Effect of an acute coronary syndrome triage protocol in an emergency department on the door-to-balloon time for patients with ST elevation myocardial infarction

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TITLE

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ABSTRACT

Introduction: Chest pain is a major reason for emergency department (ED) visits and acute hospital admittance. Identifying patients with acute coronary syndrome (ACS) within the large proportion of patients with suspected cardiac chest pain represents a diagnostic challenge for professionals in the ED. Based on assessment of symptoms, history and the 12-lead electrocardiogram (ECG) findings, a patient with ST-elevation myocardial infarction (STEMI) should be identified and treated as soon as possible, since door-to-balloon time is strongly associated with the likelihood of survival. In case of STEMI, primary percutaneous coronary intervention (primary PCI) is indicated, international guidelines recommend a door-to-balloon time in patients with STEMI less than 90 minutes. Within the ED of Medisch Spectrum Twente (MST) the protocol "ACS triage ED" was introduced in January 2010, to shorten door-to-balloon times in patients with STEMI. To identify STEMI, a monitor with computer algorithm interpretation of the 12-lead ECG was used. Aim of this study was to evaluate the effect of the ACS triage protocol, executed by emergency nurses.

Methods: A quasi-experimental cohort control group design was used to compare patients with chest pain before and after implementation of the protocol “ACS triage ED”. Primary outcome measure was door-to-balloon time and secondary endpoints included enzymatic infarct size, length of stay in the ED and in hospital, and presence of chest pain, mortality and re-admission at 30-day follow-up. Data were extracted retrospectively from ED, hospital and PCI databases and cardiology medical records.

Results: In the after period, 215 consecutive patients were registered in the ED database with chest pain. Seven patients underwent PCI for myocardial infarction (MI), four of them had STEMI. Before implementation, 881 consecutive patients presented to the ED with chest pain, 29 underwent PCI, of which 20 were diagnosed with STEMI. Patient characteristics were comparable between the two total groups, but not between the two subsets of patients with MI who underwent PCI. Median door-to-balloon time for patients with STEMI was longer in the after group (88 minutes before and 120 minutes after; *P*=0.10), but was shorter for the patients with NSTEMI (1518 minutes before versus 277 minutes after; *P*=0.78). None of the STEMI patients in the after group was treated within 90 minutes after arrival at the ED. Peak CK level was higher in the after group (1071 ng/ml before versus 1458 ng/ml after; *P*=0.59), length of stay in the ED was prolonged (from 31 minutes before to 49 minutes after; *P*=0.42), as well as length of stay in the hospital (from 5 days before to 6 days after; *P*=0.50). Clinical outcomes at 30-day follow up did not differ between before and after group.

Conclusions: In the after group a longer median door-to-balloon time was registered in patients with STEMI undergoing a primary PCI after admission through the ED of MST. Time of arrival during off-hours and hemodynamic instability at arrival were identified as possible reasons for delay in these patients. Clinical outcomes appear to be worse in the after group, but may have been caused by the poorer health status at arrival of these patients. For patients with NSTEMI, the median door-to-balloon time appeared to be shorter in the after group, despite increases in the median length of stay in the ED.

Keywords: chest pain, acute coronary syndrome (ACS), emergency department (ED), door-to-balloon time, ST-elevation myocardial infarction (STEMI)

SAMENVATTING

Aanleiding: Pijn op de borst is een belangrijke reden voor bezoek aan een Spoedeisende Hulp (SEH) en acute ziekenhuisopname. Identificeren van patiënten met acuut coronair syndroom (ACS) binnen de grote groep van patiënten met verdenking op cardiale pijn op de borst, vormt een uitdaging voor professionals in de SEH. Gebaseerd op symptomen, de medische voorgeschiedenis en een 12-afleidingen elektrocardiogram (ECG), dient een patiënt met ST-elevatie myocardinfarct (STEMI) zo spoedig mogelijk geïdentificeerd en behandeld te worden, omdat door-to-balloon tijd sterk geassocieerd is met de kans op overleving. In geval van STEMI, is primaire percutane coronaire interventie (primaire PCI) geïndiceerd, internationale richtlijnen bevelen een door-to-balloon tijd aan van minder dan 90 minuten. Binnen de SEH van Medisch Spectrum Twente (MST) werd het protocol "ACS triage SEH" ingevoerd in januari 2010, om de door-to-balloon tijd te verkorten bij patiënten met STEMI. Voor het identificeren van STEMI, werd een monitor met computeralgoritme interpretatie van het ECG gebruikt. Doel van dit onderzoek was de evaluatie van het effect van het ACS triage protocol, uitgevoerd door SEH verpleegkundigen.

Methode: Met behulp van een quasi-experimenteel cohort control group design werden patiënten met pijn op de borst vergeleken voor en na invoering van het protocol “ACS triage SEH”. Primaire uitkomstmaat was de door-to-balloon tijd en secundaire uitkomsten betroffen infarctgrootte, verblijfsduur in de SEH en ligduur in het ziekenhuis, en de aanwezigheid van pijn op de borst, sterfte en heropname bij 30-dagen follow-up. De gegevens werden retrospectief verzameld uit SEH-, ziekenhuis- en PCI-databases en medische dossiers van de cardiologie.

Resultaten: In de na periode werden 215 opeenvolgende patiënten geregistreerd in de SEH database met pijn op de borst. Zeven patiënten ondergingen PCI voor myocardinfarct (MI), vier van hen hadden STEMI. Voor invoering, kwamen 881 opeenvolgende patiënten met pijn op de borst naar de SEH, 29 ondergingen PCI, waarvan 20 in verband met STEMI. Patiënt kenmerken waren vergelijkbaar tussen de twee groepen in totaal, maar niet tussen de twee subgroepen van patiënten met een MI die PCI ondergingen. Mediaan door-to-balloon tijd voor patiënten met STEMI was langer in de na groep (88 minuten voor en 120 minuten na; *P*=0,10), maar was korter voor patiënten met NSTEMI (1518 minuten voor versus 277 minuten na; *P*=0,78). Geen van de STEMI patiënten in de na groep werd behandeld binnen 90 minuten na aankomst in de SEH. Hoogste CK waarde was hoger in de na groep (1071 ng/ml voor versus 1458 ng/ml na; *P*=0,59), de verblijfsduur in de SEH was verlengd (van 31 minuten voor naar 49 minuten na; *P*=0,42), evenals de ligduur in het ziekenhuis (van 5 dagen voor tot 6 dagen na; *P*=0,50). Klinische uitkomsten bij 30-dagen follow-up verschilden niet tussen beide groepen.

