Optimal Use of Coronary Care Units: A Review

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Patients at a low probability of acute cardiac pathology constitute a considerable proportion in many coronary care units (CCUs), such that physicians should consider more effective alternatives than CCU admission "to rule out myocardial infarction." In this article, strategies to increase the efficiency of managing patients with acute chest pain are reviewed. Algorithms aiming to improve the diagnostic accuracy of the general practitioner have been developed but require an electrocardiogram recorded at the home of the patient. Another method of triage encompasses the identification in the emergency room of the hospital of

patients at a low probability of acute cardiac pathology by using predictive models that include laboratory assessments. A third strategy includes alternatives to CCUs for patients at a low risk of acute cardiac pathology, such as the creation of a simple observation unit. Finally, some investigators have sought to identify patients with good prognosis for early transfer from the CCU to lower levels of care. It is concluded that a combination of these approaches will be most efficient, and that the most appropriate choice will be determined by local circumstances.
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IN THE EARLY 1960s coronary care units (CCUs) were introduced to ensure prompt response to life-threatening arrhythmias in patients with acute myocardial infarction (MI). After the introduction of thrombolytic therapy in the 1980s, treatment of patients with acute MI has undergone major changes. This therapy has beneficial effects on ventricular function, morbidity, and mortality.[1-6] The earlier treatment is initiated the better, which underlines the importance of early diagnosis. Therefore, a rapid evaluation of patients with chest pain and other related symptoms is of paramount importance.

In the Netherlands, most patients with acute chest pain or other symptoms first contact their general practitioner. However, in general practice, immediate recognition of acute MI in patients with chest pain is often difficult. The clinical information available to the general practitioner is often insensitive or nonspecific.[7-9] If the diagnosis is uncertain, general practitioners tend to refer patients to hospitals to "rule out myocardial infarction" rather than risk missing the diagnosis. This strategy ensures a high admission rate for patients with evolving MI, but also leads to admission of many patients without acute cardiac pathology (eg, stable angina pectoris, atypical chest pain). Consequently, in 30% to 70% of the patients admitted to the CCU with symptoms suggestive of MI, this diagnosis is not confirmed.[10] If the differentiation of MI and unstable angina pectoris from other causes of chest pain could be improved, the CCU might be used more effectively.

Various strategies have been proposed to increase the efficiency of managing patients

with acute chest pain. Some investigators have tried to improve the diagnostic accuracy of the general practitioner.[7,11-13] Others have developed predictive models to identify patients at low risk in the emergency department to minimize unnecessary admissions.[14-24] A third strategy included the creation of a simple observation unit.[25-28] Finally, some investigators have sought to identify patients with good prognosis for early transfer from the CCU to lower levels of care.[29-37] These different approaches will be reviewed in this report.

IMPROVEMENT OF DIAGNOSTIC ACCURACY OF PATIENTS WITH CHEST PAIN BY THE GENERAL PRACTITIONER

Immediate recognition of MI in patients with chest pain is often difficult for the general practitioner, but relatively few data are available on the diagnostic accuracy of predicting acute cardiac pathology in general practice. In the Imminent Myocardial Infarction Rotterdam (IMIR) study, the significance of prodromal symptoms, identified by means of history-taking and physical examination, were studied prospectively in patients with a suspected MI.[7] The study population included all patients who visited their general practitioner with symptoms

suggestive of MI. The following variables were associated independently with higher risk of MI: recent (within 48 hours) onset or worsening of chest discomfort, duration of symptoms of at least 30 minutes, the presence of more than 3 premature ventricular complexes per minute at physical examination, and the value of the systolic minus the diastolic blood pressure, and a systolic blood pressure lower than 110 mm Hg. Stabbing pain was negatively associated with the diagnosis of MI. With use of these variables, a model was developed to quantify the risk of MI in general practice without laboratory assistance. The aim of the IMIR study was to provide guidelines for proper management of patients with symptoms suggestive of MI in general practice, rather than to make the diagnosis. This study was the first to apply quantative methods in identifying patients with possible MI. Regretfully, the results of this study were never formally applied in general practice.

