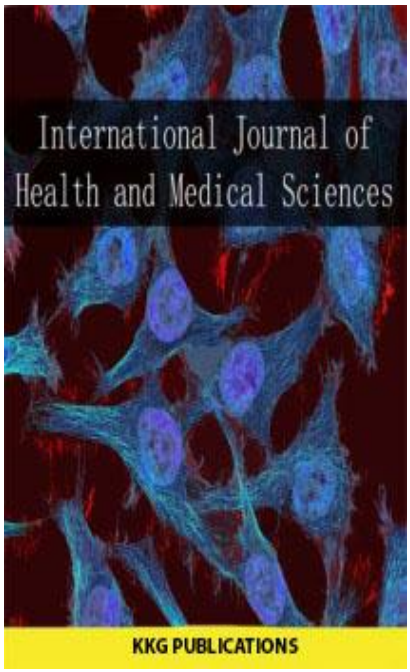

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PROBLEMS OF MEDICAL CARE IN AN EMERGENCY SITUATION HEALTH INSURANCE KENDARI CITY, INDONESIA

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Abstract. The article suggests an approach to settlement of the issue of rendering emergency medical care (EMC) on the basis of medical unmanned aircrafts (quadcopters) (MQ) and medical informational-analytical system (MIAS), gives grounds to the principles for rendering EMC, the functions algorithm of MIAS and requirements to MQ. The proposed concept ensures the provision EMC during «the golden hour». This is achieved by inclusion of medical unmanned aircrafts (quadcopters) and medical information-analytical system into MTMC. The implementation of this approach considerably reduces time for the processing of information and increases the likelihood of medical care within the "golden hour".

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INTRODUCTION

Unprecedented engineering activities, which developed in XX century and the resulting changes in the natural area, have dramatically increased the occurrence of emergency situations (ES) of man-made and natural and man-made character. The most tragic side of disasters is the loss of life.

In this regard, the arrangement of elimination of ES medical consequences and scientific substantiation of emergency medicine activity are of fundamental importance. Disasters, which occurred in recent years in the world, showed insufficient preparedness of the health system to rendering emergency medical care (EMC) [1]. There is the problem of arrangement of elimination of ES medical consequences and rendering EMC to the injured.

A complex, multi-level and heterogeneous mechanism of the arrangement of elimination of ES medical consequences, based on interaction of many different components, determines the need for an integrated multidisciplinary approach to solving the problem of rendering EMC to the injured. Recent advances in medicine, biophysics, electrochemistry, physiology, electronics, robotics, computer science and math are used for solution of this problem.

The Aim of the Research

The development of the concept of rendering EMC on the basis of medical unmanned aircrafts (quadcopters) (MQ) and medical informational-analytical system (MIAS), which allows to increase the effectiveness of the EMC at the expense of timeliness, mobility and speed.

Timeliness is a basic prerequisite for successful EMC. In a previous article the author suggested a model for making optimal decisions about the order of rendering of medical aid in emergency situations [2]. In the frames of the model: monitoring of the injured, medical selection and adjustment of the order of rendering EMC according to the results of functional state of the organism (FSO) of the injured are considered.

The means of rendering EMC are mobile telemedicine complexes (MTMC) placed on the chassis of the all terrain vehicle. The noted MTMC contain technical modules that form medical stations, supplied with medical equipments, devices and technical means to ensure survivability, interconnected with each other when deployed in areas. Each station is formed by semi-van, mounted on the vehicle chassis and equipped with a docking

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device with a neighboring station. Furthermore, the known MTMC contain the wireless communication unit and satellite communication unit, as well as telemedicine station that provides two-way communication and video-conferencing [3].

The injured receive a qualified and versatile aid due to the known mobile telemedicine complexes. The disadvantages of the known MCMC implemented on the vehicle are: a long deployment time; the need for the territory prepared for deployment; the impossibility of rendering immediate EMC upon arrival.

To eliminate these drawbacks and to pass to a qualitatively new level of rendering we need:

- development of theoretical provisions aimed at improving the efficiency of EMC;
- availability of mathematical models allowing to predict ES consequences, to describe FSO of the injured and visual representation of the environment surrounding MTMC;
- improving the means of rendering EMC.

