Optimization of secondary prevention and risk stratification in patients with coronary heart disease

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Chapter 8.

Efficacy of a novel pre-hospital triage protocol for the cardiac emergency department

Under review

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Abstract

Introduction
Overcrowding in emergency departments (ED) is a major public health problem. Pre-hospital triage can help to allocate patients to the appropriate ED and thereby increase the efficacy of acute care in hospitals. The current study aims to evaluate the efficacy of a novel pre-hospital triage protocol for the cardiac ED.

Methods
During 6 months, all consecutive patients admitted to the cardiac ED were included. Eligibility for admission at the cardiac ED was based upon a dedicated pre-hospital triage protocol. Efficacy of the pre-hospital triage protocol was defined as the percentage of patients with a primary cardiac complaint without needing other medical care. Secondly, both HEAR and HEART scores were evaluated for risk stratification in chest pain patients in the pre-hospital setting. Thirdly, a historical control group was added to investigate to what extent the cardiac ED helps to reduce the caseload of the general ED.

Results
Ninety-four percent of the pre-hospital triaged patients (63.3±13.2 years, 56% male) were patients with primary cardiac complaints without needing other medical care. In the subgroup of chest pain patients (n=590), both the HEAR (AUC 0.80) and HEART (AUC 0.85) score adequately identified patients with low and high risk for adverse cardiac events. The cardiac ED reduced the caseload of cardiac patients at the general ED by 34%.

Conclusion
This novel pre-hospital triage protocol is an effective tool to allocate patients to the cardiac ED and may substantially reduce the caseload of the general ED.

Introduction

Overcrowding in emergency departments is a major public health problem.(1) Contributors to overcrowding include a rising number of patients due to the ageing population and a higher severity of illness. Introduction of dedicated cardiac emergency departments may substantially reduce the caseload of the general emergency department. The strength of these cardiac emergency departments is to quickly rule out acute cardiac pathology.(2) However, the majority of cardiac symptoms, such as chest pain, dyspnoea and syncope, may also have a non-cardiac aetiology.(3-5) A thorough analysis of potential non-cardiac pathology at the cardiac emergency department is time consuming since it often requires consultation of other medical specialists and additional diagnostics. This may reduce the quality of care and increase the risk of decisional errors due to potential miscommunication during periods of large patient volumes.(1, 6, 7) Accordingly, it is crucial that patients with primary cardiac symptoms present at the cardiac emergency department. In contrast, patients with a suspicion of a non-cardiac diagnosis should be presented at the general emergency department. Potentially, a pre-hospital triage protocol may help to allocate patients to the appropriate emergency room and thereby increase the quality and efficacy of acute care in hospitals. To achieve this, a dedicated pre-hospital triage protocol for the cardiac emergency department was developed and implemented. The aim of the current study is to evaluate efficacy of this novel pre-hospital triage protocol for the cardiac emergency department.

Methods

Study design and patient population

The current study is a prospective cohort study with a historical control group.

