Expert System for Emergency Management of Myocardial Infarction

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Introduction:

More than 5 million Americans visit hospital emergency departments each year with the complaint of chest pain. Two million patients are admitted to hospitals because of chest pain, but the diagnosis of coronary heart disease is confirmed in only one fourth of them. Acute coronary syndrome represents a clinical syndrome that includes unstable angina, non-Q-wave myocardial infarction and Q-wave myocardial infarction. The goal of management of patients with acute coronary syndrome is to rapidly recognize and manage their cardiac ischemic event, define the risk of myocardial ischemia and recurrent cardiac events, and minimize unnecessary risk to the patient. (Rogers 2000)

In half of the patients admitted with chest pain on suspicion of an acute myocardial infarction (AMI), this diagnosis is not confirmed (non-AMI). Both AMI and non-AMI patients have a mortality which exceeds the mortality of the background population in the years following discharge based on a high incidence of cardiac death. (Fruergaard et al. 1992)

The use of Diagnostic criteria can help in better decision making for such patients. In one of the studies, uses of such criteria have reduced the number of 'unnecessary' coronary-care-unit admissions from 298 to 162, a 46% reduction (P less than 0.001). In the same patient sample, use of the criteria have reduced
the number of patients with definite acute myocardial infarction, admitted to the general wards, from 47 to 22, a 53% reduction (P less than 0.01) (Jonsbu et al. 1991)

One of the first computerized decision support algorithms for the diagnosis of myocardial infarction documented in the literature and validated for clinical use was the one described by Goldman, L.et al, which in prospective testing on 468 patients, the protocol performed as well as the physicians. Moreover, an integration of the protocol with the physician’s judgments resulted in a classification system that preserved sensitivity for detecting infarctions, significantly improved the specificity (from 67 per cent to 77 per cent, P less than 0.01) and positive predictive value (from 34 per cent to 42 per cent, P = 0.016) of admission to an intensive-care area. (Goldman et al. 1982)

Some researchers reported that Computer based algorithms are less reliable than the clinical judgment of Physicians (Poretsky et al. 1985)

Few Years Later, The development of decision support systems for chest pain became an issue addressed by some of the experts in the field, “The patient with chest pain in the emergency room–will the computer resolve the physician's dilemma” (Hod 1994), “Do we need computer-based decision support for the diagnosis of acute chest pain: discussion paper” (Kennedy et al. 1993).
In 1988 Goldman, L.et al developed a computer protocol for management and triage of patient with chest pain, in their paper, they tested this protocol prospectively in 4770 patients at two university hospitals and four community hospitals, the computer-derived protocol had a significantly higher specificity (74 vs. 71 percent) in predicting the absence of infarction than physicians deciding whether to admit patients to the coronary care unit, and it had a similar sensitivity in detecting the presence of infarction (88.0 vs. 87.8 percent). Decisions based solely on the computer protocol would have reduced the admission of patients without infarction to the coronary care unit by 11.5 percent without adversely affecting the admission of patients in whom emergent complications developed that required intensive care (Goldman et al. 1988).

In 1999 Qamar et al conducted both retrospective and prospective study to reevaluate the Goldman's algorithm and they concluded that Routine adherence to the Goldman algorithm for the evaluation of patients with acute chest pain could have decreased the number of CCU admissions for suspected AMI by 5%. This strategy would result in significant cost savings to the health care system without jeopardizing patient safety(Qamar et al. 1999).

Decision Tree analysis based on only the presenting ECG recording and the Myocardial marker levels of the initial blood sample that was drawn immediately after emergency department admission was reported to be of 90% accuracy in
correctly classifying patients with Myocardial infarction from others with chest pain.(Mair et al. 1995).

In patients with acute chest pain, clinicians must distinguish myocardial infarction (MI) from all other causes of acute chest pain. If MI is suspected, current therapeutic practice includes deciding whether to administer thrombolysis or primary percutaneous transluminal coronary angioplasty (PTCA) and whether to admit patients to a coronary care unit. The former decision is based on electrocardiographic (ECG) changes, including ST-segment elevation or left bundle-branch block, the latter on the likelihood of the patient's having unstable high-risk ischemia or MI without ECG changes. Despite advances in investigative modalities, a focused history and physical examination followed by an ECG remain the key tools for the diagnosis of MI(Panju et al. 1998)

Patient with acute myocardial infarction who are mistakenly discharged from emergency department have a short term mortality of about 25%. The legal costs that can result from such cases constitute the largest category of losses from malpractice litigation in the emergency department. However, the admission of such patient who are at low risk of AMI costs an average of $2000 to $5000. Therefore, with increasing economic pressure on health care, most physician, health plans, and medical centered are interested in improving the efficiency of care for patient with acute chest pain (Lee et al. 2000).
From what was stated above, it is obvious that most researchers concentrated in their research on the diagnostic aspect more than the treatment of the acute myocardial infarction. In this paper, I am describing an expert system which deals more specifically with the management of patient with acute myocardial infarction.

**Methods and Tools:**

The algorithms were derived mainly from the latest American college of cardiology guidelines *Figure 1 &2*(Rayan et al. 2000) and latest medical literature review article(Hamm et al. 2001).

*Figure 1, Management of patient with ST elevation MI.*
Figure 2, Management of patient with non ST elevation MI

Both of the above algorithms were studied carefully and updated with minor modification from the recent medical literature specifically from the review article of Hamm et al (Hamm et al. 2001). The algorithm was further modified to include patients whom are suspected to have acute myocardial infarction on clinical grounds without having chest pain.
To make the system more efficient, it was necessary to add extra definitions to the knowledge base, which included absolute and relative contraindication of thrombolytic therapy, criteria to classify the patient as high risk, and consideration for the availability of highly qualified clinicians like interventional cardiologist and cardiac surgeons.

.Exsys® CORVID™ which is a decision support systems development shell was used as the basic tool to build the system. Forward chaining “data driven” mechanism was chosen for this design, because it would probably serve better for this model of decision support algorithm.

All the variables of possible system input and output were defined carefully before building the system nodes in order to minimize unpredictable outcome of the inference engine.

**Results:**

The system was tested for many possible scenarios for both categories of patient with or without chest pain in whom acute myocardial infarction is suspected. Few software bugs were identified and fixed.
The output of the inference engine was very accurate and corresponded well to expected output when matched to the input (figure 3).

![Exsys CORVID Runtime](image)

**Figure 3 – system output.**

The system successfully identified any patient who falls in the high risk category and recommended the necessary action based on the existing clinical condition.

**Discussion & Conclusions:**

This system was designed to be used primarily by physicians, however, the general design is relatively simple which would enable nurse practitioners and paramedics to use it.

In order to make any decision support system widely accepted by the end user, the graphical user interface (GUI) has to be intuitive, and the data input method
has to be easy and fast. Both of these criteria were implemented in this system. The entire GUI was designed to have radio button or checklist “no text entry required”.

Another intention of having a check lists, was to improve the quality of data acquisition by the end user, which will ultimately improves diagnostic and management accuracy.

The inclusion of definitions for contraindication in the knowledge base serves as an alert and should help preventing potential complications of thrombolytic therapy.

At this stage, this system can not be used in clinical practice. To validate this system, at least two major steps need to be accomplished. First, it has to be tested extensively by a group of domain experts “Cardiologists”, who would agree or suggest modification. Second, a controlled prospective study conducted on a statistically significant sample has to be done, the result of which will determine the validity of this system as an expert in the emergency management of acute myocardial infarction.

It would be of great interest if this project can be extended by designing a neural network to serve the same purpose, and then conduct a controlled prospective comparative study for both systems.
References:


