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Dispatcher Assistance in Out-of-hospital Cardiac Arrest: Approaches for Diagnosing Cardiac Arrest by Telephone

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ABSTRACT Rapid recognition of cardiac arrest based on the data reported by a bystander, and delivering telephone cardiopulmonary resuscitation instructions by emergency medical services (EMS) dispatcher promote timely provision of first aid by people who witness the emergency, and this may significantly influence the outcome of out-of-hospital cardiac arrest (OHCA). This review is aimed to analyze the up-to-date scientific literature on EMS dispatcher recognition of OHCA. In particular, general concept and experience of algorithm-based diagnosis of cardiac arrest, difficulties of telephone OHCA recognition, approaches for dispatcher diagnosis quality evaluation and assurance are discussed herein. Based on the analysis results, recommendations on organizing and improving the effectiveness of EMS dispatcher recognition of cardiac arrest are formulated. The review is designed primarily for EMS and public health specialists.

Keywords: cardiac arrest, circulatory arrest, dispatcher, cardiopulmonary resuscitation, diagnosis, algorithm, emergency medical services, first aid

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CBD — criteria-based dispatch
CPR — cardiopulmonary resuscitation
EMS — emergency medical services
ERC — European Resuscitation Council
MPD — medical priority dispatch
OHCA — out-of-hospital circulatory arrest

INTRODUCTION

The dispatcher of emergency medical services (EMS) is usually the first and, often, decisive person in the process of assisting patients with life-threatening conditions, including out-of-hospital circulatory arrest (OHCA). The main tasks of the dispatcher when receiving telephone calls include confirmation of the need for assistance, identification of priorities and mobilization of the resources of the EMS system, respectively [1]. The decisive role of the dispatcher is reflected in each of the links of the generally accepted concept of "chain of survival" which is a sequence of actions that have a direct impact on the outcomes of patients with OHCA [2]. So, dispatching is designed to provide:

1) early recognition of cardiac arrest or manifestations indicative of the threat of circulatory arrest (for example, retrosternal pain as a manifestation of myocardial ischemia);

2) timely initiation of cardiopulmonary resuscitation (CPR) by bystanders according to instructions via telephone;

3) determining the location of the automatic external defibrillator closest to the scene of the accident and, accordingly, early defibrillation of the OHCA by bystanders;

4) early arrival of the EMS team with initiation of the extended protocol of CPR and early post-resuscitation assistance [2, 3].

The current recommendations of the European Resuscitation Council (ESR) emphasize the great importance of effective interaction between the EMS dispatcher and the bystander to increase the survival of patients with OHCA [3]. The ability of the dispatcher to quickly recognize the problem and provide instructions for first aid is especially important when the circulatory system suddenly stops and the patient's chances of survival are reduced by 5-10% with each minute of delay in initiating resuscitation [4].

Early recognition of OHCA by the dispatcher on the basis of data obtained via telephone significantly increases the yhe chance of bystanders resuscitation and defibrillation, and also allows the dispatcher to send a specialized resuscitation team. All these factors determine the outcome for a patient with circulatory arrest [4]. Today, it has been proven that the

survival of patients with OHCA depends on the timely and correct diagnosis of cardiac arrest by the dispatcher [5, 6].

DISPATCHER ALGORITHM OF OHCA DIAGNOSIS

To increase the speed and accuracy of the patient's condition assessment by EMS dispatchers, algorithms and scheduling criteria may be used, also known as “decision support tools” [1, 7]. Dispatching algorithms that use a specific sequence of questions aimed at detecting a circulatory arrest, may significantly improve the efficiency of OHCA diagnosis in comparison with an arbitrary dispatch survey, when inappropriate and unnecessary questions often cause a delay in the provision of vital assistance [4, 8, 9].

The first experience of using the dispatch algorithm for recognizing OHCA and providing bystanders with circulatory arrest instructions for CPR via telephone was obtained in the USA in the early 1980s [10, 11]. The implementation of the algorithm in the work of the King County Dispatcher Service (Washington) led to an 11% increase in the number of cases when CPR was conducted by OHCA bystanders [11]. Later, the programs of dispatching in OHCA were introduced and demonstrated high efficiency in many other countries [4, 7, 9, 12, 13].

The analysis of the OHCA diagnostic algorithms, presented in foreign literature, showed that they are based on a similar, well-established structure that is displayed in a tree-like sequence of dispatcher questions with yes, no, or unsure options (Fig. 1) [4, 8, 12, 14, 15]. After a brief assessment of the reason for the appeal and confirmation of the address, the dispatcher asks two questions to determine the presence of consciousness and normal breathing in the victim. Negative answers of the respondent to both questions indicate a high probability of OHCA, and the dispatcher immediately proceeds to the algorithm for providing instructions on CPR [4, 8, 12, 15].

