Clinical research

Low-risk patients with chest pain and without evidence of myocardial infarction may be safely discharged from emergency department

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Aims This study is an audit of the risk stratification of patients admitted to a university hospital emergency department with a suspected acute coronary syndrome (ACS). The main aim of the study was to investigate the prognosis of those patients who were discharged to home from the emergency room (ER) or adjacent chest pain observation unit (CPU).

Methods and results Three thousand one hundred and seven consecutive patients admitted to the ER with a suspected ACS were retrospectively identified. Seven hundred and sixty-four (25%) patients were discharged from the ER and 417 (13%) from the CPU after observation and ruling out myocardial infarction (MI) and high-risk ACS. One thousand seven hundred and two patients were hospitalized. Follow-up endpoints were cardiovascular mortality, hospitalization for ACS and incidence of any cardiovascular disease event during 6 months. During 4 weeks after the discharge from the ER and CPU cardiovascular mortality was 0.1% and 0.5% and during 6 months 0.8% and 1.7%, respectively. Within 6 months 4.2% and 8.4% of the patients were hospitalized for ACS and 9.3% and 11.5% had a cardiovascular disease event.

Conclusions Patients admitted with chest pain may be safely discharged from the emergency department, if there is no evidence of MI or high-risk ACS. However, further examination and appropriate treatment must be arranged.

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KEYWORDS
Acute coronary syndrome; Myocardial infarction; Prognosis; Emergency room; Chest pain observation unit

Introduction

Triage of patients presenting to the emergency department with acute chest pain is a demanding management task, because missed diagnosis of myocardial infarction (MI) or unstable angina may have severe consequences. Audits of admission practices of patients with acute coronary syndrome (ACS) based on a retrospective review of clinical data have shown that in about 2% of the patients with MI and in about 2% of the patients with unstable angina, the diagnosis had been missed and the patient discharged.1,2 Introduction of sensitive and specific biochemical markers of myocardial injury, creatine kinase isoenzyme MB mass (CK-MBm) and troponins, has substantially improved the diagnosis of ACSs. The diagnostic problems, however, still remain, as demonstrated by a recent study auditing the incidence of missed diagnosis of MI in patients admitted with acute chest pain but discharged from emergency department.3 The patients were asked to re-attend within 12–48 h after the first presentation and examined by electrocardiography and troponin T (TnT) measurements. In 6% of them a myocardial damage of potential prognostic importance was detected.
The present study is an audit of the risk stratification of patients with a suspected ACS admitted to the emergency department of the Kuopio University Hospital. The main aim of our study was to investigate the prognosis of patients in whom MI or a high-risk ACS was considered to be ruled out and who were discharged to home from the emergency room (ER) itself or adjacent chest pain observation unit (CPU). We used cardiovascular mortality, hospitalization for ACS and the occurrence of any subsequent cardiovascular disease (CVD) event during 6 months of follow-up as study end-points.

Methods

Triage of patients at emergency department

The physician on duty at the emergency department of the Kuopio University Hospital evaluates patients presenting with acute chest pain on the basis of clinical history, clinical examination, and the electrocardiogram (ECG) which is recorded as soon as possible after the arrival in the ER. ECG examination is repeated at intervals considered appropriate on the basis of the evolution of symptoms. A blood sample is drawn for CK-MBm and TnT determinations soon after arrival in the ER and another sample within 6–12 h, if the patient has not been meanwhile admitted to the hospital wards. The cut-off limit of ≤5.0 µg/l was used for CK-MBm and ≤0.10 µg/l for TnT in ruling out MI.

Patients whose symptoms continue, those showing progressive ECG changes and those who are considered to have adverse prognosis for other reasons are admitted to the hospital. High-risk patients are preferably admitted to the coronary care unit (CCU). If chest pain is considered to be non-cardiac and benign, the patient is discharged from the ER. The physician can also discharge patients with chest pain symptoms of cardiac origin, if they are regarded to be at low risk, which means that the symptoms are relieved, there are no progressive ECG changes, and CK-MBm and TnT are within normal limits. Patients requiring closer or overnight observation can be admitted to the adjacent CPU. The CPU of the Kuopio University Hospital has facilities for intravenous nitroglycerin infusion and continuous positive airway pressure (CPAP) therapy. The facilities for continuous monitoring of arrhythmias and ST-segment changes are, however, more limited than in the CCU. The patient may be discharged from the CPU after the observation of up to 24 h if the symptoms are relieved, there are no new Q waves or other progressive changes in the ECG, and the biochemical markers of myocardial injury are repeatedly within normal limits. If considered necessary for the immediate care or risk assessment of the patient, an exercise test can be performed before the discharge from the CPU. However, the exercise test was performed in only a small minority of patients before the discharge and in the majority it was postponed to a later phase.

