Optimization of emergency management in patients with acute coronary syndromes in big urban district through generalized nets model

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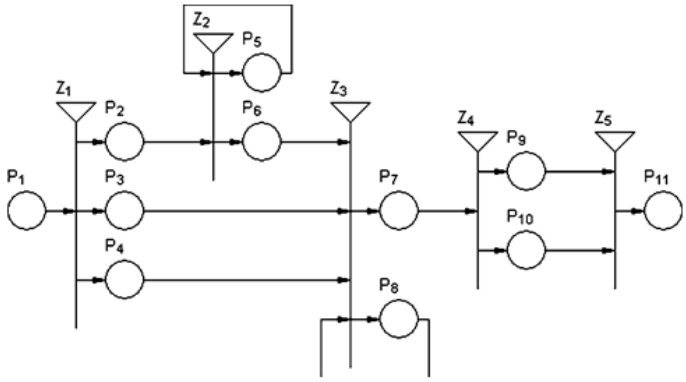
Introduction

According to the World Health Organization, in the period 2004–2030 year cardio-vascular diseases will remain a leading cause of human deaths on global scale. Among these, the major cause of mortality are the acute coronary syndromes (ACS). Key aspects of controlling the ACS are the early diagnostics and the early reperfusion therapy—primary percutaneou coronary intervention (PPCI) or fibrinolysis. However, PPCI exhibits some essential advantages by better dilatation and preserving the integrity of the infarct-related artery (IRA). The goal of the present research is to optimize the emergency management in patients with ACS in big urban districts through simulation model based on generalized nets (GN) [1].

Methods

The model evaluates how prehospital diagnosis (PHD) affects the time span from contacting an emergency medicine/paramedicine team (ET) to performing PPCI with 3 groups of STEMI patients, inhabiting a big urban district. The first group consists of patients without PHD who have not been directed to a medical center for PPCI. The second group consists of patients with PHD, who have not been directed for PPCI. The patients in the third group are given PHD and directed for PPCI. The data, registered for the three groups, correspond to the performed activities. Within Group 1: Subgroup 1—transportation from the patient's address to a healthcare unit with the possibility of diagnosing and without a possibility of PPCI; transportation from the healthcare unit to a PPCI centre. The average distances and times for both transportation courses are determined, as well as the average time spent in the first unit (for diagnosing) and the average time until PPCI in the second one; Subgroup 2—transportation to a healthcare centre for both diagnosing and PPCI. The average distance, average time for transportation and average time for diagnosing and PPCI are determined. Within the Group 2, the same parameters are determined as in Subgroup 1, and further is estimated the difference between the average times spent in the healthcare unit without PPCI possibility in both cases. Within Group 3, the same parameters are determined as in Subgroup 2, and further is estimated the difference in the average times from reception in the healthcare centre to performing PPCI in both cases.



GNs are extensions of the Petri nets and their other modifications. They, similarly to the other Petri nets, have static structure and dynamical elements (tokens), but they have some specific components: (1) Matrices, associated to the separate transitions, with elements—predicates that determine the directions of tokens' transfer and representing the logical conditions that determine the develop- ment of the modelled process. (2) GN-tokens obtain initial, current and final characteristics that contain the analytical description of the information for the real processes. (3) Different time-components, representing initial and final moments of the GN-functioning, ele- mentary time-step of the used time-scale; initial moment of the modelled events' realization and duration. During last 20 years, the GNs obtained application in the areas of artificial intelligence, med- icine, chemistry, telecommunications, transport and other. Especially in medicine, the GN-applications are related to modelling of diagnosis processes, of processes in a human body and especially of processes in managing hospital units [2, 3].

Results

The particular generalized net model is presented in the figure below. The model consists of 5 transitions and 11 places. In place P1, tokens corresponding to patients enter. They have as an initial characteristic information about the patient's health status, infor- mation whether the patient has PHD, information about the patient's PPCI (if any). Place P5 and P8 respectively correspond to the primary healthcare unit and the specialized healthcare centre where PPCI can be performed. By keeping track of these characteristics, there can be accounted the possibility of accepting new patients and the necessary time for the procedures over them.

The token, corresponding to the current patient, enters either place P2 (if the patient has not been assigned a PHD and has not been directed to a PPCI centre), or place P3 (if the patient has been assigned a PHD, but has not been directed to a PPCI centre) or place P4 (if the patient has a PHD assigned and is directed to a PPCI center). The tokens obtain the characteristic ''duration of trans- porting the patient to the hospital unit'' in places P6 and P7, and the characteristic ''duration of examining the patient in the PPCI centre'' in place P9. The tokens do not obtain any characteristic in place P10, because there enter the patients from Group 3. Finally, the tokens obtain in place P11 the characteristic ''total time span for the current patient from contacting the ET to performing PPCI''. The so constructed GN model gives possibility to simulate different situa- tions with respect to the workload of the healthcare units and the patients' health status.

In 70 % of the patients from Group 2 and Group 3, the clinical recommendations for the time span from contacting the ET to per- forming PPCI have been kept under 120 min (the average time is respectively 50 and 76 min), while in Group 1 this condition has been kept in only 30 % of the cases (the average time being 145 min). On the basis of a generalized net model, a simulation has been performed on the assumption that patients without a diagnosis are assigned ECG PHD in the ambulance (including a telemetric consultation of the ECG with a cardiologist) and the patients are transported to a healthcare centre for PPCI. In the simulation, the average distances and times, obtained from the PHD patients, have been used. The results exhibit reduction of the average time span from contacting an ET to PPCI down to 84 min.

References

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