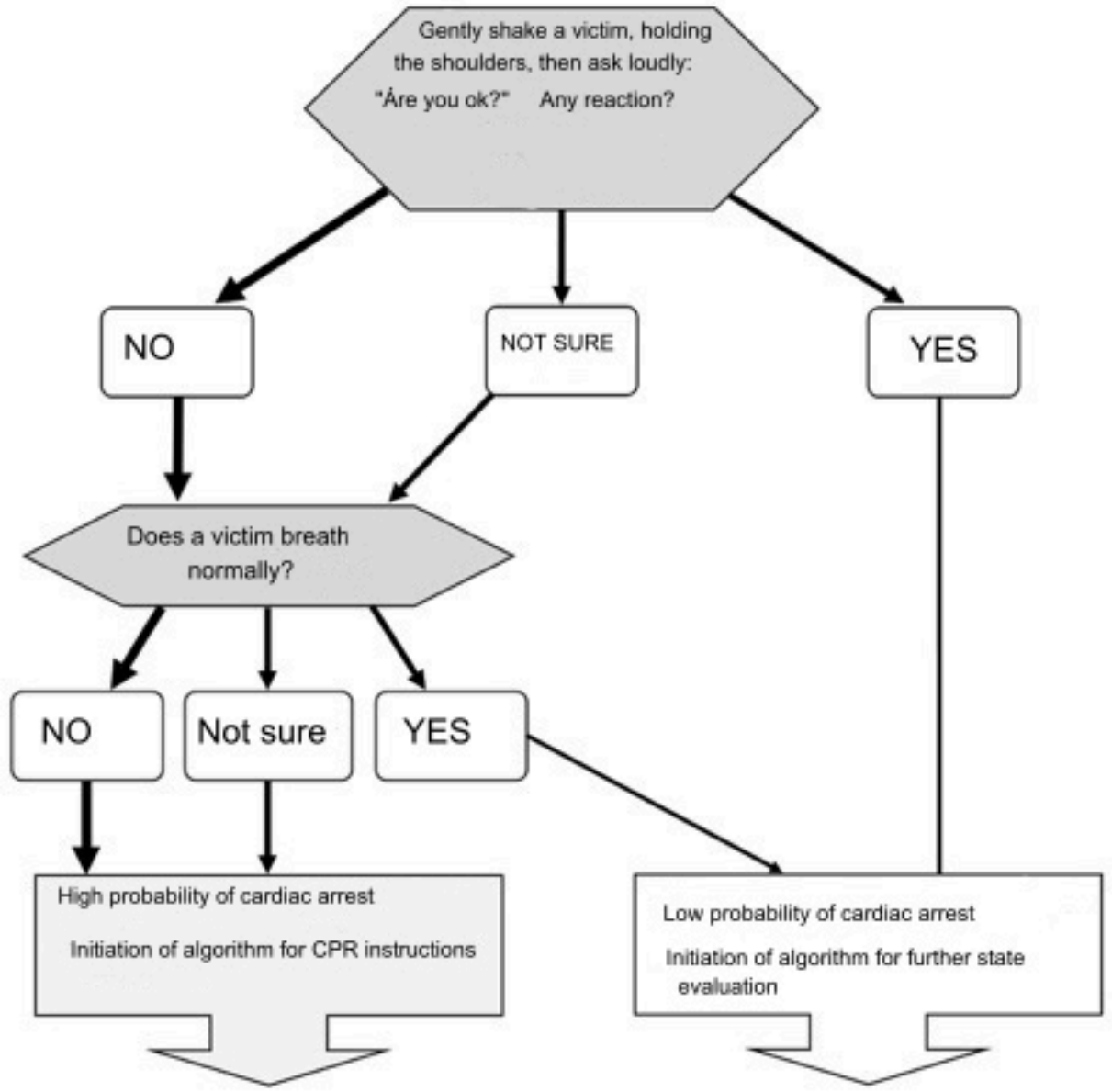

Fig. 1. The algorithm of OHCA recognition via phone

Note: * — the additional brief survey may be used to reveal the type of breathing in accordance with a set of “trigger words” predictors of agonal respiration, as well as calculation of the duration of pauses between breaths (see below)

According to the recommendations of the ERC 2015, the main signs of cardiac arrest are the lack of response to external stimuli and normal breathing [3]. The combination of "unconsciousness" with "lack of breathing" or "abnormal breathing" is most often used by EMS dispatchers for recognizing cardiac arrest via telephone [4, 8, 16]. Interrogation algorithms based on identifying these signs provide approximately 70% (from 38 to 97%) that the OHCA will be unmistakably recognized by the dispatcher [16].

While testing the response to external stimuli and the patient's breathing under the guidance of the EMS dispatcher, OHCA bystanders may also arbitrarily report additional data for which a reliable association with correct recognition of OHCA has been confirmed [6, 17]. The analysis of more than 14 thousand audio records of ambulance calls in Amsterdam (Netherlands) for 8 months showed that reliable predictors of cardiac arrest are cyanotic, pale or gray complexion, and the words "died" or "die" [6]. Knowing such “trigger words” and “trigger phrases” may help a dispatcher suspect cardiac arrest already at the initial description of the incident by an OHCA bystander (before the beginning of the survey) or clarify the diagnosis of circulatory arrest if the results of the evaluation of the response and breathing are doubtful [17] .

Currently, there is no consensus which of the diagnostic algorithms should be used for optimal dispatch of cases of OHCA, and the practice of dispatching in cardiac arrest does not have common standards [7, 18]. The most widely used dispatcher tracking tools for calls to the EMS service, which include the OHCA recognition algorithms, are the medical prioruty dispatch (MPD), mainly used in the United States, and the criteria-based dispatch (CBD), which is more common in countries of the European Economic Union. According to a comparative analysis, these systems have approximately the same ability to reliably identify OHCA, and the most frequent cause of unrecognized cardiac arrest for both systems is the incorrect interpretation of agonal respiration [18]. Although the *MPD* and *CBD* systems are the most popular, many EMS services prefer the development and implementation of their own algorithms and case dispatching programs for OHCA [6–8, 19].

DIFFICULTIES OF OHCA DIAGNOSIS VIA TELEPHONE

Factors such as incomplete, inaccurate, incorrect, or incorrectly interpreted information by the EMS dispatcher may complicate the recognition of OHCA and, therefore, delay the provision of resuscitation [1, 3]. Often, OHCA remains undetected when a bystander mistakenly believes that the victim has signs of life, or as a result of an incomplete survey by the dispatcher (for example, when the dispatcher does not ask for breathing) [6, 20]. In order to avoid cases of unrecognized OHCA, it is recommended that the EMS dispatchers maintain a initially high level of alertness regarding possible cardiac arrest when processing each incoming call [8].

One of the main factors preventing the correct identification of OHCA by a dispatcher is agonal breathing [3, 6, 8, 16, 18, 21, 22]. Rare and deep convulsive respiratory movements may be mistakenly interpreted by individuals without special knowledge as a sign of life, while the prevalence of agonal respiration in the first minutes after the heart stops reaches 40% [21, 23]. As a consequence, the chance of timely CPR for cases of OHCA in the presence of agonal respiration may be several times lower than for cases of cardiac arrest accompanied by apnea (23% vs. 92%, respectively [24]). According to some reports, agonal respiration is the cause of unrecognized circulatory arrest in 50% of cases [16, 21].

Considering the significant negative effect of agonal respiration on the effectiveness of OHCA diagnosis, it is recommended to focus on this problem in the process of CPR learning [3]. According to the study of *Bohm et al.* (2009), due to the additional training of EMS dispatchers to recognize agonal breathing via telephone as part of a one-day course, it is possible to achieve a more than two-fold increase in the bystander CPR incidence [22].

Roppolo et al. (2009) demonstrated the advantages of a modified dispatch algorithm, which included an assessment of the duration of pauses between breaths in cases where the caller could not confidently answer whether the victim's breathing was “normal” [25]. To do this, the dispatcher asked the bystander to say “*now*” each time the victim breathed. The interval between breaths of more than 10 sec in an unconscious patient was a criterion for initiating CPR. After the introduction of the new algorithm, the percentage of undiagnosed cardiac arrest fell from 28% to 19% [25]. The positive experience of the practical application of algorithms for determining the duration of pauses between breaths in order to identify pathological respiration as a criterion for the provision of CPR instructions was subsequently described by other authors [19, 26].

In some cases, cardiac arrest may be accompanied by short-term convulsions caused by a sudden cessation of blood flow to the brain [3]. A bystander and a dispatcher may regard this manifestation as an epileptic seizure that delays recognition of circulatory arrest and assistance [27].