Conclusies: In de na groep werd een langere mediaan door-to-ballloon tijd geregistreerd bij patiënten met een STEMI, die via de SEH van MST een primaire PCI ondergingen. Tijd van aankomst buiten kantooruren en hemodynamische instabiliteit bij aankomst werden geïdentificeerd als mogelijke redenen voor vertraging. Klinische uitkomsten lijken slechter in de na groep, maar dit zou veroorzaakt kunnen zijn door de slechtere gezondheidstoestand van deze patiënten bij aankomst. Voor patiënten met NSTEMI, blijkt de mediaan door-to-balloon korter te zijn in de na groep, ondanks de stijging van de mediane duur van verblijf in de SEH.

Trefwoorden: pijn op de borst, acuut coronair syndroom (ACS), spoedeisende hulp (SEH), door-to-balloon tijd, ST-elevatie myocard infarct (STEMI)

INTRODUCTION

Background

Chest pain is a major reason for emergency department (ED) visits and acute hospital admittance; more than six million patients present with chest pain and suspected acute coronary syndrome (ACS) to ED's across the United States (U.S.) annually.[1-3] Chest pain can be the presenting complaint in multiple disorders, ranging from a life threatening condition such as an acute myocardial infarction (AMI), to mild disorders such as muscle strain.[3] Distinguishing the patients with ACS within the large proportion of patients with suspected cardiac chest pain represents a diagnostic challenge for professionals in the ED.

When a patient presents with symptoms of chest pain, the initial goal is to assign the patient without delay to a working diagnosis on which the treatment strategy will be based. Next to assessment of the likelihood of ACS (symptoms, risk factors and medical history), the 12-lead electrocardiogram (ECG) findings are used to triage or classify the patient into one of three groups.[4, 5] Based on these findings the patient can be assigned to one of the following working diagnosis: (1) ST segment elevation that is diagnostic of acute ST-elevation myocardial infarction (STEMI), (2) non-ST segment elevation myocardial infarction (NSTEMI), or (3) ACS (highly) unlikely: patients with a so-called non-diagnostic or normal ECG.[4, 5]

In the ED setting, the ECG is the most readily available and most reliable tool to detect ischemia or acute coronary injury in broad, symptomatic emergency care populations.[6]

If the ECG indicates acute heart damage (STEMI, new left bundle branch block), immediate reperfusion treatment for an AMI is indicated. Numerous randomized clinical trials have demonstrated the superiority of primary percutaneous coronary intervention (primary PCI), as opposed to fibrinolytic therapy, for treating STEMI.[7-9] As compared with fibrinolytic therapy, primary PCI is associated with a relevant mortality reduction irrespective of PCI-related delays (up to 120 minutes).[10]

In the absence of ST-elevation, additional ECG recordings should be obtained, especially in patients with persisting chest pain to distinguish between NSTEMI and 'ACS (highly) unlikely'. Blood must be drawn promptly for Troponin measurement, elevation of cardiac Troponin in patients with chest pain reflects irreversible myocardial cellular necrosis and has to be labeled as AMI. A single negative test for Troponin on arrival of the patient in hospital is not sufficient for ruling out an elevation. In order to demonstrate or to exclude myocardial damage, repeated blood sampling and measurements are required 6–12 hours after admission and after any further episodes of severe chest pain.[5]

ECG recording, blood sampling and interpretation are necessary to distinguish between the three diagnostic groups, but can also prolong the time to reperfusion. Time to reperfusion is commonly measured by door-to-balloon time, which reflects the time between hospital arrival to when a balloon is inflated in the coronary artery.[11] The door-to-balloon time is strongly associated with the likelihood of survival.[4, 7, 8] Therefore internationals guidelines recommend that the door-to-balloon time in patients with STEMI should be less than 90 minutes, for at least 75% of non-transferred patients.[4, 7, 8] Patients with longer door-to-balloon times will experience longer periods of vessel occlusion, resulting in more ischemia and greater damage of the heart muscle than patients with shorter time to treatment.[8, 12] In a recent prospective cohort study (n=43,801)[12] was found that a reduction in door-to-balloon time from 90 to 60 minutes was associated with 0,8% lower mortality. Any delay in primary PCI is associated with higher mortality in hospital for patients admitted with STEMI. Time to treatment should therefore be as short as possible, even in centers currently providing primary PCI within 90 minutes.[12]
In case of NSTEMI the need for and timing of a coronary angiography (CAG) followed by reperfusion treatment (PCI or coronary artery bypass graft (CABG)) has to be tailored according to the acuteness of risk into three categories: urgent invasive (as soon as possible after diagnosis), early invasive (<72 hours), or conservative.[5]

Thus, all patients attending an ED with chest pain that could be ACS should be given a high priority by the triage nurse to allow rapid assessment and treatment.[3] A 12-lead ECG, together with a targeted medical history, should be obtained as soon as possible, at least within 10 min after ED arrival.[4]
Potential delay during the in-hospital evaluation period may occur from door to ECG, from ECG to decision for PCI, and from decision to PCI. All care providers must focus on minimizing delays at each of these points. Out-of-hospital transport time constitutes only 5% of delay to treatment time; in-hospital evaluation constitutes 25% to 33% of this delay.[4] Waiting for the right physician at the bedside of the patient and the decision for PCI in case of STEMI were indicated as major delaying factors on door-to-balloon times.[13-18]

Problem statement

During a quality improvement project in 2008-2009, a regional working group, composed of representatives of emergency services, general practitioners, interventional cardiology department, coronary care units (CCU's) and ED's, formulated several goals to improve AMI patient care. One of these goals was to shorten the door-to-balloon time for patients who are admitted in the hospital through the ED by systemic changes in emergency care.

Policy advisors, together with nurses and physicians from the cardiology and emergency departments, developed a protocol "Acute Coronary Syndrome triage Emergency Department" ("ACS triage ED"). The protocol consists of a flowchart (Figure 1, appendix 1) with instructions on early triage, start of treatment and referral to primary PCI if needed by emergency nurses in patients presenting with suspected ACS. The protocol is analogous to the protocol used by paramedics in the Netherlands for four years[19], which has been proven to be effective in reducing prehospital time to reperfusion and improving patient outcomes.[20, 21] To identify STEMI, a monitor with computer algorithm interpretation of the 12-lead ECG is used. The protocol was implemented in the ED of Medisch Spectrum Twente (MST) in January 2010.