Patients

During the 3-year period from 1 January 1997 until 31 December 1999, 3107 consecutive patients with a suspected ACS, aged ≥30 years, were admitted to the emergency department of the Kuopio University Hospital. There were 1656 (53%) men and 1451 women, aged 30–99 years (median age 67 years). The patients were retrospectively identified from the emergency department register and the hospital discharge register on the basis of clinical diagnoses. The 10th version of the International Classification of Diseases (ICD) was used in Finland during the study period. The patients with ICD-10 codes I20 (angina pectoris), I21-22 (first or recurrent MI), I23 (acute complications of MI), I24 (other acute ischaemic heart diseases), I25 (chronic ischaemic heart disease), R07.2 (precordial pain), R07.3 (other chest pain, including musculoskeletal pain), or R07.4 (unspecified chest pain) were included. The first admission of each patient during the 3-year period was regarded as the index admission, and the subsequent admissions were regarded as follow-up events.

Collection of follow-up data

Data on hospitalizations due to ACS and admissions to the ER due to chest pain within 6 months from the index admission were collected. The dates and diagnoses of these re-admissions in the Kuopio University Hospital were obtained from the local outpatient clinic register and the hospital discharge register. The dates and diagnoses of hospitalizations in other hospitals in Finland were obtained from the database of the national Hospital Discharge Register (National Research and Development Centre for Welfare and Health, STAKES). The dates and causes of death were obtained from the database of the national Causes-of-Death Register (Statistics Finland). Cardiovascular deaths were defined as ICD-10 codes I10–I25, I44–I50, and I60–I73. However, the following ICD-10 codes for non-atherosclerotic causes for death were excluded: I45.6, I63.6, I67.1, I67.5, and I68. Additionally, R96 (sudden death of unknown cause) and R98 (unattended death) were classified as cardiovascular deaths. Complete 6-month follow-up data were available for all patients. The study was approved by the Ethics Committee of Kuopio University Hospital.

Statistical analysis

The study is based on register data from index admissions and databases comprising the follow-up data linked with each other by using the social security number of each patient. The linkage and the analyses of the data were performed with SPSS for Windows Release 11.5 software (SPSS Inc., Chicago, IL, USA). Continuous variables were compared by the Student’s t test and categorical variables by the χ² test. Kaplan–Meier survival analyses were used to get estimates for the incidence of study end-points at different periods of follow-up. The 95% confidence intervals for the Kaplan–Meier estimates were calculated using Egret for Windows, Version 2.0.3 (Cytel Software Corporation, Cambridge, MA, USA). Cox proportional hazards models adjusting for age and gender were used in the comparison of the risks in different patient groups. Assumption of proportional hazards was checked by visual comparison of log minus log function curves for categories. Statistical significance was based on the 0.05 level.

Results

The flow chart of the 3107 patients admitted to the ER with a suspected ACS is presented in Fig. 1. Twelve deaths occurred in either the ER or CPU soon after admission; the cause of death was MI in 11 cases and CHD without confirmed MI in one case. Altogether 1181 patients were discharged to home from either the ER (764 patients) or CPU (417 patients) within 24 h from the admission. Among these 1181 patients the discharge
diagnosis was ACS without MI in 297 patients (25.1%), unspecific chest pain in 853 patients (72.2%) and other disease in 31 patients (2.6%). The number of patients admitted to the University Hospital wards (to the CCU, intensive care unit (ICU) or directly to wards) was 1702. Of these patients 89 (5.2%) died during the hospitalization; 75 from MI, 10 from CHD without confirmed MI, one from non-CHD cardiovascular disease, and three from non-cardiovascular disease. Among the 1702 patients admitted to the wards (including those who died, were discharged to home or transferred to other hospitals, health centres or institutions) the final diagnosis was MI in 834 patients (49.0%), ACS without MI in 526 patients (30.9%), unspecific chest pain in 162 patients (9.4%) and non-cardiovascular disease. Among the 1702 patients admitted to the wards the final diagnosis of ACS without MI (mean age 64.6 vs. 57.5 years; \( P < 0.001 \)) was also older than those discharged from the ER or CPU (mean age 68.2 years) in hospitalization. The patients discharged from the CPU were older than those discharged from the ER (mean age 64.6 vs. 57.5 years; \( P < 0.001 \)). The proportion of men among the patients discharged from the ER was 52.2%, among those discharged from the CPU 47.7% (NS) and among those admitted to the wards with the diagnosis of ACS without MI 50.8% (NS, as compared with those discharged from the ER or CPU). Among patients discharged from the ER the discharge diagnosis was ACS without MI in 13.1%, unspecific chest pain in 86.9% and other disease in 0% and among those discharged from the CPU 47.3%, 45.3% and 7.4%, respectively (\( P = 0.001 \)).

Table 1 shows the number of deaths from different causes within the 4 week and 6 month follow-up among patients discharged from the emergency room (ER) and from the chest pain observation unit (CPU) and among those hospitalized for ACS without MI.

<table>
<thead>
<tr>
<th></th>
<th>4 weeks</th>
<th>6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharged from ER (n=764)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>CHD without MI</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Non-CHD cardiovascular death</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non cardiovascular death</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Discharged from CPU (n=417)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>CHD without MI</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Non-CHD cardiovascular death</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Non cardiovascular death</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Hospitalized for ACS without MI (n=526)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>CHD without MI</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Non-CHD cardiovascular death</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Non cardiovascular death</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

\( ^a \) Including in-hospital deaths.

Both from CHD) among those discharged from the CPU, and 11 deaths (2.1%; all CHD deaths) among those hospitalized for ACS without MI. Within 6 months the number of deaths in these patient groups was 15 (2.0%; six CHD deaths and nine non-cardiovascular deaths), 13 (3.1%; five CHD deaths, two non-CHD cardiovascular deaths and six non-cardiovascular deaths), and 26 (4.9%; 19 CHD deaths, one non-CHD cardiovascular death and six non-cardiovascular deaths), respectively.

Crude Kaplan–Meier 4 week and 6 month estimates for cardiovascular mortality, hospitalizations for ACS and incidence of any CVD event in patients discharged from the ER, in patients discharged from the CPU and in patients hospitalized for ACS without MI are shown in Table 2. The risks of these end-point events in the patient...
groups were compared by age- and gender-adjusted Cox model analyses. The 4-week cardiovascular mortality was low in patients discharged from the ER and in those discharged from the CPU (0.13% and 0.79%, respectively) and in the combined group of patients discharged from the ER or CPU the risk was less than one-fifth of that in patients hospitalized for ACS without MI. Over the 6 month follow-up the risk of cardiovascular mortality in patients discharged from the ER or CPU still remained markedly lower than in patients hospitalized for ACS without MI. During the 4 week follow-up the risk of hospitalization for ACS and the risk of any CVD event in patients discharged from the ER was only one-third of that in patients discharged from the CPU, but during the 6 month follow-up these differences between the two groups diminished. When the Cox models were also adjusted for the discharge diagnosis (ACS without MI versus unspecific chest pain or other disease) the differences in the risk of patients discharged from the ER and CPU became non-significant (data not shown). Both during the 4 week and 6 month follow-up the risk of hospitalization for ACS in patients discharged from the ER or CPU was only one-third and the risk of any CVD event less than one-half of that observed in patients hospitalized for ACS without MI.

Table 3 shows crude Kaplan–Meier estimates for the 4 week and 6 month cardiovascular mortality, incidence of hospitalization for ACS and incidence of any CVD event by discharge diagnosis in patients discharged from the ER or CPU and compares the risks of these end-point events in patients discharged with the diagnosis of unspecific chest pain and those discharged with the diagnosis of ACS without MI. The number of end-point events occurring in the small group of patients with the diagnosis of other disease was too low to allow any comparisons with other patient groups. During the 4 week follow-up none of the patients with the diagnosis of unspecific chest pain died and there were three cardiovascular deaths among the patients with the diagnosis of ACS without MI. The number of end-point events occurring in the small group of patients with the diagnosis of other disease was too low to allow any comparisons with other patient groups. During the 4 week follow-up none of the patients with the diagnosis of unspecific chest pain died and there were three cardiovascular deaths among the patients with the diagnosis of ACS without MI. During the 6 month follow-up the risk of cardiovascular mortality in patients with the diagnosis of unspecific chest pain was only one-fourth of that in patients with the diagnosis of ACS without MI. During the 4 week follow-up the risk of other end-points, hospitalization for ACS and development of any CVD event, in patients with the diagnosis of unspecific chest pain was also only one-fourth of that in patients with the diagnosis of ACS without MI. During the 6 month follow-up these risks were still markedly lower in patients with the diagnosis of unspecific chest pain than in patients with the diagnosis of ACS without MI.