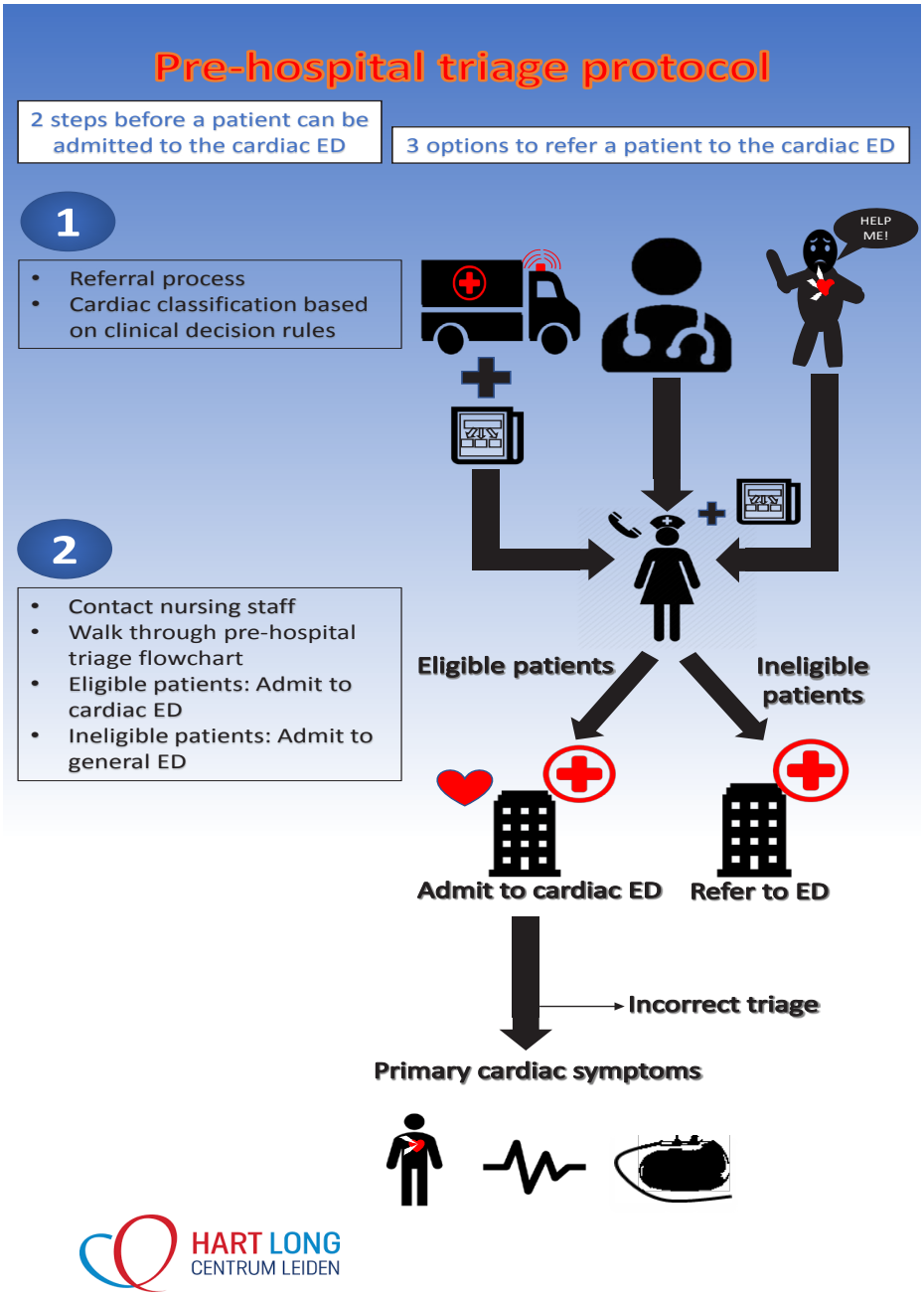

Figure 1. Overview of the pre-hospital admission protocol. Abbreviations: ED, emergency department.

The intervention group comprises all consecutive adult patients admitted to the cardiac emergency department from June 2017 until December 2017. Eligibility for admission at the cardiac emergency department was based upon the novel dedicated pre-hospital triage protocol (Figure 1). The historical control group consists of adult patients visiting the general emergency department with a suspicion of cardiac symptoms in the 2 months before the opening of the cardiac emergency department. This study was conducted according to the declaration of Helsinki and the institutional ethical committee approved the protocol.

Objective and outcome measures

The aim of the current study is to evaluate the efficacy of a novel pre-hospital triage protocol for the cardiac emergency department. The primary outcome is the percentage of patients presenting with a primary cardiac complaint without needing other medical care.

In addition, the following secondary end-points were evaluated:

- The value of the HEAR score as compared to the HEART score in the ability to predict MACE in chest pain patients admitted to the cardiac emergency department. The HEAR score was assessed upon arrival at the cardiac emergency department whereas the HEART score was evaluated after evaluation at the cardiac emergency department. MACE was defined as a composite endpoint of all-cause mortality, myocardial infarction (MI) or coronary revascularization (CABG and/or PCI) within 6 weeks after admission at the cardiac emergency department. (14)
- To what extent the pre-hospital triage protocol could relieve the crowds on the general emergency department.

Pre-hospital triage and patient's inclusion

The Heart Lung Centre of the Leiden University Medical Centre opened a cardiac emergency department in January 2017 and developed a novel dedicated pre-hospital triage protocol in close collaboration with the regional ambulance service "Hollands-Midden". This pre-hospital triage protocol aimed to allocate patients to the appropriate emergency department and consisted of 2 consecutive parts as illustrated in Figure 1.

The first part of the pre-hospital triage protocol concerned the *referral process*, in which patients could either be referred by ambulance or by another health care provider, such as a general practitioner or cardiologist. In addition, self-referral of (known) cardiac patients was possible. Eligibility for referral by ambulance or other health care providers was based on clinical decision rules, pre-defined standard operating procedures and the national protocol ambulance care (LPA)(8).