Another strategy to improve diagnostic accuracy in general practice is the use of a structured interview by the general practitioner and a computerized out-of-hospital electrocardiogram (ECG), evaluated in the Prehospital ECG Project.[11,12] The Prehospital ECG Project, which is described in detail,[12] was designed to improve the selection criteria for hospital admission of patients with suspected acute cardiac disease in general practice. The study consisted of two phases. In the first phase, a decision rule was developed to categorize patients into a group at high risk of acute cardiac pathology (MI, unstable angina pectoris) and into a low-risk group (stable angina pectoris, atypical chest pain). In the second phase, the decision rule was tested and validated prospectively.

During the first phase, all patients with symptoms of possible cardiac origin who were observed by a general practitioner and for whom an ambulance was called with the intention to transfer the patient for specialized cardiologic evaluation were eligible. For each patient, the general practitioner completed a standardized questionnaire, that included the history and findings at physical examination. After arrival of the ambulance at the home of the patient, the ambulance nurse recorded a 12-lead ECG. In the first phase of the project, all patients were subsequently transported to the hospital. Final

discharge diagnoses were obtained from the hospital medical records or the general practitioner. Based on the principal symptoms from history, ECG, and final hospital discharge diagnosis, a decision rule was developed to identify patients in need of immediate hospitalization and those in whom nonadmission could be considered. As from 1993, the decision rule has been implemented in Rotterdam. In this second test phase of the Prehospital ECG Project, the general practitioner assessed the probability of acute cardiac pathology with use of the decision rule. In patients at low risk for acute cardiac pathology, the general practitioner was asked to reconsider the need for immediate hospital admission. In all patients who were not hospitalized, a follow-up visit was obtained the following day. An additional ECG was recorded and serum cardiac enzymes were determined to ascertain whether the decision had been indeed correct. The decision rule advised hospitalization in all patients with a moderate or high probability of acute cardiac pathology. A total of 1,020 patients were studied. In 234 patients (23%), the decision rule recommended no hospitalization. The general practitioner followed this advice in 44% (n = 121) of these patients. Among these, 7 patients were diagnosed as having sustained a non–Q-wave MI, but no complications occurred in these patients. The results from this study show that the decision rule can safely reduce the admission rate of patients at low risk of acute cardiac pathology without increasing the risk of complications for these patients.[11,12]

IMPROVEMENT OF THE DIAGNOSTIC ACCURACY OF ACUTE MI IN THE HOSPITAL EMERGENCY DEPARTMENT

To achieve more appropriate triage, several algorithms have been developed to distinguish patients with evolving MI and unstable angina pectoris from those with less acute or noncardiac pathology observed at hospital emergency rooms (ERs).

Pozen and coworkers developed a predictive instrument, based on 925 consecutive patients seen in the Boston City Hospital (Boston, MA) ER for suspected acute ischemic heart disease.[16] Clinical data and ECG variables possibly related to acute cardiac pathology were col-

lected. In 1980, the predictive instrument was slightly modified, based on data of another 2,320 patients observed in six hospitals.[17] The final predictive model included four clinical variables and three ECG variables (Table 1). This model generated probabilities of acute cardiac pathology. Implementation of the predictive instrument in the physician's decision-making process did not change the number of CCU admissions of patients with acute cardiac pathology or the number of patients inappropriately sent home from the emergency department. However, the number of CCU admissions of patients without acute cardiac pathology was reduced by 30% (Table 2).[17]

Goldman et al[14] developed a computer-derived decision protocol, based on 482 patients

Table 1. Predictive Parameters of Acute Cardiac Pathology in Previous Studies

Variables	Pozen et al[17]	Goldman et al[15]	Tierney et al[18]	van der Does and Lubsen[7]
Age	NR	X	—	X
Male gender	NR	NR	—	X
Presence of				
Chest pain as main symptom	X	NR	X	X
Localization of pain	X	NR	—	X
Radiation of chest pain*	NR	X	—	—
Duration of symptoms	NR	X	—	X
Positive reaction on nitrates	X	NR	—	—
No stabbing pain	NR	X	—	X
No radiation to back, abdomen	NR	X	—	—
Time of onset	NR	X	—	X
No pain at palpation	NR	X	—	—
Previous history†	X	X	X	—
Clammy skin	NR	NR	NR	X
Tachycardia	NR	NR	NR	X
>3 PVC/min	NR	NR	NR	X
Hypotension	NR	NR	NR	X
ECG abnormalities				
ST elevation and Q waves	NR	X	—	
STT segment changes	NR	X	—	
ST depression	X	NR	—	
ST elevation	X	NR	X	
Abnormal T waves	X	NR	—	
Q waves	NR	NR	X	

Abbreviations: X, significant predictor; —, no significant predictor; NR, not reported; PVC, premature ventricular complexes.

*Radiation of pain to left arm, left shoulder, or neck.

†Previous included MI, angina pectoris, percutaneous transluminal coronary angioplasty, or coronary artery bypass graft surgery.

Table 2. Diagnostic Accuracy of the Physicians Working in the ER Compared With the Accuracy of the Predictive Models in Identifying Acute Cardiac Pathology in Patients With Chest Pain: Results of 6 Studies

Reference	Patients with MI Misallocated to General Wards or Sent Home		Patients without MI Misallocated to CCU	
	Physicians	Computer Protocol	Physicians	Computer Protocol
Pozen et al 1980[16]	10	14	20	8
Pozen et al 1984[17]	7	6	24	17
Goldman et al 1982[14]	9	9	33	30
Goldman et al 1988[15]	12	12	30	26
Tierney et al 1985[18]	13	20	22	14
Aase et al 1993[20]	17	7	51	37

with chest pain observed in the Yale-New Haven Hospital (New Haven, CT) ER. In 1980, new patients were added to the original cohort, and a new computer protocol was designed and validated.[15] Ten distinctive clinical variables from the history and ECG appeared to be independent predictors of MI. Again, the number of patients with MI correctly admitted to the CCU was not altered after implementation of the predictive model in comparison with the admission rate after the physician's judgement (87.8% v 88.0%). The number of patients without MI admitted to the CCU slightly decreased from 30% to 26% ($P < .01$).

In 1982 and 1983, Tierney and colleagues[18] evaluated clinical and ECG data of 540 adults treated in an urban hospital ER for acute chest pain to derive a decision rule to aid in the diagnosis of MI. With the use of the decision rule, the number of patients incorrectly admitted to general wards or sent home increased from 13% to 20%, whereas the number of patients without MI admitted to the CCU decreased from 22% to 14%.

Aase and coworkers[20] developed a decision support system based on a large number of variables collected from the patients' history in the ER. During 1982 to 1983, clinical information was gathered from 918 consecutive patients referred with acute chest pain to the Central Hospital of Akershus (Akershus, Norway). The decision support system correctly classified 92% of patients with acute cardiac pathology (MI, unstable angina pectoris) and 84% of patients without acute cardiac pathology. After implementation of the decision rule, the number of patients correctly admitted to the CCU in-

creased from 78% to 88%, whereas the number of patients misallocated to the CCU decreased from 51% to 37%.

Another strategy emphasized the value of Thallium-201 myocardial perfusion scintigraphy in the ER of the hospital to select patients for appropriate CCU admission.[21,22] In the study of Wackers et al,[21] 1,861 patients were referred to the CCU.[21] In 203 (17%) patients with an atypical history and a nondiagnostic ECG, Thallium scintigraphy was performed as soon as possible after admission. Thallium results were available within 1.5 to 2 hours after arrival. In retrospect, the results of Thallium scintigraphy showed that 29% of the patients were unnecessarily admitted to the hospital, whereas the percentage of patients inappropriately sent home was 25%. Thus, Thallium scintigraphy may improve the efficiency of CCU management. This approach has not been implemented in clinical practice because of organizational restrictions and the high costs of scintigraphy.