Results from earlier studies show that interpretation of the ECG for STEMI in chest pain patients and referral to the catheterization laboratory, can not only be adequately performed by physicians, but also by paramedics,[8, 11, 20, 22, 23] and emergency nurses.[14, 24] This implies that waiting for the right physician to decide for PCI in case of STEMI is no longer necessary.

The emergency nurse is at the forefront of early recognition of a STEMI in patients presenting with chest pain in the ED and can directly affect the timeliness of reperfusion therapy.[25] However, the effect of the protocol "ACS triage ED" and the use of computer algorithm interpretation of STEMI by nurses in the ED setting, on the door-to-balloon time and clinical outcomes of patients with STEMI is unknown.

Based on previous results with comparable interventions on reduction of door-to-balloon times of 38 to 40 minutes in patients with STEMI, we expected to shorten the door-to-balloon time in MST with 30 minutes.[14, 16]

Objective

Aim of this study was to evaluate the effect of the protocol "ACS triage ED" on door-to-balloon time and outcomes in patients undergoing primary PCI for STEMI, admitted through the ED.

Research question

In this study the following research question was formulated: "What is the effect of the protocol "ACS triage ED" carried out by emergency nurses, on the door-to-balloon time and outcomes of patients with STEMI undergoing a primary PCI after admission through the ED of MST?"

METHODS

Study design

A quasi-experimental cohort control group design[26] was used to compare patients with chest pain, who were presented to the ED, after implementation of the protocol "ACS triage ED" with patients before implementation. The subset of patients diagnosed with an AMI who underwent primary PCI was further investigated. Before and after groups were compared in terms of door-to-balloon time and patient outcomes (enzymatic infarct size, length of stay in ED and in hospital, and presence of chest pain, mortality and re-admission at 30 days after arrival in hospital). Data were extracted retrospectively from ED, hospital and PCI databases and cardiology medical records.

Setting

The study was conducted at Medisch Spectrum Twente (MST), a large regional hospital in the Eastern part of the Netherlands with 1,070 beds and 27,000 annual ED visits.[27] The hospital serves as a 24/7 regional cardiac catheterization referral center with 1,900 annual PCI's of which about 500 primary PCI.[28]

Participants and sample size

Subjects of study were all consecutive patients presented to the ED of MST with symptoms of chest pain, identified with the Manchester Triage System (MTS) as chief complaint by an emergency nurse, during two periods: before and after implementation of the protocol "ACS triage ED". Patients with chest pain in the ED database from the before group, January 1 to December 31, 2009, and the after group, March 15 to June 15, 2010, were identified within the records of patients diagnosed with an AMI in the PCI database for the same periods and were further analyzed as subset. Patients who were registered in one or both databases for more than one time, but with different date and time of arrival, were indicated as separate cases. The sampling process is shown in the flowcharts in Figure 2 (appendix 2).

Analysis was done for the whole sample of patients with chest pain in the ED and for the subset of patients who were admitted through the ED with an AMI, and subsequently underwent primary PCI.

The sample size to detect differences between the before group and after group was calculated based on previous study results on door-to-balloon time reduction of 38 to 40 minutes in patients with STEMI, with comparable interventions.[14, 16] Together with the evidence for lower mortality associated with a 30 minutes reduction of the door-to-balloon time[12, 29], it was therefore assumed that a 30 minutes reduction in door-to-balloon time after implementation was realistic and clinically relevant.

With a power of 80% and a two-sided significance level of <0.05 a target sample size of 52 subjects (26 in each group) was calculated when a Student's t-test would be used to compare means.[30] In order to use the Mann-Whitney U test to compare median door-to-balloon times with the same statistical power, the target sample size was adjusted to a minimum of 55 patients (28 in each group).[31]
Based on historical data of approximately 25 patients with chest pain visiting the ED of MST per month, of which half was thought to be diagnosed with STEMI, the expectation was to complete the target sample within three months before and three months after implementation.[32]
The study was approved by the institutional review board in MST. No informed consent was required, because the protocol "ACS triage ED" consists of the standard STEMI care regime in the emergency services and cardiology departments in the service area of the regional PCI center MST.

Intervention

Situation before implementation

After initial triage (using Manchester Triage System (MTS)), the emergency nurse obtained an ECG for every patient presenting with chest pain. The patient and the ECG were evaluated by the resident on call at the ED (mostly surgical or orthopedic resident). In case of an abnormal ECG the ED resident consulted the on-call cardiology resident, who then came from the coronary care unit (CCU) to the ED to evaluate the patient. In case of STEMI the cardiology resident called the interventional cardiologist and the catheterization laboratory team to prepare for primary PCI. Following orders from the cardiology resident the patient was premedicated and transported to the catheterization laboratory or CCU. Primary PCI care is provided 24 hours a day, seven days a week, but during off hours the interventional cardiologist and catheterization laboratory team is available on call, which adds a maximum of 30 minutes for the catheterization laboratory to start PCI.

New situation

Since March 15, 2010, the protocol "ACS triage ED" was used at the ED of MST. Emergency nurses obtained the 12-lead ECG using a monitor eligible reporting an automated diagnosis (Medtronic LIFEPAK®12 monitor/defibrillator with the Marquette Medical Systems 12SL ECG analysis program). In stead of evaluation of the ECG by the on-call residents, trained emergency nurses identified STEMI and patients' eligibility to PCI, based on the clinical symptoms supported by the automated diagnosis from the LIFEPAK©12. In case of STEMI, emergency nurses administer oxygen, sublingual nitroglycerin, aspirin, clopidogrel and intravenous heparin, according to predefined criteria from the protocol.

After calling the cardiology resident to refer the patient for primary PCI, the patient is directly transferred to the catheterization laboratory, without the cardiology resident coming to the ED. In case a PCI could not be performed immediately, the patient was transported from the ED to the CCU.
In case the automated ECG diagnosis did not indicate STEMI, but reported an abnormal ECG, the emergency nurse directly called the on-call cardiology resident to evaluate the patient in the ED. Patients with a normal ECG but with ongoing chest pain were also evaluated in the ED by the cardiology resident.