The second part of the pre-hospital triage protocol consisted of the *pre-hospital triage flowchart*, in which the referring health care provider and the nursing staff of the cardiac emergency department walked through the pre-hospital triage

flowchart step-by-step (Figure 2). In this triage flowchart, patients with a ST-elevation myocardial infarction (STEMI) were directly excluded for admission at the cardiac emergency department and were treated according to the previously described institutional MISSION! infarction protocol.(9) Thereafter, patient's eligibility was assessed by a set of pre-defined exclusion criteria (Figure 2, yellow box). The exclusion criteria were used to identify cardiac patients without major non-cardiac disease. In the absence of these exclusion criteria, patients were eligible for admission at the cardiac emergency department if they presented either with chest pain, palpitations or a cardiac device related problem. In case of self-referral, or when patients were referred by another healthcare provider, the nursing staff used the complete triage flowchart in the same chronological order as the paramedics to consider whether a patient was eligible for admission at the cardiac emergency department. Patients who were classified as eligible based upon clinical decision rules in combination with the novel triage flowchart were subsequently admitted at the cardiac emergency department. Patients who were classified as ineligible were referred to the general emergency department.

Patient admission at cardiac emergency department – Classification and Diagnosis

Patients admitted to the cardiac emergency department were classified into three groups based upon presenting symptoms: chest pain, palpitations or cardiac device related problems. Device related problems were defined as alerts originating from an implanted cardiac device, the suspicion of malfunctioning of a cardiac device as well as appropriate/inappropriate cardiac device therapy. Patients with other primary symptoms who were admitted to the cardiac emergency department were considered as incorrect triage. For each group, the final diagnosis was extracted and evaluated.

Historical control group

The historical control group comprised patients visiting the general emergency department with the suspicion of cardiac symptoms in November 2016 and December 2016 (that is the 2 months before opening of the cardiac emergency department). This historical group was used to evaluate to what extent the cardiac emergency department using the pre-hospital triage protocol could potentially relieve the crowds on the general emergency department. For this purpose, the pre-hospital triage protocol was retrospectively applied to all these patients to evaluate to which ED they would have been allocated.

Risk Stratification using the HEAR and HEART risk scores in chest pain patients

The HEAR and the HEART score were both used for risk stratification of cardiac chest pain patients admitted to the cardiac emergency department.