Finally, the impact of the use of serum cardiac enzymes in the ER on the decision of whether or not to admit a patient was studied.[23,24] However, in patients who presented within 4 hours after symptom onset, the sensitivity of an elevated total creatine kinase (CK) was only 38% at a specificity level of 80%, whereas the sensitivity of CK-MB was 34% with a specificity of 88%. The sensitivities of total CK and CK-MB increased in patients who arrived after 4 hours. Thus, the knowledge of the serum cardiac enzyme levels may be more useful after an observation period of several hours.

SHORT-STAY CORONARY OBSERVATION UNIT

Alternatives to CCUs have been developed for patients at low risk of acute cardiac pathology to reduce costs and to increase the efficiency of hospital admission. Gazpoz and co-workers[25] established a new short-stay coronary observation unit, consisting of two beds with telemetry monitoring adjacent to the ER. The nurse:patient ratio was 1:5, which is similar to the nursing intensity of general medical departments. All patients at low risk of MI according to the algorithm of Goldman et al[15] and with a normal initial ECG were eligible for admission to the coronary observation unit. Patients were subsequently transferred to the cardiology de-

partment if they developed an MI or other serious complications. Of 512 consecutive admissions to the coronary observation unit, MI was diagnosed in 15 patients (3%) and unstable angina pectoris in 28%, whereas 315 (61%) had a noncardiac diagnosis. Only 0.4% developed complications. A total of 425 (83%) patients were discharged directly from the coronary observation unit. Of this group, 1 patient, who left against medical advice, developed an acute MI. Among the others, 24% had unstable angina and 68% had noncardiac pathology. Six months after discharge, the survival rate was 99%. It was concluded that such a coronary observation unit is a safe and adequate setting to rule out acute cardiac pathology.

Short-stay units have also been acquired at the Academic Medical Centre and the Academic Hospital of the Free University in Amsterdam (The Netherlands).[26,27] These facilities were designed to offer rapid access for specialized cardiologic evaluation of patients with symptoms that may be caused by MI. The patients were referred by the general practitioner, by the ER physician, or arrived on their own initiative. After an observation period of a few hours, a decision was made about the admission policy. Both studies evaluated the prognosis of patients with a diagnosis of atypical chest pain who were sent home. After 6 weeks of follow-up, Koster et al[26] reported a survival percentage of 99.4% in 460 patients. Similarly, Kooter et al[27] reported a survival percentage of 99.5% after 1 year of follow-up in 404 patients.

In the University Hospital of Rotterdam (Rotterdam, The Netherlands), a precoronary care unit (pre-CCU) was established in 1976 as part of the intermediate care area, consisting of four beds with ECG telemetry.[28] In the ER, a decision was made for admission to the CCU, the pre-CCU, or otherwise based on the findings from history, physical examination, and the ECG. During 6 consecutive months, 174 patients were admitted to the pre-CCU. Acute MI was diagnosed in 10% of these patients and unstable angina pectoris in 24%, whereas 53% had other or no acute pathology. The use of the precoronary care significantly reduced the number of CCU admissions of patients who did not have acute cardiac pathology from 22% to 8%, whereas the number of patients with acute

cardiac pathology correctly admitted to the CCU increased from 32% to 45%.[28]

IDENTIFICATION OF LOW-RISK PATIENTS FOR EARLY TRANSFER FROM THE CCU

Rapid identification of patients with chest pain who are at low risk for acute cardiac pathology and its complications could lead to a shorter observation period in the CCU and earlier transfer to beds outside the CCU. Additional diagnostic information that becomes available after hospital admission can be used to provide early prognostic stratification of such patients. Several studies assessed the feasibility of identifying patients at low risk shortly after admission to the CCU.

Lee et al[29] developed a strategy to identify patients at low probability of infarction within 12 hours after admission. Patients whose clinical characteristics in the ER predicted a low probability of MI had only a 0.5% risk of infarction if they had neither abnormal levels of cardiac enzymes nor recurrent ischemic chest pain during the first 12 hours of hospitalization.[29] The patients at high probability of MI were referred to the CCU within these 12 hours. This study showed that, within a 12-hour period after admission, a large group of patients at low risk can be identified on the basis of their ER clinical data.