Methods of measurement

Data collection was done by retrospective extraction from multiple existing databases and additional (electronic) chart review. All variables were registered by professionals during the routine process for care of patients in the ED, catheterization laboratory, CCU and during an outpatient visit or telephone consultation 30 days after PCI (follow up data).
The ED database held demographic details for all patients as well as the characteristics of the patients' arrival/stay at the ED, such as priority (MTS), mode of referral, arrival and departure times. The ED database underwent some changes in January 2010 that caused different registration of e.g. chief complaint (thoracic pain in 2009, chest pain in 2010), and mode of referral (different categories) in the before and after situation. Comparability of data was ensured through renaming and recoding variables in coordination with ED database experts. The hospital database was used to collect laboratory results for Creatinine Kinase (CK) and Troponin T levels, dates and times of admission and discharge. The cardiology medical record held the data on all patients who underwent PCI, such as risk factors and cardiac history as well as the presence of chest pain, death and re-admission at 30-day follow up. The PCI database contained the recorded dates and times of the PCI procedure.
Data quality was ensured through the use of standardized variables and definitions, systematic data extraction from existing registries and review by a cardiologist (KvH) before analysis. Invalid automated time registrations were manually checked with original records and corrected.

Data were obtained by a data manager and a researcher (RE) in March 2010 for the before group (January 1 to December 31, 2009) and in July 2010 for the after group (March 15 to June 15, 2010). No data were collected from January 1 to March 14, 2010 because in this period the implementation of the protocol and instruction of emergency nurses took place.

Outcome measures

Primary outcome measure was door-to-balloon time, defined as the time between a patient's arrival at the ED and the first balloon inflation or device deployment as documented in the patient's medical record. Door-to-balloon time was presented as median with 5th and 95th percentiles as well as percentage at goal. The latter was defined as the proportion of patients with STEMI meeting the international guidelines of a door-to-balloon time of less than 90 minutes[7], or less than 4320 minutes (72 hours) in patients with NSTEMI.[5]

Secondary endpoints included enzymatic infarct size (assessed by maximum CK level in first 24 hours after admission), length of stay in the ED and in the hospital, and presence of complaints of chest pain, death (all-cause mortality) and readmission (with chest pain related diagnosis) at 30-day follow up, i.e. assessed at 30 days after admission to the hospital.

To satisfy the condition of minimally different cohorts for using the cohort control group design, patient demographics were abstracted, as well as cardiac risk factors, clinical characteristics and laboratory results. These patient characteristics were also collected to see if generalization of the results to other populations was suitable.

Data analysis

For all analysis, data from the different sources were imported into the Statistical Package for the Social Sciences for Windows (SPSS Inc., Chicago, IL, V.S.), version 15.0.

Categorical data are presented as proportions, comparisons between the groups before and after implementation were made using Pearson Chi-square analysis or Fisher's exact test (variables such as gender, priority, mode of referral, risk factors, cardiac history, percentage at goal and complaints of chest pain, mortality and readmission at 30-day follow up). Continuous variables are summarized as means with standard deviations (age) or medians with 5th and 95th percentiles (Troponin T and CK level, door-to-balloon time and length of stay) and were compared with an independent Student's t-test (normally distributed data) or the Mann-Whitney U test (skewed distribution of data). The significance level was set at $p < 0.05$ (2-tailed).

RESULTS

Study population

After implementation of the protocol "ACS triage ED", 215 consecutive patients were registered in the ED database with chief complaint of chest pain from March 15 to June 15, 2010. The subset consisted of seven patients with chest pain who underwent PCI for MI (Figure 2, appendix 2), four of them had STEMI. The results of these patients were compared with the historical control group before implementation. From January 1 to December 31, 2009, 881 consecutive patients presented to the ED with chest pain, 29 underwent PCI, of which 20 were diagnosed with STEMI.

Baseline characteristics

Demographics and initial presentation details were similar in both total groups of patients with chest pain in the ED (Table 1). Demographics, initial presentation details, risk factors and cardiac history of both subsets who underwent primary PCI are presented in Table 2. Mean age in the before group was 56.5 (standard deviation (SD) 10.2) years and in the after group 61.7 (SD 7.0) years, most patients were male (86.2% before and 71.4% after). No significant differences were found for the baseline characteristics comparing the before and after groups, except smoking. A higher prevalence of smokers was found in the before group (*P*=0.02). Although not significantly different, preexisting hypercholesterolemia appeared to be more prevalent in the before group (66.7% versus 28.6%, *P*=0.10). The median Troponin T levels in both groups did not differ significantly, but the median Troponin T level at arrival in the STEMI patients seems to be higher in the after group (0.45 ng/ml versus <0.01 ng/ml; *P*=0.15), possibly indicating more myocardial damage at arrival.

Another relevant and almost significant difference (*P*=0.07) between the groups concerned the time of arrival. In the before group 58.6% arrived during off-hours, when the catheterization team had to be called to the hospital, versus 100% in the after group.

In the after group one patient was triaged yellow, indicating a lower priority and thus a longer waiting time allowed before assessment in the ED. In the after group there were less self-referred patients (37.9% before versus 14.3% after) and less patients referred by ambulance (20.7% before versus 14.3% after), while more patients were referred otherwise, e.g. transfer from other facility or internal physician (3.4% before versus 28.6% after). Most patients had no registered cardiac history, two patients in the before group had a prior MI wherefore they had a previous PCI and one patient in the after group had a prior coronary artery bypass graft (CABG).

Door-to-balloon time

The total median door-to-balloon time is 24 minutes longer in the after subset (from 115 to 139 minutes; *P*=0.24) (Table 3). For patients with STEMI the difference in the median door-to-balloon time was +32 minutes (*P*=0.10) and for NSTEMI patients –1241 minutes (*P*=0.78). None of the four STEMI patients in the after group was treated within 90 minutes of arrival at the ED, where this percentage in the before group was 50% (*P*=0.16). The median door-to-balloon times were the longest and showed the largest difference in patients in the after group referred by an ambulance (137 minutes before versus 5236 minutes after) or a general practitioner (104 minutes before versus 198 after). The door-to-balloon time during off-hours, was 40 minutes longer in the after group (139 minutes). Median door-to-balloon time was only shorter for patients referred by 'other' (e.g. transfer from other facility), from 122 minutes before (n=1) to 99 minutes after (n=2).

Infarct size, length of stay and 30-day follow up

As secondary endpoints the effect of the protocol on enzymatic infarct size, length of stay in the ED and in the hospital and the presence of complaints of chest pain, death (all-cause mortality) and readmission (with complaints of chest pain) at 30-day follow-up, was assessed (Table 4). No significant differences were found for these clinical outcome parameters comparing the before and after groups.