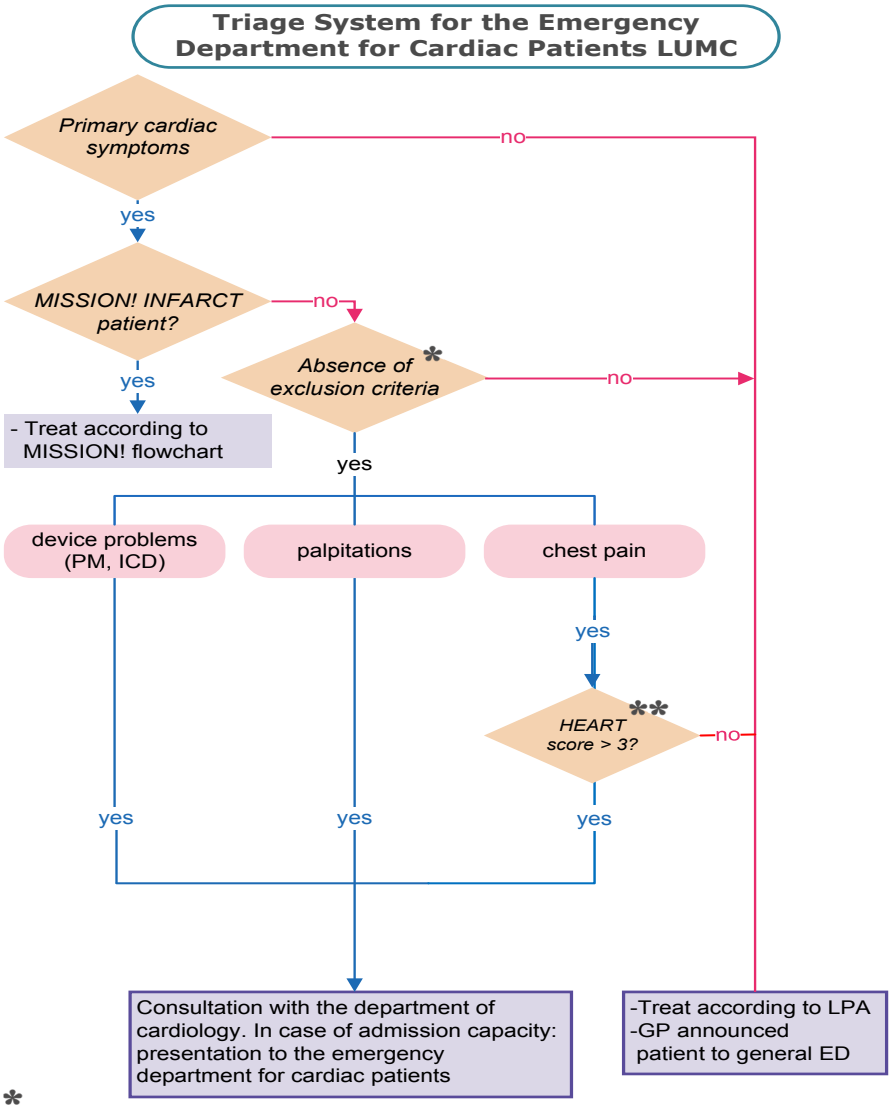

Figure 2. Triage system for the cardiac emergency department for cardiac patients Leiden University Medical Centre (LUMC).

Abbreviations: PM, pacemaker; ICD, internal cardioverter-defibrillator; NPA, national

protocol ambulance care; GP, general practitioner; ED, emergency department; LVAD, left ventricular assisting device; HEART, History, ECG, Age, Risk factors, Troponin.

Upon arrival, the HEAR score was calculated using 4 commonly available parameters: History, Electrocardiogram (ECG), Age and Risk factors. The HEAR score can potentially be used for risk stratification in the pre-hospital setting.(10) Based on the history, ECG, age and cardiovascular risk factors a score between 0 and 8 is calculated, which may predict the risk of a major adverse cardiac event (MACE) within 6 weeks after initial presentation.(10)

After evaluation at the cardiac emergency department, the HEART score was calculated in chest pain patients. The HEART score has shown to be an easy, quick and effective tool to predict outcome in chest pain patients.(11-13) The HEART score was calculated using 5 parameters: History, Electrocardiogram (ECG), Age, Risk factors and Troponin. The score (ranging between 0 and 10) was calculated and can be used to predict the risk of a MACE within 6 weeks after initial presentation. For risk stratification using the HEART score, patients with chest pain were categorised into 3 groups: low risk (score 0-3), intermediate risk (score 4-6) and high risk (score 7-10) (Figure 4).

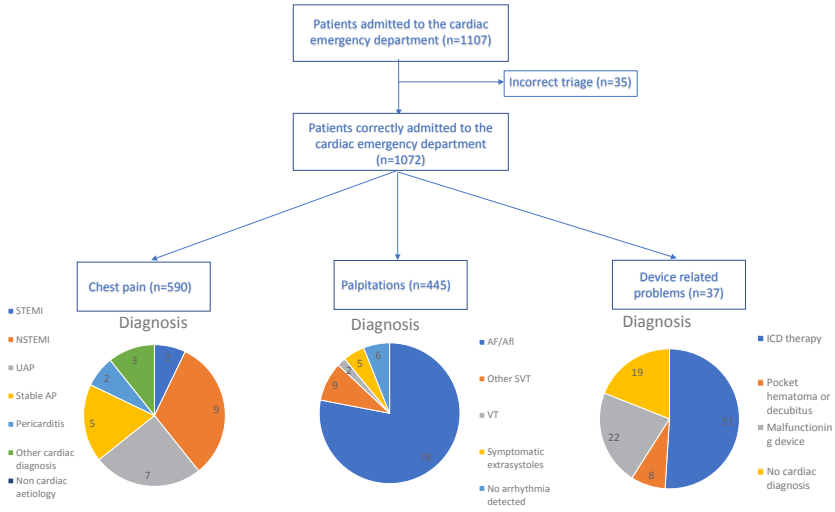

Figure 3. Flowchart with final diagnosis for each admission cause. The percentages represent the proportion of the patients with that diagnosis. Abbreviations: AP, angina pectoris; UAP, unstable angina pectoris; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; AF, atrial fibrillation; AFl, Atrial flutter; SVT, supraventricular tachycardia; VT, ventricular tachycardia; ICD, internal cardiac defibrillator.