Discussion

Our study was based on a series of 3107 consecutive patients admitted with a suspected ACS to the emergency department of the Kuopio University Hospital during a 3-year period and concentrated on the prognosis of those 1181 patients (38%) who were discharged to home either from the ER (764 patients) or adjacent CPU
Low-risk patients with chest pain may be safely discharged

Two other studies of patients presenting with acute chest pain but discharged from the emergency department have used cardiovascular mortality and the occurrence of CHD events during a follow-up as end-point criteria in the assessment of the success in the risk stratification. In a Swedish study of 157 consecutive patients with a suspected ACS admitted to a university hospital emergency department, 83 patients (53%) were discharged from there to home. On the basis of history, physical examination and ECG these patients were considered to have only a vague or no suspicion of ACS. Among the early-discharged patients there were no hospitalizations for ACS or cardiac deaths within 6 months. In an Italian study conducted in a general hospital, one-third of 13762 chest pain patients admitted to the emergency department which included a multidisciplinary CPU were regarded as low-risk patients on the basis of either normal ECG and serum markers of myocardial injury <6 h after initial evaluation or a negative exercise test or myocardial scintigraphy. Among the low-risk patients, 60% were discharged within 6 h after initial evaluation and 20% at 6–24 h. All patients with a diagnosed CHD were, however, admitted to the hospital. Within 6 months, 0.1% of the patients discharged within 6 h had MI or unstable angina. None of the patients discharged at 6–24 h had cardiac events or died from a cardiovascular cause within 6 months. In both of these studies the cardiovascular mortality and incidence of non-fatal CVD events in patients discharged from the emergency department was even lower than in our patients discharged from the ER or CPU. The threshold for discharging patients from the emergency department appears, however, to have been higher in the Swedish and Italian hospitals in which these studies were conducted than in our hospital, because in those hospitals only patients in whom ACS was considered to have practically been excluded were discharged, whereas among our patients discharged from the ER or CPU one out of four was considered to have low-risk ACS.

Table 3: Kaplan–Meier estimates and their 95% confidence intervals (CI) for the incidence of cardiovascular end-points in patients discharged from the emergency room (ER) or chest pain observation unit (CPU) during the follow-up of 4 weeks and 6 months according to discharge diagnosis

<table>
<thead>
<tr>
<th>End-point</th>
<th>A: ACS without MI (n=297)</th>
<th>B: unspecific chest pain (n=853)</th>
<th>C: other diseasea (n=31)</th>
<th>HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalization for ACS (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 weeks</td>
<td>0.04 (0.02; 0.07) (3)</td>
<td>– (0)</td>
<td>– (0)</td>
<td>–</td>
</tr>
<tr>
<td>6 months</td>
<td>0.30 (0.21; 0.41) (10)</td>
<td>0.47 (0.18; 1.25) (4)</td>
<td>– (0)</td>
<td>0.27 (0.08; 0.94)</td>
</tr>
<tr>
<td>Any CVD event (%)b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 weeks</td>
<td>8.75 (6.05; 12.59) (26)</td>
<td>2.11 (1.33; 3.33) (18)</td>
<td>3.23 (0.46; 20.77) (1)</td>
<td>0.27 (0.14; 0.52)</td>
</tr>
<tr>
<td>6 months</td>
<td>17.54 (13.66; 22.37) (52)</td>
<td>7.66 (6.06; 9.66) (65)</td>
<td>6.45 (1.65; 23.41) (2)</td>
<td>0.53 (0.36; 0.79)</td>
</tr>
</tbody>
</table>

a Age- and gender-adjusted Cox model hazard ratios (HR) and their 95% CIs are given for the comparison of the risks between patient groups.
b Statistical comparison with other patient groups not possible due to small number of end-point events.
c Number of patients in parentheses.
d Cardiovascular death, hospitalization for ACS or visit to ER due to acute chest pain.