Mulley et al[30] studied 360 patients admitted after presentation with uncomplicated chest pain. They were categorized into three risk groups on the basis of clinical data collected during the first 24 hours of admission. The low-risk group encompassed all patients without major complications, with normal serum cardiac enzymes, and with a normal ECG. Only 3% of the patients in the low-risk group subsequently developed MI, and 2% had late complications. Identification of low-risk patients was feasible and safe and could reduce the total number of days spent in the CCU by 55%.

Slater et al[31] studied 775 consecutive patients with symptoms suggestive of acute MI who were admitted to the CCU after initial screening at the ER. In total, 180 patients had no or minimal, nonspecific abnormalities on the entry ECG. MI evolved in 17 (9%) of these patients, and 5 (3%) patients developed a major complication. They concluded that the initial ECG can

effectively separate patients into a high- and a low-risk group for acute cardiac pathology or its complications. Admission to a CCU may not be necessary in the latter group. This was confirmed in the study by Yusuf and coworkers.[34]

DISCUSSION

Patients at low probability of acute cardiac pathology constitute a considerable proportion in many CCUs, to such an extent that physicians should consider more effective alternatives than CCU admission "to rule out myocardial infarction." Different approaches to identify patients at low probability of cardiac pathology were described in this report.

The first strategy aimed to improve the diagnostic accuracy of the general practitioner.[7,11,12] In the IMIR study, 11 independent variables predicted the probability of MI in patients with chest pain. Unfortunately, implementation of this predictive model in general practice was never realized. Still, additional results of this study showed that the ECG contributes considerably to the improvement of the diagnostic accuracy in general practice. Subsequently, this could be applied in the Prehospital ECG Project, in which a structured interview combined with a computerized ECG was used in general practice to identify patients with a low probability of acute cardiac pathology.[11] Application of this predictive model resulted in a reduction of inappropriate hospitalization of low-risk patients.

The second strategy encompassed the identification in the ER of the hospital of patients with a low probability of acute cardiac pathology by using predictive models. Again, application of the algorithms resulted in a more accurate triage to CCUs.[14-24]

Alternatives to CCUs have been developed for patients at low risk of acute cardiac pathology.[25-28] These studies confirmed that an observation period before admission to the CCU is a safe approach and will lead to a reduction in unnecessary CCU admission. The success of such pre-CCUs partly depended on their situation in the hospital. When the pre-CCUs functioned independently, early discharge of low-risk patients was facilitated.

The final approach of rapid identification of patients at low probability of acute cardiac

pathology and its complications after a short observation period in the CCU indicated that data collected at admission, particularly serial ECGs and serum enzymes, can be used to identify a subgroup of patients with a low risk of acute cardiac pathology.[29-37] However, a fundamental and practical problem of early transfer of low-risk patients to beds outside the CCU is, in our experience, shortage of beds on the general wards. Rapid transfer to the more economical facilities on the general wards is only possible when enough beds are available.

Each approach helps to identify patients at low probability of acute cardiac pathology to achieve more appropriate triage to the CCUs. The results of the different approaches apply to the same group of patients with symptoms suggestive of MI in whom a definite diagnosis

can not be established in the first instance. The choice of the most efficient approach will depend on local circumstances.

In Dutch practice, many patients primarily contact their general practitioner before they are referred to the hospital; therefore, the general practitioner is the most important intermediate to select patients with symptoms suggestive of acute cardiac pathology. The Prehospital ECG Project investigated the ability to select patients for hospital admission or to stay at their own home and confirmed the necessity of a computerized ECG for optimum diagnostic accuracy. This appears to be the most effective triage strategy in Rotterdam at this moment. However, in combination with a triage decision model applied in the ER of the hospitals, it may even lead to a more optimal use of CCUs.

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