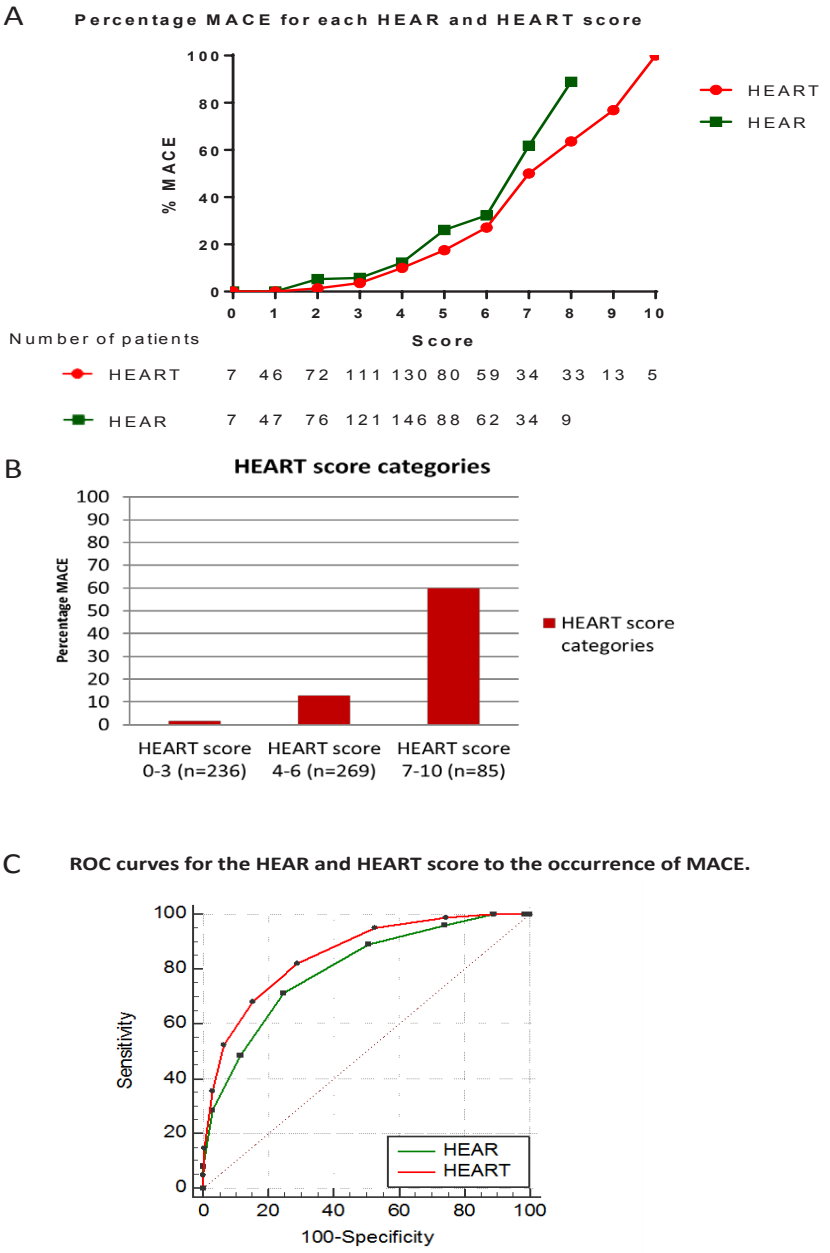

Figure 4ABC. A: Percentage MACE for each HEAR and HEART score in patients admitted with chest pain (n=590). B: Percentage MACE for each HEART score category in patients admitted with chest pain (n=590). HEART scores were dived into 3 categories. Low risk patients with a HEART score from 0-3 (n=237), intermediate risk patients with a HEART score from 4-6 (n=270) and high-risk patients with a HEART score from 7-10 (n=85). C:

ROC curves for the HEAR and HEART score to the occurrence of MACE. Abbreviations: HEART, History, ECG, Age, Risk factors, Troponin; HEAR, History, ECG, Age, Risk factors; MACE, major adverse cardiac event.

Data acquisition
All patient's clinical and follow up data were collected from the institutional electronic patients file system. Information on all-cause mortality was obtained from the Dutch Municipality Records registry.

