e.g. respiratory infection) / Больной […] госпитализирован […] с […например, обструктивным бронхитом] — They have had (... operation/procedure/investigation) / Ему проведена [процедура … анестезия … операция …] — Child (...)'s condition has changed in the last (... mins) / Состояние больного […] изменилось в последние […минут] — Their last set of obs were (...) / Последние показания витальных функций составили […]

Table 1 (continued) / Окончание табл. 1

System element / Элемент системы	Version of a formulation of a problem / Варианты формулировки проблемы
A (Assessment)	— I think the problem is (...) and I have… (e.g. given O_2 /analgesia, stopped the infusion) / Я думаю, что проблема состоит в следующем […]. Я сделала [начала оксигенотерапию, обезболила, остановила инфузию и пр.] OR / ИЛИ — I am not sure what the problem is but child (X) is deteriorating / Я не знаю, что случилось, но пациент ухудшился OR / ИЛИ — I don't know what's wrong, but I am really worried / Я не знаю, что не так, но я переживаю
R (Recommendations)	— I need you to… / Вам нужно […] — Come to see the child in the next (... mins) / Подойдите посмотреть на ребенка в следующие [… мин] AND / И — Is there anything I need to do in the meantime? (e.g. stop the fluid/repeat the obs) / Мне нужно что-либо сделать в ближайшее время? [Провести инфузию… дать антибиотик, повторить измерение ЧСС и пр.]

timely identification of the signs of clinical deterioration, avoid emergency transfer of the patient to the ICU, reduce mortality rate, and increase overall treatment efficacy.

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