EVALUATION OF EMERGE, A MEDICAL DECISION MAKING AID FOR ANALYSIS OF CHEST PAIN

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Abstract

EMERGE, a rule-based medical decision making aid for analysis of chest pain in the emergency room, was evaluated using retrospective patient data. The analysis consisted of two phases. In the initial phase, patient cases were run in order to make minor modifications and adjustments in the criteria used for determination of admission. In the second phase, patient cases were analyzed to determine the effectiveness of the EMERGE system in arriving at the proper conclusion.

Introduction

The expert system as a clinical decision making aid has gained in prominence over the last decade, as demonstrated by systems such as MYCIN [1], INTERNIST [2], CASNET [3], and EXPERT [4]. An overview of these and related systems is given [5]. These projects are still largely experimental, and are undergoing further analysis and modification.

The emergency room is an area where rapid and accurate decision making is required. Several approaches directed toward incorporating computers into this environment have been pursued [6]. A rule-based system oriented toward emergency room decisions, EMERGE, was developed utilizing medical knowledge acquired from a retrospective medical auditing procedure known as a criteria map [7]. Criteria maps exist in several medical specialties. EMERGE was originally developed using the criteria map which had been designed for chest pain analysis. Another approach to the analysis of chest pain is given [8].

The purpose of this paper is to describe the evaluation of the chest pain application of EMERGE utilizing existing medical records obtained from the Veterans Administration Medical Center in Fresno, California. The evaluation consisted of two phases. Initially, the EMERGE consultation program was used to analyze patient cases with the objective of evaluating the performance of the current rule base. During this phase, some additions, changes, and modifications were made to the original rule base. This phase is described in the following section.

In the second evaluation phase, the modified rule base which resulted from phase one was used, with no further modifications. The purpose of this phase was to evaluate the decision making capabilities of EMERGE by comparing the conclusions of the consultation program with the actual disposition of the patient case. Four representative case studies from this phase are analyzed in section III.

Analysis of the Rule Base

The original rule base was derived directly from the existing criteria map for chest pain. The major objective of this set of rules is to determine whether or not a given patient should be admitted to the hospital. In addition, in some cases, treatments are recommended.

The rule base for EMERGE is maintained separately from the consultation program. The rule base is contained on three disk files, plus two additional disk files, denoted the SC and ST files, which contain standard conditions and standard treatments, respectively. The purpose of these latter two files is to consolidate conditions and treatments which are used repeatedly by multiple rules.

During the first phase of the evaluation, several improvements to the original set of rules were suggested. A portion of the original map is shown in figure 1. A positive response causes a branch to the right; a negative response or no information causes a downward branch. The left-hand column comprises a set of rules known as the level zero control flow. Since the maps were developed several years ago (1976), some of the recommended treatments required updating. For example, instead of the propanolol treatment, shown on the original map, an option of verapramil or propanolol is given. In addition, verapramil can be given to patients with asthma.

In the original rules, the standard treatments prescribed dosages for some drugs, as shown in figure 1. The dosage information was eliminated, as the precise dosage became a source of disagreement. The modified version of the portion of the map from figure 1 is shown in figure 2.
In addition to these and similar minor changes, some rules were added. For example, as seen in figure 1, the original map contained a check for hypotension, but no check for hypertension. The latter was added, as indicated in figure 2.

During this initial evaluation procedure, several observations were made. Rules can be easily added, changed, or deleted by utilizing the file maintenance program, with no change to the consultation program. In fact, because of the SC and ST file structures, treatments and conditions can be modified simply with a single change to the appropriate file. For example, the following standard treatments were modified to remove the dosage:

ST2  SWAN-GANZ  IV DOPAMINE  5-15 MCG/KG/MIN

ST3  LIDOCAINE BOLUS  50-100 MG
     LIDOCAINE Drip  1-4 MG/MIN

This change required the modification of two ST's in the ST file. ST2 appeared in the conclusion portion of ten rules, and ST3 appeared in seven rules. These seventeen rules required no modification to incorporate the new treatment.

It appears that modification of a set of production rules to fit the needs and perceptions of each new group using the consultation program is a reasonable and common occurrence. The structure of the EMERGE rule base permits easy adaptation to meet the needs of new users, as well as readily accommodating changes which are necessary to incorporate new knowledge.

Case Studies

Four case studies are presented in this section. Details of each case are first given, which are summarized from the patient charts. The computer consultation is then shown.

The first patient, a 38 year old male, presented to the outpatient department with chest pain. He had a previous history of myocardial infarction. His blood pressure was 138/85, chest pain was similar to his previous angina. There was no related dizziness, shortness of breath, nausea, or vomiting. He had a history of ethanol abuse, EKG showed PVC's and ST-T wave changes. The patient was admitted to the coronary care unit for observation. The chest pain was relieved with morphine and intravenous nitroglycerine. An exercise tolerance test (treadmill) was done which showed with significant ST depressions (4mm in leads V$_2$-V$_5$). The patient was referred for catheterization, which showed triple vessel disease. Coronary artery bypass was done, involving grafts to the left anterior descending, circumflex, and right coronary arteries.

The consultation for this patient is shown in figure 3. EMERGE was able to arrive at a decision to admit based on the first available symptoms. The user has the option of continuing the consultation. In the case of this patient, a decision to admit is reached in several locations.

The second patient was a 51 year old male who presented to the outpatient department with chest pain for 1½ hours. He had history of angina, with similar pain, sometimes triggered by emotional stress. The chest pain was associated with radiation to the left arm, nausea, and diaphoresis. The EKG showed ST-T wave changes. Blood pressure was 154/94, lasting for more than 15 minutes, heart rate was 106. The patient was obese. Chest pain was relieved with sublingual nitroglycerine. The patient was admitted to the coronary care unit. Enzymes were negative. After stabilization, he had a treadmill test, which showed inferior/lateral ischemia. He was sent for catheterization, and eventually had angioplasty.

The remaining computer consultation are omitted due to space considerations.

Again, the patient is admitted at several different points in the program. One advantage of this approach is that significant findings will produce a rapid decision, and the consultation may be terminated at that point, if desired.

Patient 3 was a 41 year old male who presented to the outpatient department with complaint of chest pain for one day. He had no previous history of coronary artery disease, although he had been admitted in the past for evaluation, all of which were negative. Vital signs were stable, EKG showed no abnormalities, with no changes during chest pain. He was a smoker with a positive family history, and was depressed. The patient was admitted. He was given a thallium treadmill test, which was negative, as were past treadmill tests.

EMERGE ran through the entire level zero control flow, with insufficient information to admit, since no significant positive findings were encountered. In contrast to the first two cases, this patient would not have been admitted. This is significant, due to the shortage of beds, especially in critical care units. Reducing unnecessary admissions allows available resources to be directed toward the seriously ill patients, as well as producing considerable economic benefits. It should also be noted that the sensitivity and specificity of the criteria coordinate well with clinical opinion.

The last patient case was a 47 year old male with chest pain after eating. His EKG was normal. He exhibited mild shortness of breath and leg pain. He also had a history of sciatic nerve disease. His blood pressure was 150/100, but returned to normal limits within 15 minutes. He was a smoker. He had taken soda bicarbonate and got relief. He was admitted and given norgesic for the leg pain. The patient was discharged from the hospital. No further cardiac evaluation was felt to be warranted. He was scheduled for follow-up in the medical clinic.
In this case, the consultation program arrived at the correct diagnosis of indigestion for this patient, as indicated by follow-up information. Again, the patient would not have been admitted by the consultation program.

**Discussion**

It appears that several benefits can be gained through the use of a consultation program during the admission process. First, it forces certain questions to be asked which may otherwise be overlooked. Secondly, it establishes a protocol for the admission of patients with chest pain. In addition, in the process of running the computer consultations, it was noted that the answer to some key questions has a great impact on the outcome of the consultation. For example, one rule has the following form:

**IF** History of previous MI
**THEN** Rule 410

where Rule 410 eventually leads to admission. If there is history of myocardial infarction, then the question of whether the pain is similar is crucial. If the answer is no, the consultation continues, and the patient may or may not be admitted. The response to this question is indeed not clear cut, and depends on a value judgement. On the other hand, it is important that the question is asked. The identification of such key questions seems to be very desirable in order to maintain a consistent system of admission.

During the analysis of the cases, the relative value of the criteria have been established. The trial consultation runs for EMERGE demonstrate several points. It appears that the use of the consultation program during the admission procedure results in the analysis of parameters which in some cases may be otherwise overlooked. The resulting admission decisions are consistent, and lead to better utilization of hospital facilities, as well as better treatment for the patient. EMERGE recommended admission for all cases run where the patient was subsequently found to be suffering from a serious illness. In addition, it recommended in a number of instances that patients should not be admitted. In these cases, either the patient had not been admitted, or he was admitted and subsequently discharged with no positive findings.

**Further Investigations**

Additional patient studies are continuing to further evaluate the EMERGE consultation program. An additional revision which will be incorporated is a differentiation between admission to the hospital, and admission to a coronary care unit. This determination will be based on the values of the certainty factors, which are also undergoing a process of refinement. Addition of more criteria for further refinement is also under consideration.

**References**

7. R.S. Ledley, T.F. Landau, Interactive decision-support system for the emergency medical triage process, Proceedings, Symposium on Computer Application in Medical Care (1979), pp. 52-55.
Figure 1: Portion of Criteria Map Before Revision

- BP < 100/60
- Acute mental status
- GCS <= 8
- Gray zone chest
- Weak peripheral pulses
- Female
- Established I.V. access
- Currently taking Warfarin
- Female

Figure 2: Portion of Criteria Map After Revision

- BP > 100/60
- No acute abnormal mental status
- GCS = 15
- Gray zone chest
- Normal peripheral pulses
- Both
- Known heart block
- Proved old anterior wall MI
- Most abnormal QTc
- Known
- Stat
- Infusion
- ECG monitor
- Admit

The following treatment is recommended:
- OXYGEN
- ECG MONITOR
- IV LINE
- ADMIT

The certainty that the patient has an admissible disease is 1.00.

DO YOU WISH TO CONTINUE THE CONSULTATION?

1 Y

BP > 150/90

1 N

CHEST X-RAY INTERPRETATION

1 N

SYMPTOMS

1 N

NEW NEUROLOGICAL DEFECT

1 N

PATIENT NOT ALERT AND ORIENTED

1 N

PAIN EXCRUCIATING

1 Y

PATIENT UNREMITTING

1 Y

The following treatment is recommended:
- OXYGEN
- ECG MONITOR
- IV LINE
- ADMIT

The certainty that the patient has an admissible disease is 0.25.

DO YOU WISH TO CONTINUE THE CONSULTATION?

1 Y

BP < 100/60

1 N

HISTORY OF PREVIOUS MI

1 Y

PAIN ANTERIOR

1 Y

PAIN REPRODUCED AT ONE OR MORE LOCI IN CHEST

1 N

HISTORY OF TRAUMA

1 N

REFERRED PAIN ON ANTERIOR-POSTERIOR OR SIDE-TO-SIDE

1 Y

X-RAY SHOWS BROKEN RIB

1 N

HISTORY OF MI

1 Y

PAIN SIMILAR TO PREVIOUS MI

1 Y

DEPERDENT RALES

1 N

RHEUMATOID ARTHRITIS

1 Y

F3 GALLOP, NEW OR INCREASED

1 N

PESTAL EDEMA, NEW OR INCREASED

1 N

JVP

1 N

NEW OR INCREASED

1 N

The following treatment is recommended:
- NITROGLYCERINE
- MORPHINE
- OXYGEN
- IV TINE
- ECG MONITOR
- ADMIT

The certainty that the patient has an admissible disease is 1.00.

DO YOU WISH TO CONTINUE THE CONSULTATION?

1 Y

PAIN ANGINA

1 Y

HISTORY OF PREVIOUS EPISODES

1 Y

INCREASED IN SEVERITY OR INTENSITY

1 N

DURATION > 30 MINUTES

1 N

The following treatment is recommended:
- NITROGLYCERINE
- Morphine
- OXYGEN
- ECG MONITOR
- ADMIT

The certainty that the patient has an admissible disease is 1.00.

Figure 3: Consultation for Case Study 1