Statistical analysis
Normally distributed continuous variables were presented as mean ± standard deviation. Non-normally distributed continuous variables were presented as median and 25-75% interquartile range (IQR) and categorical variables were presented as number and percentages.

To evaluate and compare the discriminative power of the HEAR versus the HEART score in their ability to predict MACE, receiver operating characteristics (ROC) curve analysis was performed to determine the area under the curve (AUC) (MedCalc v18.6 (MedCalc software, Belgium). An accuracy of 0.80-0.90 is considered to be good. All statistical analyses were performed with the SPSS software package (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.).

Results

Pre-hospital triage in the intervention group
During the study period, the pre-hospital triage process allocated 1107 patients to the cardiac emergency department. The majority of patients was referred by ambulance (n=532; 48%) or by another healthcare provider (n=451; 41%). The self-referral rate was relatively low (n=124; 11%). Re-triage upon arrival at the cardiac emergency department revealed that in 35 (3%) patients the pre-hospital triage flowchart was not correctly followed. Accordingly, the pre-hospital triage protocol was correctly followed in 1072 patients (97%). Correct triage was similar for patients transported by ambulance, referred by other healthcare providers and self-referred patients (P=0.126). Analysis of the efficacy end-point was evaluated in the 1072 correctly triaged patients.

Patients' characteristics
Table 1 displays the patient characteristics of the 1072 patients correctly triaged to the cardiac emergency department. Mean age was 63.3±13.2 years and 56% was male. The presenting symptom was chest pain in 590 patients (55%), palpitations in 445 patients (42%) and device-related problems in 37 patients (3%). As shown in Table 1, previously known coronary artery disease and risk

factors for atherosclerosis were highly prevalent in all subgroups.

Primary outcome: efficacy of pre-hospital triage

The pre-hospital triage protocol yielded a high efficacy of 94% for the selection of patients with a primary cardiac complaint without the need for other medical care. In 60 (6%) patients another medical specialist was asked for consultation. In 36 of the 60 patients (60%) the admission cause was chest pain and 23 patients (38%) presented with palpitations. The final diagnosis was atrial fibrillation in 21 patients (33%) and chest pain from non-cardiac aetiology in 23 (38%) patients. Of these patients 5 of them (8%) was admitted to a non-cardiac ward.

Of the total population 608 patients (57%) had a final cardiac diagnosis and 464 patients had a non-cardiac final diagnosis (43%). The most common non-cardiac diagnosis was idiopathic thoracic pain (n=422; 91%) and no arrhythmia detected (n=29; 6%). Figure 3 shows the final diagnosis after evaluation at the cardiac emergency department for each presenting symptom. Of the 590 chest pain patients, 10 patients had a STEMI (2%), 52 patients had a NSTEMI (9%), 40 patients had unstable angina (7%), 29 patients had stable angina (5%) and 13 patients had pericarditis (2%). In total, 18 patients had another cardiac diagnosis (3%) whereas the remaining 428 patients had chest pain without observed cardiac abnormalities (72%). Of the 445 patients evaluated for palpitations, 349 patients had atrial fibrillation or atrial flutter (78%), 39 patients had another type of supraventricular tachycardia (9%), 8 patients a ventricular tachycardia (2%) and 20 patients had symptomatic (supra)ventricular extra systoles (5%). In 29 patients, no arrhythmia could be detected despite the complaints of palpitations (6%). Of the 37 patients evaluated because of a device-related problem, 19 patients experienced an ICD shock (51%), 3 patients had a pocket hematoma or decubitus (8%) and 8 patients had a malfunctioning pacemaker or ICD (22%). In total, 7 patients with potential device related problem had a non-cardiac diagnosis (19%).

After evaluation at the cardiac emergency department most patients were discharged home (N=920; 86%). A total of 34 patients were admitted to the cardiac care unit (3%), 110 to the cardiology ward (10%) and 8 were admitted to a non-cardiac ward (1%).

Added value of HEAR and HEART score for triage of cardiac patients

In the subgroup of 590 patients presenting with chest pain, the HEAR score was calculated upon arrival and the HEART score was calculated after evaluation. Figure 4 depicts the 6-week MACE rate for both the HEAR and HAERT score. The median HEAR score was 4 (IQR 3-5). For both scores, there was a clear relation between a higher score and a higher MACE rate. Similar event rates were observed for the HEAR and the HEART score. As shown in Figure 4B, the 6-week MACE rate for low (score 0-3; n=236), moderate (score 4-6; n=) and high (score 7-10) HEART score patients was 2.1%, 16.0% and 62.4% respectively.