Although not significant, the median length of stay in the ED was longer for the total group (from 31 to 67 minutes, *P*=0.41), but shorter for self referred patients and patients referred by a general practitioner.

The overall increase in the length of stay in the ED for the after group and decrease in two subgroups, is difficult to interpret because of the small sample size. We therefore also compared the length of stay in the ED of the two groups of all patients with chest pain in the ED (Table 5). Total median length of stay in the ED is similar in both groups, but was 20 minutes longer for patients who arrived during regular hours in the after group (from 141 to 161 minutes), an almost significant difference (*P*=0.07). Although not significantly, for patients classified orange in triage (very urgent), the median length of stay in the ED was 13 minutes shorter in the after group (*P*=0.69). Length of stay in the ED for lower triage categories were longer in the after group (from 142 to 159 in yellow , *P*=0.19; and from 108 to 161 minutes in green, *P*=0.22). Patients referred by a general physician have a longer length of stay in the ED in the after group, from 105 to 125 minutes (*P*=0.23).

A detailed description of the seven patients in the after group can be found in appendix 3.

DISCUSSION

The results of this study show that after implementation of the protocol "ACS triage ED", a longer median door-to-balloon time was registered in patients with STEMI undergoing a primary PCI after admission through the ED of MST. It appears that the longer median door-to-balloon time could not fully be explained by longer median length of stay in the ED. As possible reasons for delay in these patients, time of arrival during off-hours and hemodynamic instability at arrival were identified.

The number of patients with chest pain visiting the ED was higher than expected, based on historical data.[32] On the other hand, the number of patients with STEMI undergoing a primary PCI after admission through the ED was lower than expected. It was therefore not possible to complete the target sample of 28 patients in each group, within three months before and three months after implementation. The period for the before group was extended to one year, the period for the after group could not be extended due to limited time for this research project. This resulted in a small sample size of 36 patients in total, of which 24 were diagnosed with STEMI. Furthermore, the subset before and after group were not comparable based on the patient characteristics, regarding risk factors, time of arrival, priority, mode of referral and Troponin T level at arrival. In a larger sample size the results could have been adjusted for these variables. Because demographics and initial presentation details were comparable in both total groups of patients with chest pain in the ED, we assume that nothing major has changed in the patient population in the ED of MST.
Because of the small sample size and incomparable subsets, results and conclusions must be interpreted with caution. Despite the fact that we did not have the statistical power to perform a thorough analysis, we described the results and performed statistical tests to present this research project as part of the requirements to complete the master of science in nursing.

Door-to-balloon time

Our data demonstrate that after implementation of the protocol "ACS triage ED" the median door-to-balloon time was 24 minutes longer in all patients of the after group, and even 32 minutes longer in patients with STEMI. None of the four STEMI patients in the after group underwent primary PCI within the recommended goal of 90 minutes after arrival at the ED.
In a recent systematic review[33], self-referral, arrival during off-hours, patient factors such as age > 70 years, female gender, diabetes, previous PCI and hemodynamic instability, and inefficient processes between arrival at the ED and PCI were factors found to be responsible for the longest delays in door-to-balloon time.[33] We investigated whether we could identify these factors of delay in the in the four cases with STEMI in the after group.

Only one of these four patients referred himself to the ED. Because his initial automated ECG report of the LIFEPAK©12 monitor showed a normal ECG he was not directly transferred to the catheterization laboratory. The classic clinical symptoms in this patient were the reason for the cardiology resident to evaluate him in the CCU, where he was transferred within 30 minutes of arrival. A STEMI was diagnosed based on a second ECG, as well as an elevated Troponin T level of 0.07 ng/ml, and he subsequently underwent primary PCI. Thus, self-referral seems not to be the reason for delay in this patient. Furthermore, the median door-to-balloon time of self-referred patients in the before group was 85 minutes, indicating that a shorter door-to-balloon time in self-referred patients is possible in this ED setting.

All patients in the after group arrived at the ED during off-hours, when the catheterization team had to be called to the hospital. Although longer door-to-balloon times during off-hours were also seen in some previous studies[34-37], the median door-to-balloon time in the before group was 40 minutes shorter during off-hours. Furthermore, earlier studies where a comparable intervention was introduced[13, 38-40], found a reduction of the door-to-balloon time during off-hours. A shorter door-to-balloon time during off-hours should therefore be possible. Although other factors of delay may have played a more important role in this setting, the arrival during off-hours could be a reason for delay in these patients.

Age > 70 years, female gender, diabetes and previous PCI are known to be an important reason for longer door-to-balloon times.[17, 29, 36, 37, 41] All four patients with STEMI in the after group were younger than 70 years and male, no diabetes or previous PCI were registered. Therefore these factors do not explain the longer door-to-balloon times in these patients. Hemodynamic instability at arrival can be a reason for delay since stabilizing the patient before primary PCI takes time.[17, 37] Two of the four STEMI patients were hemodynamic unstable. One patient was in cardiac arrest and cardiogenic shock and was assessed by the resuscitation team. After stabilizing at the ED during 75 minutes, the patient was directly transferred to the catheterization laboratory. The other patient, presented with chest pain and respiratory distress, was diagnosed with a STEMI based on a ruptured papillary muscle. 67 minutes after arrival he was transported from the ED to the thoracic intensive care unit, where he was further stabilized before he underwent primary PCI. The condition of these two patients at arrival, is a possible reason for delay in the observed door-to-balloon times.

To identify inefficient processes between arrival at the ED and PCI responsible for a longer door-to-balloon time[14, 24, 39, 42, 43], we observed the priority, indicated by a triage nurse, and the length of stay in the ED as part of the door-to-balloon time. All four patients with STEMI were triaged red or orange, indicating that in all patients the need for rapid assessment and treatment was recognized.

The median length of stay in the ED for STEMI patients in the after group was 18 minutes longer than in the before group, but the maximum length of stay in the ED went from 92 in the before group to 75 minutes in the after group. In the two cases with the longest length of stay in the ED (75 and 67 minutes), the delay was probably caused by the time needed for stabilization. The other two cases stayed in the ED for only 18, respectively 30 minutes, before they were transferred to the CCU for further analysis. Because we did not have sufficient data about the sub-intervals of the door-to-balloon time, including door-to-ECG time, and the period between departure from the ED and balloon inflation, it is unclear if there were other factors in those intervals that may have delayed door-to-balloon time, e.g. transfer from ED to CCU and from CCU to catheterization laboratory, calling and arriving of the catheterization laboratory personnel and difficulties experienced during PCI procedure.
In a recent prospective, multicenter, randomized clinical trial (RCT) (n=546)[34], a significantly reduced door-to-balloon time and smaller infarct size was found in patients with STEMI undergoing primary PCI, who were brought directly from the ED to the catheterization laboratory, with bypass of CCU/cardiac ward admission.

Despite the fact that this research was primarily aimed at STEMI patients, we investigated all patients who underwent primary PCI after arrival at the ED, including patients with NSTEMI. The median door-to-balloon time in patients with NSTEMI appeared to be much shorter in the after group (-1241 minutes) and seems to be a positive side-effect of the protocol “ACS triage ED”. However, it has to be remarked that the patient with NSTEMI that was not treated within the goal of 4320 minutes (<72 hours), may have been indicated to undergo PCI conservatively based on the acuteness of risk. In a recent RCT (n=1,200) on outcomes between early invasive (<24-72 hours) and conservative treatment in patients presenting with NSTEMI and elevated Troponin T, no long-term benefit was found of an early invasive strategy in reducing death or MI.[44] Therefore a longer door-to-balloon time in these patients might be acceptable.

In-hospital and 30-day clinical outcomes

Clinical outcomes are worse for the STEMI patients in the after group in terms of infarct size, length of stay in the ED and length of stay in the hospital, but it is unknown if this observed negative effect is caused by the longer door-to-balloon times, or by the worse condition at arrival of the STEMI patients in the after group.
Median infarct size in patients with STEMI was increased in the after group (median peak CK-level +387 ng/ml), indicating more myocardial damage compared to the before group. But according to the higher Troponin T level at arrival in the patients in the after group, the STEMI patients already presented with more myocardial damage at arrival.

Since the Troponin T level rises in patients with MI after three to four hours after onset of symptoms[5], a higher level of Troponin T at arrival could indicate that patients arrived at the ED with longer pre-existing symptoms (relatively late presentation). In one patient in the after group symptoms of MI were already present for more than 12 hours.
As mentioned earlier, the median length of stay in the ED for STEMI patients in the after group was longer than in the before group, but the delay was probably caused by the time needed for stabilization in two patients. The other two cases had a relatively short stay in the ED. There appears to be no difference in before and after group regarding clinical outcomes at 30-day follow-up (complaints of chest pain, death, and readmission).

Other aspects of the implementation of the protocol "ACS triage ED"

The emergency nurse's primary role in this research project was to follow the "ACS triage ED" flowchart in order to prioritize patients, start the appropriate treatment and facilitate rapid transfer to the cardiac catheterization laboratory in case of STEMI. Of the 215 patients with chest pain in the ED after implementation, in only 42 cases the use of the protocol was registered, possibly due to poor registration or incomplete implementation. It is unknown how many of the 215 patients with chest pain in the ED in the after group would have been eligible for screening with the LIFEPAK©12 monitor. A further analysis of all patients with chest pain in the ED has to be done.

Since the start of this project in January 2010, we noticed an increased level of communication and cooperation between the ED and CCU/cardiology department, not only at the level of patient care but also between management and medical specialists.
Great challenge during implementation of the protocol "ACS triage ED" was not to change the process in the hospital, but the empowerment of emergency nurses to use the protocol and the LIFEPAK©12 monitor. The fear of greater responsibility by emergency nurses, especially regarding the independent administration of medication and referral to the catheterization laboratory based on patients' symptoms and automated ECG report, has been described in earlier research to influence the use of such a protocol.[14]

Strengths and limitations

Strengths

To ensure correct identification of patients in the sample, the sampling process from the available data was reviewed and approved by a cardiologist (KvH) before analysis.
Retrospective extraction from existing data has several advantages[26, 45]: First, it is less time consuming and costs less compared to prospective studies.

Secondly, professionals and researchers need no additional effort in data registration since most variables are already registered during the routine care process. In the current study, data quality had been ensured through the use of standardized variables and definitions, systematic data extraction from existing registries and review by a cardiologist (KvH) before analysis.

Limitations

The most important limitations are the small sample size and incomparable groups, as has been described earlier. Therefore results must be interpreted with caution and cannot be generalized to other populations. We attempted to increase the number of patients by extending the before period to one year and to analyze all patients with chest pain in the ED, who underwent primary PCI. Extending the after period was not possible because of limited time for this research project, but we continued data collection in order to be able to analyze a larger sample in the near future.

Why the number of patients with STEMI undergoing a primary PCI after admission through the ED was lower than expected is not clear. It is possible that in this specific region most patients who experience chest pain call the emergency services and are triaged and treated in the prehospital setting and referred directly to the catheterization laboratory if necessary, bypassing the ED.

Furthermore, we only included patients whose chief complaint registered in the ED database was chest pain. It is possible that patients who presented without chest pain but ACS equivalent symptoms, such as shortness of breath, weakness, gastric pain, neck/shoulder/back pain, were registered with another chief complaint and thus were not included in this study. We recognize the importance of identifying ACS equivalents, but we decided to first start with using the protocol, and evaluating it, in patients with evident chest pain. To identify the possible missing eligible cases with ACS in the ED, all ED patients should be searched for in the PCI database and their chief complaints reviewed.

Assessment of sub intervals of the door-to-balloon time was impossible because of invalid time registrations. The assumption that all used systems in one hospital would be synchronized appeared not to be true. Consecutive times were not chronologically registered (e.g. ECG time before arrival time due to immediate ECG at arrival and then followed by registration in the ED database; and catheterization laboratory arrival time before ED departure time due to registration at pre-notification of the patient and not real-time arrival).

Data registered by different professionals for other than research purposes, has the disadvantage of inconsistency and incompleteness. Next to that, the used databases appeared to allow professionals to register the same variables in different ways, e.g. risk factors in the cardiology medical record.

Furthermore, the ED database underwent some changes that caused different registration of e.g. chief complaint (thoracic pain in 2009, chest pain in 2010), and mode of referral (different categories) in the before and after situation. Data in the ED database was thus sensitive to information bias.[45]

Finally, as our analysis was based on observational data our findings might be attributable to biases introduced by unmeasured factors. We cannot preclude the possibility of confounding by other non-measured patient or hospital factors associated with door-to-balloon time (e.g. occupied catheterization laboratory by patients outside the ED, difficulties experienced during PCI procedure, etc.).

Implications

Implications for practice

We believe that based on the evaluation of the effect of the protocol “ACS triage ED” with this small sample size, (medical) management and policy makers can not be advised yet on (regional) adoption, adaptation or rejection of the protocol.

Though maybe premature, the results of this research project should be distributed among involved professionals to motivate them to reduce door-to-balloon time in STEMI patients, rather than to accept possible explanations for the delay in these patients. The results of this research project should also be used in the current development of hospital wide clinical pathways for all patients with ACS.

In order to obtain more reliable data in the future, the existing ED and cardiology databases should be evaluated and adapted, especially regarding real-time time registrations.

Implications for further research

First of all we would recommend to continue collecting data for the after period in order to create a larger sample size and be able to evaluate the effect of the protocol “ACS triage ED” with more statistical power. To identify the possible missing eligible cases with ACS in the ED, all ED patients of the current study period should be searched for in the PCI database and their chief complaints reviewed.

In order to evaluate the effect of the protocol “ACS triage ED” regionally, a multi centered study is recommended in which also ED’s of hospitals without PCI facilities participate. Door-to-balloon times are longer in patients presented in hospitals without PCI facilities and therefore more benefit of rapid ACS triage is expected in these settings. The design should be prospective to be able to collect all necessary variables, including those not present in existing databases. Special attention should be paid to a valid, synchronized time registration in all patients.

CONCLUSION

With respect to the known limitations of this research project, we carefully formulate the following conclusion. After implementation of the protocol “ACS triage ED”, a longer door-to-balloon time was observed in patients with STEMI undergoing a primary PCI after admission through the ED of MST. The 32 minutes longer median door-to-balloon time could not fully be explained by the 18 minutes longer median length of stay in the ED. Time of arrival during off-hours, and hemodynamic instability at arrival were identified as possible reasons for delay in these patients.

The worse clinical outcomes in STEMI patients in the after group in terms of increased infarct size, prolonged length of stay in the ED and length of stay in the hospital, may have been caused by the poorer health status at arrival of these patients and not by the longer door-to-balloon times. At 30-day follow up the differences in clinical outcomes seem no longer apparent.

For patients with NSTEMI, the median door-to-balloon time appeared to be shorter in the after group, despite increases in the median length of stay in the ED. For this category of patients the protocol “ACS triage ED” seems to have a positive effect on the door-to-balloon time.

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Competing interests

None.

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Ethics approval

Ethics approval for this study was received from the Medisch Spectrum Twente Ethics Committee.

Patient consent

Not applicable.

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TABLES

Table 1. Patient characteristics in total groups of patients with chest pain in the ED.

Characteristic	**Before intervention** 01/01– 31/12 2009 (n=881)	**After intervention** 15/03-15/06 2010 (n=215)	**P-value***
Age in years, mean (SD)	51.0 (18.8)	49.5 (18.4)	0.29
Male gender, n (%)	510 (57.9)	131 (60.9)	0.42
Priority Manchester Triage System, n (%)			0.17
Red (immediate)	26 (3.0)	5 (2.3)	
Orange (very urgent)	479 (54.4)	113 (52.6)	
Yellow (urgent)	271 (30.8)	80 (37.2)	
Green (standard)	105 (11.9)	17 (7.9)	
Blue (non-urgent)	0 (0.0)	0 (0.0)	
Mode of referral, n (%)			0.25
Self-referral / walk-in	334 (37.9)	89 (41.4)	
General practitioner	308 (35.0)	81 (37.7)	
Ambulance	126 (14.3)	27 (12.6)	
Other	113 (12.8)	18 (8.4)	
Time of arrival, n (%)			0.34
Regular hours (8 am – 5 pm weekdays)	334 (37.9)	74 (34.4)	
Off-hours (5 pm – 8 am and weekends)	547 (62.1)	141 (65.5)	

ED = emergency department; SD = standard deviation

**significant difference at P<0.05*

Table 2. Patient characteristics in subsets of patients with chest pain in the ED who underwent primary PCI for AMI.

Characteristic	Before intervention 01/01– 31/12 2009 (n=29)	After intervention 15/03-15/06 2010 (n=7)	P-value*
Age in years, mean (SD)	56.5 (10.2)	61.7 (7.0)	0.21
Male gender, n (%)	25 (86.2)	5 (71.4)	0.35
Type of myocardial infarction, n (%)			0.66
STEMI	20 (69.0)	4 (57.1)	
NSTEMI	9 (31.0)	3 (42.9)	
Priority Manchester Triage System, n (%)			0.16
Red (immediate)	2 (6.9)	1 (14.3)	
Orange (very urgent)	27 (93.1)	5 (71.4)	
Yellow (urgent)	0 (0.0)	1 (14.3)	
Green (standard)	0 (0.0)	0 (0.0)	
Blue (non-urgent)	0 (0.0)	0 (0.0)	
Mode of referral, n (%)			0.17
Self-referral / walk-in	11 (37.9)	1 (14.3)	
General practitioner	11 (37.9)	3 (42.9)	
Ambulance	6 (20.7)	1 (14.3)	
Other	1 (3.4)	2 (28.6)	
Time of arrival, n (%)			0.07
Regular hours (8 am – 5 pm weekdays)	12 (41.4)	0 (0.0)	
Off-hours (5 pm – 8 am and weekends)	17 (58.6)	7 (100.0)	
Risk factors, n (%)			
(History of) smoking	24 (88.9)	3 (42.9)	0.02*
Hypertension	12 (42.9)	4 (57.1)	0.68
Hypercholesterolemia	18 (66.7)	2 (28.6)	0.10
Diabetes Mellitus	2 (6.9)	1 (14.3)	0.49
Positive family history	13 (50.0)	4 (57.1)	1.00
Cardiac history, n (%)			
Prior MI	2 (6.9)	0 (0.0)	1.00
Prior PCI	2 (6.9)	0 (0.0)	1.00
Prior CABG	0 (0.0)	1 (14.3)	0.19
Troponin T level, ng/ml, median (5-95 percentiles)			
At arrival			
STEMI	<0.01 (<0.01-0.40)	0,45 (<0.01-1.21)	0.15
NSTEMI	0.02 (<0.01-0.48)	0,05 (0.05-0.05)	0.51
6 hours after arrival			
STEMI	1.35 (<0.01-8.96)	4,01 (0.96-6.90)	0.44
NSTEMI	0.13 (<0.01-2.26)	0,63 (0.38-0.63)	0.31
Troponin T level >0.05 ng/ml, n (%)			
At arrival			
STEMI	7/20 (35.0)	3/4 (75.0)	0.27
NSTEMI	4/9 (44.4)	1/3 (33.3)	1.00
6 hours after arrival			
STEMI	19/20 (95.0)	4/4 (100.0)	1.00
NSTEMI	6/9 (66.7)	3/3 (100.0)	0.51

ED = emergency department; (A)MI = (acute) myocardial infarction; PCI = Percutane Coronary Intervention; SD = standard deviation; STEMI = ST-elevation myocardial infarction; NSTEMI = Non ST-elevation myocardial infarction; CABG = Coronary Artery Bypass Graft

Missing values in before group for: (History) of smoking (n=2); Hypertension (n=1); Hypercholesterolemia (n=2); Positive family history (n=3); Troponin T level 6 hours after arrival (n=2); % based on valid cases only.