Other factors preventing identification of OHCA via phone include the absence of a bystander at the scene of an incident during a conversation with the dispatcher, lost connection, inability to change the victim’s position and assess consciousness and breathing, bystander’s refusal to carry out the assessment, EMS team arrival, and language barrier [8, 13, 15].

While unrecognized cardiac arrest seems to be the most significant problem, a false positive diagnosis of OHCA may also have some medical and economic consequences. The criteria for diagnosing cardiac arrest, offered by the current international guidelines which underlie most control algorithms, correspond to a number of other conditions common in the practice of emergency medicine, including stroke, epileptic seizure, hypoglycemia and drug poisoning, which create prerequisites for overdiagnosis of OHCA and performing CPR when it is not indicated [28].

It is known that chest compressions may cause serious injuries, including fractures of bone structures, damage to blood vessels and parenchymal organs [29]. *White et al.* (2010) determined the prevalence of cases of CPR under the supervision of the dispatcher to the injured without OHCA, and also analyzed the frequency, type and severity of injuries associated with chest compressions [30]. It was found that in 45% of cases when the dispatcher provided instructions on CPR, the victim actually did not have a circulatory arrest, and in about 18% of cases bystanders performed a closed chest massage to the victims without OHCA. Complications of CPR in patients without OHCA were limited to discomfort or chest pain (9%)

and rare cases of fractures (2%) [30]. The absence of serious undesirable consequences of resuscitation by witnesses in cases of false-positive diagnosis of OHCA via phone is also confirmed by the results of other studies [14].

EVALUATION AND QUALITY ASSURANCE OF OHCA DIAGNOSIS VIA TELEPHONE

There are no generally accepted criteria for assessing the functioning of the dispatch EMS in cases of OHCA [8]. To determine the effectiveness of diagnosis of OHCA, the dispatcher most often uses time indicators, the gap between the incoming call and identification of cardiac arrest and the gap between the incoming call and the first compression of the chest [8, 9]. These figures vary widely: from 40 s to 4 min for the time until confirmation of cardiac arrest and from 2.5 to 6 min for the time before initiations of compressions. As a possible standard, 1 min and 2 min, respectively, are offered [8, 9]. The correct identification of OHCA by dispatchers in 95% cases, when there is an opportunity to assess the consciousness and breathing of the victim via phone, is recommended as a target indicator of the effectiveness of the OHCA dispatching diagnosis in the EMS system [8].

An important measure to ensure the quality of the dispatching in OHCA is periodic monitoring of the compliance by the dispatchers of the emergency medical system with the adopted algorithms for cardiac arrest based on the expert evaluation of randomly selected audio recordings of telephone calls [4, 15]. Having analyzed the work of dispatchers of the London Ambulance Service for 32 months, *Heward et al.* (2004) revealed a positive correlation between the dispatchers' adherence to the current algorithm and the accuracy of the OHCA diagnosis [4].

Although the effectiveness of the OHCA diagnosis via telephone depends on the knowledge and skills of the dispatcher, currently there are no uniform international recommendations for additional training of EMS dispatchers [7]. Depending on the country and the characteristics of the EMS service, the role of the dispatcher may may performed by both medical workers (for example, nurses or paramedics), and people without medical education who had special training in dispatching [7, 13]. To improve the performance of the dispatch service, it is necessary to carry out regular training of the EMS dispatchers on the principles of algorithmic diagnostics of the OHCA by telephone [22, 31]. Implementing a telephone training program for dispatchers to identify cardiac arrest helps increasing the frequency of dispatching instructions for CPR and chest compressions performed by bystanders in cases of OHCA [32, 33]. The improved survival rates with a favorable neurological outcome were also demonstrated for some training programs after their introduction [32].

The particular attention in the learning process should be given to the recognition skills of agonal breathing based on the signs described by the bystanders via phone [8, 22]. An important element of training and advanced training programs for dispatchers of the Emergency Medical Service is a detailed analysis of cases of unsuccessful diagnostics of OHCA with listening to audio recordings of real telephone calls [8, 22, 27]. The system of simulation training of dispatchers showed high efficiency. It involves working out the recognition skills of OHCA via phone by simulating calls to the dispatch service and the subsequent assessment of the actions of the dispatcher by an instructor [28, 34].

DOMESTIC EXPERIENCE

Currently, there is no unified approach to the dispatching support of OHCA cases in the Russian Federation. Some attempts have been made in some regions to introduce the instruction for bystanders by dispatchers via phone. However, scientific publications describing such experience are extremely few. It is reported that the provision of CPR instructions via telephone to bystanders of road traffic accidents had been put into practice in Novosibirsk since 2011, and subsequently the proportion of bystander CPR has doubled [35]. The Territorial Center of the Disaster Medicine in the Perm Territory has introduced a system of operational regulation of assistance in case of road-traffic accidents, which particularly included providing bystanders with “comprehensive recommendations for first aid” [36].