Figure 4C shows the comparison of ROC curves which revealed an AUC of 0.80 for the HEAR score and 0.85 for the HEART score for the occurrence of MACE (P<0.001).

Historical control group

The historical control group consisted of 100 patients (68.0±13.8 years; 65 (65%) male) admitted to the general emergency department (Table 2). The presenting symptom was chest pain in 33 patients (33%), palpitations in 7 patients (7%) and device-related problems in 1 patient (1%). Other common presenting symptoms were collapse (21 patients; 21%), dyspnoea (12 patients; 12%) and out-hospital-cardiac-arrest (9 patients; 9%).

Once the pre-hospital triage protocol was applied to the historical control group, 34 patients (34%) would have been eligible for the cardiac emergency department. Of these 34 patients, 32 patients showed only primary cardiac complaints without the need for other medical care.

In 2 of the 34 patients (6%) another medical specialist was asked for consultation which is in line with the results of the cardiac emergency department. Among the patients that were ineligible for the cardiac emergency department, in 30% of the patients (20 of 66 of the patients) another medical specialist was consulted. These date underline the value of a pre-hospital triage protocol for selection of cardiac patients.

Table 1. Baseline characteristics

	Total group (n=1072)	Chest pain (n=590)	Palpitations (n=445)	Device related (n=37)
Baseline characteristics				
Age (yrs.), mean ± SD	63.3 ±13.2	62.7 ± 13.6	64.1 ± 12.4	63.1 ± 16.0
Male n, (%)	603 (56)	295 (50)	279 (63)	29 (78)
Referred by				
Ambulance n, (%)	520 (48)	413 (70)	97 (22)	10 (27)
Other health care provider n, (%)	435 (41)	147 (25)	268 (60)	20 (54)
Self-referral n, (%)	117 (11)	30 (5)	80 (18)	7 (19)
Clinical characteristics				
Known CHD n, (%)	318 (30)	209 (35)	92 (21)	17 (46)
Diabetes mellitus n, (%)	142 (13)	92 (16)	41 (9)	9 (24)
Hypertension n, (%)	654 (61)	367 (62)	258 (58)	29 (78)
Hypercholesterolemia n, (%)	508 (47)	312 (53)	175 (39)	21 (57)
Current smoking n, (%)	172 (16)	127 (22)	42 (9)	3 (8)
Positive family history n, (%)	318 (30)	217 (37)	98 (22)	3 (8)

Categorical variables expressed by number (%), numerical variables expressed by mean

(SD) CHD, defined as earlier myocardial infarction, percutaneously coronary intervention or coronary artery bypass graft; diabetes mellitus, defined as non-insulin dependent diabetes mellitus, insulin dependent diabetes mellitus or explicitly stated in the medical history; Hypercholesterolemia, defined as treatment with lipid lowering drugs or explicitly stated in the medical history; Hypertension, defined as use of antihypertensive medication or explicitly stated in the medical history.
Abbreviations: SD, standard deviation; CHD, coronary heart disease

Discussion

In this study, the efficacy of a novel pre-hospital triage protocol for the cardiac emergency department was evaluated. Main findings can be summarized as follows. A high efficacy of the pre-hospital triage protocol was achieved as in 94% of the patients the cardiologist was able to answer the acute care demand without consultation of another medical specialist. The HEAR score is a good, easy to apply, risk stratification tool in chest pain patients in the pre-hospital triage setting. Cardiac emergency departments using the current pre-hospital flow-chart may reduce the caseload of cardiac patients at the general emergency department by approximately one third. In addition, a pre-hospital triage protocol enables to select patients with primary cardiac complaints without the need for other medical care.

Rationale of pre-hospital triage

Pre-hospital triage has an established role in emergency medicine. In trauma patients, pre-hospital triage protocols support emergency medical services providers to identify severely injured patients and assure transport of the right patient to the right hospital.(13) Pre-hospital triage in trauma patients has proven to be effective and reduce mortality.(15-17) Similarly, in the setting of STEMI, pre-hospital diagnosis and triage has shown to reduce treatment delay and improve outcome. (18-23) Although cardiac emergency departments and chest pain units are emerging, as far as we know, a pre-hospital triage system for these units has not yet been described.