According to the authors, the concept of rendering the EMC should be based on the following principles: principle of golden hour», principle of don't cause harm to the injured, principle of modeling and visualization.

The Principle of Golden Hour

An emergency medicine has a concept of golden hour – it is the time during which the medical care was rendered on the place, or prompt delivery of the injured to the hospital guarantees him the maximum chance of survival and minimum risk of complications after trauma. In an extreme situation the human organism reacts instantly by switching on compensatory and protective mechanisms at the maximum level in order to support the livelihoods for at least an hour. Then less important organs start to switch off to fill the main organs, the heart and the brain, with blood: while the chances of the doctors to save the injured abruptly go down [4].

The optimal time for rendering EMC – up to 30 minutes after the trauma. In respiratory arrest this time is reduced to 5-10 minutes. The importance of the time factor is emphasized by the fact that among people, who received EMC during the first 30 minutes after injury, complications occur 2 times less than in those who received it later. According to WHO every 20th from 100 killed in accidents in peace time could be saved if the EMC was provided at the place. Timely medical assistance is crucial for conservation of life and health of the injured, reduction of disability and mortality.

The Principle of Don't Cause Harm to the Injured

Currently the workload of parademic doctors has dramatically increased. They have to operate in adverse conditions of an acute shortage of time, limited accuracy and reliability of information that can lead to making irrational and even erroneous decisions, and, consequently, to large losses. The cost of failure can be a human life.

To overcome the possible "analysis paralysis" when creating and processing a vast amount of information via service computer technologies it's necessary to create conditions to parademic doctors so that he/she would mostly concentrate on the diagnosis and rendering EMC, and would take minimal participation in decision of less priority tasks of analysis and information processing. Computer diagnostics of FSO of the injured is considered as an enhancement of doctor's capabilities while processing diagnostic information, all the resources of medical informational-analytical system (MIAS) are at his disposal. Summarizing the above, we can formulate the basic principle of computer diagnostics of the FSO of the injured: to help the parademic doctor, don't cause harm to the injured.

The Principle of Modeling

The main property and characteristic feature of the model is that it is able to replace the object at certain stages and give information about it when researching. Development of a mathematical model (MM), "suitable" for solving the problem, is the most challenging task [5]. For a comprehensive description MM of the object should be set three main ranges: input variable range; output variable range; and state variable range of the object. Selection criteria of MM are: adequacy, minimum entropy and dispersion. For timely MEC, MIAS needs mathematical models, allowing to predict ES consequences and model FSO of the injured. Therewith, the problem of reducing ES medical consequence assumes qualitative nature and requires the application of the methods of modeling and forecasting of both natural and anthropogenic hazards as well as FSO of the injured for its solution.

There are many models describing the process of liquidation of ES consequences [6]. The choice of a particular model is determined by the nature of the investigated ES and not always the solution of corresponding systems of equations can be obtained in analytical form. Therefore, development of methods of model decomposition, focused on numerical solution of formulated problems, remains one of the key research areas. These approaches are important at solution of system tasks such as analysis and synthesis of control systems in terms of liquidation of medical consequences of emergencies.

Liquidation of ES medical consequences is impossible without modeling and forecasting FSO of the injured. The existing mathematical models of the person's FSO properly describe the state of the person [7].

At the moment the project of creation of Virtual Physiological Human (VPH) combines the efforts of the scientists of world community on computational modeling of human organs [8]. To help the prademic doctor in professional activities it's appropriate to create semi-automated systems, involving the participation of a prademic doctor in decision-making process.

Herewith, public and known data and knowledge that are amenable to conventional formalization should be exposed to automatic processing. During automatic processing a specific, previously unknown connections between objects may be identified, which can be interpreted as a new knowledge.

The Principle of Visualization. The implementation of the principle of visualization of the process of rendering EMC provides a convenient perception of the results, processed data and facilitates decision making [9]. It is known that:

- 90% of information is perceived through vision;
- 70% of sensory receptors are in the eyes;
- about half of the neurons of the human brain are involved in processing visual information;
- 19% less cognitive function of the brain that processes and analyses the information is used when working with visual data;
- 17% higher is the productivity of a person, working with visual information;
- 4.5% better remembered the details of visual information [14].