At the same time, there are some obstacles for the large-scale implementation of dispatching in OHCA. The current regulatory framework does not provide for such instructions. According to the Order of the Ministry of Health of Russia dated June 20, 2013 No. 388n (as amended on 05/05/2016) “On Approving the Procedure for Providing Emergency Medical Services, Including Emergency Medical Care”, calls are received and the EMS team is sent to the scene by a paramedic or a nurse [37]. They are employees of the operations department, which is a structural unit of a medical organization that provides emergency care outside of a medical organization. At the same time, the list of functions of the operations department does not provide for the obligation to instruct bystanders to carry out any first aid measures, including CPR [37]. This is not provided by the Order of the Ministry of Health of Russia dated February 10, 2016 No. 83n “On Approval of Qualification Requirements for Medical and Pharmaceutical Workers with Secondary Medical and Pharmaceutical Education”, which establishes educational requirements [38].

Another problem is the low public readiness to provide first aid, including CPR. Particularly, this is evidenced by the results of recent interviews with residents of the Crimean Peninsula [39]. The survey showed an insufficient coverage of learning CPR, poor knowledge on CPR, low motivation to learn and a limited willingness to provide first aid for heart failure, and lack of knowledge and CPR skills was confirmed as the most common and significant factor preventing from assisting potential OHCA bystanders [39].

CONCLUSION

The effectiveness of the EMS system functioning largely depends on the work of the dispatch service, and the optimization of the dispatching processes is considered an economically effective method of increasing the survival of patients with life-threatening conditions, including blood circulation arrest [3]. Considering the high frequency of occurrence of OHCA and the low level of resuscitation activity [40, 41], there is a need to develop and implement a standardized dispatching program for cases of OHCA in the EMS system in the Russian Federation, which will reduce the mortality rate by increasing the incidence of bystander CPR. Three main components are required for the creation and effective functioning of the program of dispatching instructions for OHCA: 1) the development and subsequent improvement of algorithms for diagnosing cardiac arrest and providing CPR instructions via phone; 2) training for dispatchers; 3) continuous monitoring and improvement of dispatching service [27].

The timely recognition of cardiac arrest by the dispatcher significantly increases the chance of early assistance and a

favorable outcome. In order to identify OHCA quickly and accurately, the dispatcher must possess the appropriate competencies and use reliable means to support decision making [7]. The results of the analysis of foreign experience of OHCA dispatching allow us to formulate a number of recommendations, which will help increasing the efficiency of recognition of cardiac arrest by the EMS dispatcher and, therefore, will have a positive impact on the survival of patients with OHCA.

1. Recognition of OHCA via telephone should be based on a branching dispatching diagnostic algorithm based on an assessment of the victim's consciousness and breathing.

2. An EMS dispatcher should confirm cardiac arrest and provide CPR instructions via phone in all cases of lack of reaction to external stimuli together with apnea or agonal breath.

3. To improve the efficiency of diagnosis of OHCA via telephone, the algorithm may be supplemented with a list of "trigger words" that are reliably associated with cardiac arrest. The list should be formed taking into account national-cultural and linguistic peculiarities based on the analysis of audio recordings of ambulance calls.

4. The algorithm may include assessment of intervals between breaths in order to increase the probability of recognizing agonal respiration by an EMS dispatcher as a criterion for diagnosing OHCA.

5. The EMS dispatchers should regularly undergo training on the principles of diagnosis of OHCA via phone. It is advisable to include the development of the recognition skills of cardiac arrest by telephone in the conditions of simulating dispatching work and the analysis of real cases of dispatching OHCA with listening to audio recordings of telephone calls into the training program.

6. In order to control and ensure the quality of dispatching cases of OHCA within the EMS system, it is recommended to conduct a selective expert evaluation of audio recordings of telephone calls, followed by discussion and communication of the assessment results to the appropriate dispatchers, as well as carrying out a comprehensive analysis of the dispatching support of cases of OHCA within the EMS system with identification of factors complicating the diagnosis of cardiac arrest, and analysis of the effectiveness of diagnosis.

7. When evaluating the effectiveness of dispatching in OHCA cases, it is offered to use the following indicators: the gap between the incoming call and detection of cardiac arrest, the gap between the incoming call and the first chest compression, as well as the percentage of cases of correct cardiac arrest identification by dispatchers.

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