The added value of pre-hospital triage in trauma patients as well as in STEMI patients inspired us to explore whether pre-hospital triage could be of help to allocate patients with cardiac symptoms in the pre-hospital setting to the appropriate emergency department. Results from this study show that at least one third of the patients admitted to the general emergency department with a suspicion of cardiac complaints could be admitted to the cardiac emergency department. This emphasizes that immediate allocation of patients to “the right place and the right doctor” can make an important contribution to preventing overcrowding of general emergency departments which is associated with high costs and increased mortality.(24)

Added value of the pre-hospital triage protocol
The use of a dedicated pre-hospital triage protocol yielded a high efficacy as in 94% of correctly triaged patients the acute care demand could be answered on the cardiac ED without consulting other medical specialists. Accordingly, the pre-hospital triage protocol can accurately differentiate between cardiac pathology and non-cardiac pathology. Furthermore, the results of the historical comparison substantiate that the cardiac emergency department can substantially reduce the caseload of the general emergency department. Although further study is required, this may eventually lead to shorter admission times in the general emergency department.

Risk stratification in chest pain patients in the pre-hospital setting
Outside the Netherlands, patients with acute chest pain are often referred to specialized chest pain units. These chest pain units are designed with the same rationale as a cardiac emergency department, specifically to provide a rapid approach in the evaluation of cardiac patients. Chest pain units have demonstrated to be feasible, safe and effective alternatives to general emergency departments.(6, 25, 26) However, a high percentage (92%) of patients admitted to these chest pain units have a non-cardiac aetiology of their chest pain.(27) Analysis of non-cardiac pathology can be time consuming and often requires additional diagnostics and consultation of other specialists and could potentially reduce quality of care. Identifying low and high-risk chest pain patients in the pre-hospital triage setting with risk stratification tools (such as a pre-hospital triage protocol) could overcome these issues.

In the current study, the HEAR score was calculated upon arrival to explore the potential as a risk stratification tool in patients with chest pain. The HEAR score showed similar event rates after 6 weeks as compared to the HEART score.(11-13) Furthermore, the AUC of the HEAR score was 0.80, almost similar to the HEART (HEAR score plus troponin measurement) score. When compared to the HEAR score, the HEART score showed a slightly better risk stratification as indicated by a higher AUC, which indicates a good ability to discriminate patients with low and high risk for adverse cardiac events. For this reason, it may enable clinicians to decide whether patients should be either admitted at a cardiac emergency department or may stay at home. Importantly, the HEAR score is applicable in pre-hospital setting as the 4 parameters of the HEAR score can be easily obtained by paramedics without contacting cardiologists or other treating physicians.(10)

These findings are also in line with a study by Bandstein and colleagues(28), who showed that a low single in-hospital troponin level, independent of the timing of the troponin measurement, ruled out myocardial infarction with nearly 100% accuracy. Implementation of troponin measurements in pre-hospital risk scores may be even more preferable (previously referred to as 'modified HEART score') rather than in-hospital troponin measurements. Interestingly, Ishak et al.

evaluated the feasibility of the modified HEART score and showed that patients with a modified HEART score of 0-3 (36%) did not developed a MACE.(29) Using the HEAR or the modified HEART score in the pre-hospital setting has the potential to avoid a substantial number of unnecessary admissions, hereby providing a potential solution against overcrowding of emergency departments and substantially reduce health-care costs.

Clinical implications

The present study illustrates that cardiac emergency departments can significantly contribute in reducing overcrowding general emergency departments. Because of the pre-hospital triage protocol, patients are allocated to the appropriate emergency room and the number of patients with a non-cardiac diagnosis requiring hospital admission to a non-cardiac ward is very low. Future studies are warranted to evaluate whether the pre-hospital triage protocol can also help to decrease admission times and, last but not least, lower health care expenditures. The currently described pre-hospital triage protocol can also be applied to chest pain units, which in concept could lead to improved efficacy and reduced healthcare costs.

Limitations

Several limitations merit consideration when interpreting the results. First, this study was a single centre cohort study. The applicability of the pre-hospital triage protocol to other hospitals inside and outside the Netherlands remains to be explored. Second, based on the current results, the HEAR score seems to be an easy to apply risk stratification tool in the pre-hospital setting. However, prospective validation is required and the intra- and inter-observer variability in the pre-hospital setting remains to be assessed.

Conclusion

In conclusion, this study demonstrates that using a dedicated pre-hospital triage protocol is an effective tool to select patients for admission at the cardiac emergency department which may reduce the caseload of cardiac patients at the general emergency department by approximately one third.

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