It is obvious that without the use of a medical informational and analytical system (MIAS) and medical unmanned aircrafts (quadcopters) (MQ) implementation of the principles of the concept of rendering EMC is impossible. Modern MTMC must be equipped with specified means of rendering EMC. According to the authors, a synergistic effect from combination of MQ and MIAS opportunities with mathematical models of liquidation of ES consequences in MTMC and modeling the FSO of the injured will let increase the effectiveness of EMC.

Under the proposed concept of rendering EMC the following are implemented:

1. Recording of the location of emergency.
2. The arrival of the quadcopter to the emergency place.
3. The search and recording of GPS- coordinates of the injured.
4. FSO evaluation and medical triage.
5. The arrival of MTMC brigade to emergency place and adjustment of order based on the evaluation results of the FSO of the injured.
6. Rendering EMC by MTMC brigade, evaluation and hospital admission of the injured.

To implement the concept of rendering EMC based on medical unmanned aircrafts (quadcopters) (MQ) and medical informational and analytical system (MIAS) let's consider their features.

The Features of Medical Unmanned Aircrafts

Unmanned aircraft of MTMC is a medical quadcopter (MQ), which is one of the types of multicopter with four carrying motors, arranged in pairs symmetrically against geometric center and with electric motor unit [11].

MQ is a vertical take-off aircraft, during the flight it can move in any direction, maintaining at the same time horizontal position against the ground, it also can float in one place, rotating about its vertical axis.

MQ can independently fly on GPS-coordinates. With a payload up to 3 kg it speeds up to 70 kilometers per hour [1], while the quality and practicability of the roads make no difference. MQ advantages are compact size, low weight, low cost, as well as ease of assembly and setup.

According to the authors, MQ is able to ensure the timeliness, mobility and efficiency at the expense of speed of arrival and the possibility of immediate rendering EMC. Under the proposed concept of rendering EMC let's consider MQ actions:

Arrival of quadcopter at ES place. Medical quadcopter (MQ) takes off immediately after receiving emergency signal and provision of MTMC. The flight control system lays the route and controls the flight on GPS-coordinates of ES location. MQ flight control represents a certain challenge, which involves a choice of optimal trajectories and flight modes, as well as maintaining the stabilization of quadcopter approach to the injured to an optimal distance for timely rendering of EMC. During the flight MTMC operator controls the quadcopter flight and actions.

A Search and Recording GPS-Coordinates of the Injured

Upon the arrival of quadcopter at ES place MTMC parademic doctors search for the injured. For this purpose they use broadband radar, thermal and video cameras. Upon discovery they mark GPS-coordinates of each injured. While on a real time video cameras of the quadcopter define the distance to the injured.

FSO Evaluation and Medical Triage

There are necessary medical supplies for rendering EMC on MQ board. MTMC parademic doctors, watching through the video camera, assess the functional state of the organism (FSO) of the injured using the START algorithm [2]. A distinctive feature of MQ, in addition to the necessary medical supplies for rendering EMC, is the avalibility of the manipulator. A medical manipulator (MM), mounted directly on MQ body, is designed for rendering premedical EMC in the absence of the person next to the injured. MM, working remotely in copying and semi-automatic mode, is controlled by the same doctor-operator. After receiving information about FSO of the injured, a doctor-operator analyzes the situation and makes the decision for rendering EMC. Then, copying own movements, a doctor-operator remotely renders EMC to the injured via manipulator and 3D-video camera until MTMC team arrives. In particular, using the manipulator a doctor-operator can remotely apply a tourniquet on the wound, make an injection, give pills and water, fix a portable cardioanalyser [10], apply a defibrillator and carry out other actions necessary for rendering EMC.

Thus, before the arrival to place of ES, MTMC doctors have basic information about the location and severity level of the

state of the injured. With account of the data they have, a way time to the place of ES may be used to prepare the equipment and personnel to rendering EMC.

The Arrival of MTMC Team to ES Place

After arriving at the ES place and MTMC deployment the order of rendering EMC is adjusted according to FSO results [2].

Rendering Emergency Medical Care By MTMC Team

Rendering emergency medical care by MTMC team is carried out in accordance with the recommendations of emergency medicine. At this stage the injured who need secondary health care are hospitalized.