(417 patients). During the first 4 weeks cardiovascular mortality was 0.1% in patients discharged from the ER and 0.5% in patients discharged from the CPU and during the 6 month follow-up 0.8% and 1.7%, respectively. Within 6 months 4.2% of the patients discharged from the ER and 8.4% of the patients discharged from the CPU were hospitalized for ACS and a CVD event occurred in 9.3% and 11.5% of these patients, respectively. The 4 week and 6 month risks of all these end-points in patients discharged from the ER or CPU were markedly lower relative to those observed in patients who were hospitalized for ACS without MI.

Of the 1181 patients who were discharged to home either from the ER or CPU 297 (25%) got the diagnosis of a low-risk ACS. The finding that those patients whose discharge diagnosis was unspecific chest pain had much lower short-term incidence of cardiovascular events than those with the diagnosis of low-risk ACS (2.1% vs 8.8% within 4 weeks) indicates that the physicians on duty in the ER and CPU of our hospital performed reasonably well in the diagnostic classification of patients admitted with acute chest pain. On the other hand, this outcome indicates that adequate assessment of the severity of CHD and treatment has to be arranged without delay for those patients who are discharged with the diagnosis of known or possible CHD.

A CPU located within the emergency department has been recommended as a safe, effective and cost saving arrangement in the assessment of patients presenting with a suspected ACS.4 In our experience, a CPU offers increased flexibility in the early surveillance of such patients. In our study population one-third of all the patients presenting with a suspected ACS and discharged to home from the emergency department were discharged from the CPU. The patients discharged from the CPU had slightly poorer prognosis than those discharged from the ER and this was mainly explained by a larger proportion of patients with CHD diagnosis in the former patient group.
Studies from the United States based on a retrospective review of the clinical, ECG and other data of patients admitted with a suspicion of ACS to emergency departments showed that about 2% of the patients who actually had had either MI or unstable angina had been discharged from the emergency department.\(^1\)\(^2\) During the follow-up the mortality risk of those patients with MI or unstable angina who were discharged to home from the emergency department was found to be twice as high as the risk of hospitalized patients with these diagnoses.\(^1\) New biochemical markers of myocardial injury, particularly troponins, have improved the sensitivity and specificity of the diagnosis of MI, but depending on the timing of the blood sampling and factors related to the diagnostic interpretation as a whole, missed diagnoses of MI continue to occur, as shown by the British study based on re-examination of patients who presented with acute chest pain but were discharged from the emergency department.\(^3\) It is likely that also in our study population the diagnosis of MI or high-risk ACS without MI was missed in some patients who were discharged to home from the ER or CPU, but our study design did not allow the identification of such patients. It was, however, reassuring to note that the 4 week cardiovascular mortality was rather low (1.0%) among those patients who were discharged from the ER or CPU with the diagnosis of low-risk ACS, because missing the diagnosis of MI or high-risk ACS was most likely to have occurred in that group of patients.

The main limitation of our study was that it was based on a linkage of computerized hospital discharge diagnosis data with the follow-up mortality and morbidity data obtained from national cause-of-death and hospital discharge diagnosis registers and thus our database did not include any information on previous history of CHD, clinical findings, ECG findings and results of biochemical tests on admission and during the observation in the ER and CPU. Therefore we could not assess the clinical characteristics which would have explained the differences observed in the prognosis between patient groups. We cannot exclude the possibility of some human mistakes in the data recording, e.g., in assigning hospital discharge diagnosis codes. However, in general, the Finnish hospital discharge register data on CHD have been found to be rather reliable and valid for the purposes of epidemiological studies and health service research.\(^7\) The main strength of our study is the complete follow-up of our patient population.

**Conclusions**

We conclude on the basis of the findings of the present study that patients presenting with a suspected ACS may be safely discharged from the emergency department after the observation of up to 24 h from admission, if their symptoms are relieved and if there is no evidence of MI or high-risk ACS on the basis of history, clinical examination, ECG, and biochemical markers of myocardial injury. However, further examination and appropriate treatment must be arranged on outpatient basis for those patients with known or possible CHD.

**Acknowledgements**

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**References**