The Features of Medical Informational-Analytical System

Medical informational and analytical system (MIAS) lets parademic doctor in MTMC obtain information on the state of the injured, to individually evaluate FSO of the injured and make a decision on rendering EMC.

The peculiarity of MIAS is the use of multi-agent technologies. Agent-based approach is used to model complex systems consisting of large number of interacting subsystems [12]. In this approach, MIAS is considered as a set of interacting parts - agents, each of which acts independently on pre-defined rules and can interact with other agents. Thus, the behavior of all MIAS consists of the interaction of its parts.

During the simulation the agents operate individually, sharing the values of the parameters. Each agent has a local internal time as well as the time of the launch of work and ending time [13]. Thus, agents can appear and disappear during MIAS operation.

With respect to abovementioned, MIAS is a set of software tools, implemented using multi-agent technologies and designed to ensure MTMC functioning, storage and processing of large volume of medical data, as well as interoperability with MQ.

Functionally, MIAS can be represented in the form of three interrelated agents (Fig 1):

1. The agent of interaction with MQ.
2. Agent of the analysis of medical data.
3. Agent of access to the database (DB).
4. Scheduler.

Let us consider the assignment of modules:

1. The agent of interaction with MQ. The agent consists of a means of controlling MQ, means of controlling MQ manipulator and means of data exchange with MQ. Operation of these means requires the use of GPS or GLONASS system.

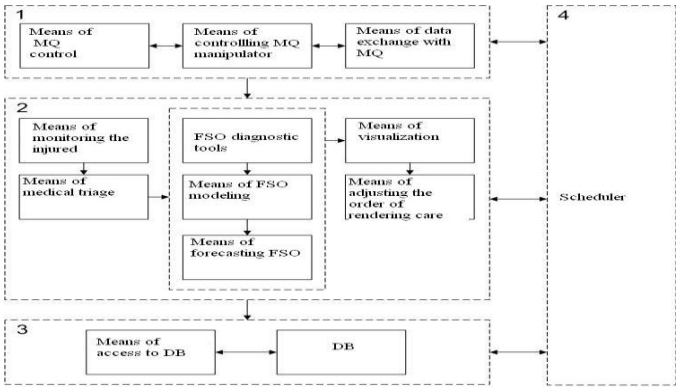

Fig. 1. MIAS structure

For communication radio and video systems are used, to control the quadcopter, for correction of the flight path, etc. Even when flying offline information about actions, coordinates and modes of flight of the quadcopter is transmitted to the control system. MIAS processes information received from the board of the quadcopter, and displays necessary information to the operator. The information may contain a photo or video file, GPS coordinates, speed, altitude, range and energy reserves of the battery, etc.

2. Agent of the analysis of medical data. This agent performs basic analytical processes of MIAS, such as: defining and monitoring FSO of the injured, medical triage and visualization of medical data. These processes are described in detail in the previous article of the authors [2].

3. Agent of access to the DB. To store medical data means of access to DB are used, including a relational database, database management system (DBMS) and software designed to operate with the DB.

The database is hosted on a server or one of the computers and contains the necessary medical information. Access of specialists for editing databases is available only upon authentication of a user authorized to edit.

DBMS is a means of access to DB. When you enter the data reporting system you are required the name and password of

the user. If authentication succeeds, the user is granted a certain level of access.

Software designed to operate with databases, allows to conveniently display all the necessary medical information for the user, to generate necessary reports, to show medical statistics, etc..

4. Scheduler. The scheduler is an important part of agent-based models, it performs a synchronous operation of the agents and the exchange of messages between them, given the disparity of time scales. The scheduler keeps a history of messages and on demand of the agents finds the values of the transmitted variables at the desired point by linear interpolation.

CONCLUSION

MTMC equipage with quick response means increases the efficiency of rendering EMC. The proposed concept ensures the provision EMC during the golden hour. This is achieved by inclusion of medical unmanned aircrafts (quadcopters) and medical information-analytical system into MTMC.

The implementation of this approach considerably reduces time for the processing of information and increases the likelihood of medical care within the "golden hour". MQ, due to its mobility, efficiency and speed can provide the parademic doctors with the necessary information on severity of the injured and their location until the arrival at the place of ES.

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