A Troponin T level of 0.05 ng/ml or higher was considered diagnostic for myocardial infarction.

**significant difference at P<0.05*

Table 3. Door-to-balloon time in subsets of patients with chest pain in the ED who underwent primary PCI for AMI.

Door-to-balloon time	**Before intervention** 01/01– 31/12 2009 (n=29)		**After intervention** 15/03-15/06 2010 (n=7)		**Difference** (minutes)	**P-value***
	n	median (5-95 percentiles)	n	median (5-95 percentiles)		
Total	29	115 (37-5957)	7	139 (93-5236)	+24	0.24
By type of myocardial infarction						
STEMI	20	88 (33-1984)	4	120 (93-138)	+32	0.10
NSTEMI	9	1518 (142-4337)	3	277 (198-277)	-1241	0.78
Percentage at goal		%		%	Difference (%)	
STEMI < 90 minutes	10/20	50.0	0/4	0.0	-50.0	0.16
NSTEMI < 4320 minutes	7/9	77.8	2/3	66.7	-11.1	0.49
By mode of referral						
Self-referral / walk-in	11	85 (40-4215)	1	139	+54	0.47
General practitioner	11	104 (49-6723)	3	198 (134-198)	+94	0.39
Ambulance	6	137 (33-1659)	1	5236	+5099	0.13
Other	1	122	2	99 (93-99)	-23	0.22
By time of arrival						
Regular hours (8 am – 5 pm weekdays)	12	135 (33-6523)	0	-	-	-
Off-hours (5 pm – 8 am and weekends)	17	99 (40-2491)	7	139 (93-277)	+40	0.11

Door-to-balloon time expressed in minutes, median (5-95 percentiles)

ED = emergency department; AMI = (acute) myocardial infarction; PCI = Percutane Coronary Intervention; STEMI = ST-elevation myocardial infarction; NSTEMI = Non ST-elevation myocardial infarction

**significant difference at P<0.05*

Table 4. Clinical outcome parameters in subsets of patients with chest pain in the ED who underwent primary PCI for AMI.

Clinical outcome parameter	**Before intervention** 01/01– 31/12 2009 (n=29)		**After intervention** 15/03-15/06 2010 (n=7)		**P-value***
	n	median (5-95 percentiles)	n	median (5-95 percentiles)	
Infarct size (peak creatinine kinase (CK)), ng/ml					
Total	29	835 (96 – 6554)	7	980 (386 – 1936)	0.70
STEMI	20	1071 (110 – 6772)	4	1458 (642 – 7361)	0.59
NSTEMI	9	486 (90 – 1256)	3	532 (386 – 532)	0.64
Length of stay in ED, minutes					
Total	29	31 (2 – 189)	7	67 (18 – 96)	0.41
STEMI	20	31 (2 – 91)	4	49 (18 – 73)	0.42
NSTEMI	9	40 (1 –126)	3	95 (20 – 95)	0.78
Length of stay in ED, by mode of referral, minutes					
Self-referral / walk-in	11	43 (11 – 208)	1	30	0.66
General practitioner	11	29 (1 – 128)	3	20 (18 – 20)	0.70
Ambulance	6	57 (2 – 95)	1	95	0.32
Other	1	65	2	71 (67 – 71)	0.22
Length of stay in hospital, days					
Total	29	5 (1 – 11)	7	5 (3 - 14)	0.27
STEMI	20	5 (1 – 11)	4	6 (3 – 13)	0.50
NSTEMI	9	5 (2 – 6)	3	5 (4 – 5)	0.39
30-day follow up		%		%	
complaints of chest pain	10	34.5	1	14.3	0.40
death	2	6.9	0	0.0	1.00
readmission	3	10.3	1	14.3	1.00

ED = emergency department; AMI = acute myocardial infarction; PCI = Percutane Coronary Intervention; STEMI = ST-elevation myocardial infarction; NSTEMI = Non ST-elevation myocardial infarction

**significant difference at P<0.05*

Table 5. Length of stay in ED in total groups of patients with chest pain.

Length of stay in ED	**Before intervention** 01/01– 31/12 2009 (n=881)		**After intervention** 15/03-15/06 2010 (n=215)		**P-value***
	n	median (5-95 percentiles)	n	median (5-95 percentiles)	
Total	881	123 (13 - 277)	215	126 (14 – 300)	0.32
By priority Manchester Triage System					
Red (immediate)	26	62 (6 – 231)	5	66 (11 – 159)	0.96
Orange (very urgent)	479	112 (10 – 247)	113	99 (10 – 290)	0.69
Yellow (urgent)	271	142 (62 – 314)	80	159 (41 – 319)	0.19
Green (standard)	105	108 (39 – 260)	17	161 (34 – 276)	0.22
Blue (non-urgent)	0	-	0	-	-
By mode of referral					
Self-referral / walk-in	334	121 (34 – 248)	89	126 (35 – 302)	0.35
General practitioner	308	105 (8 – 293)	81	125 (6 – 287)	0.23
Ambulance	126	132 (17 – 292)	27	136 (7 – 332)	0.99
Other	113	142 (57 – 303)	18	122 (28 – 296)	0.46
By time of arrival					
Regular hours (8 am – 5 pm weekdays)	12	141 (33 – 311)	74	161 (59 – 316)	0.07
Off-hours (5 pm – 8 am and weekends)	17	106 (10 – 248)	141	106 (11 – 298)	0.85

ED = emergency department

Length of stay in ED expressed in minutes, median (5-95 percentiles)

**significant difference at P<0.05*

APPENDICES

Appendix 1. Flowchart ACS triage ED.

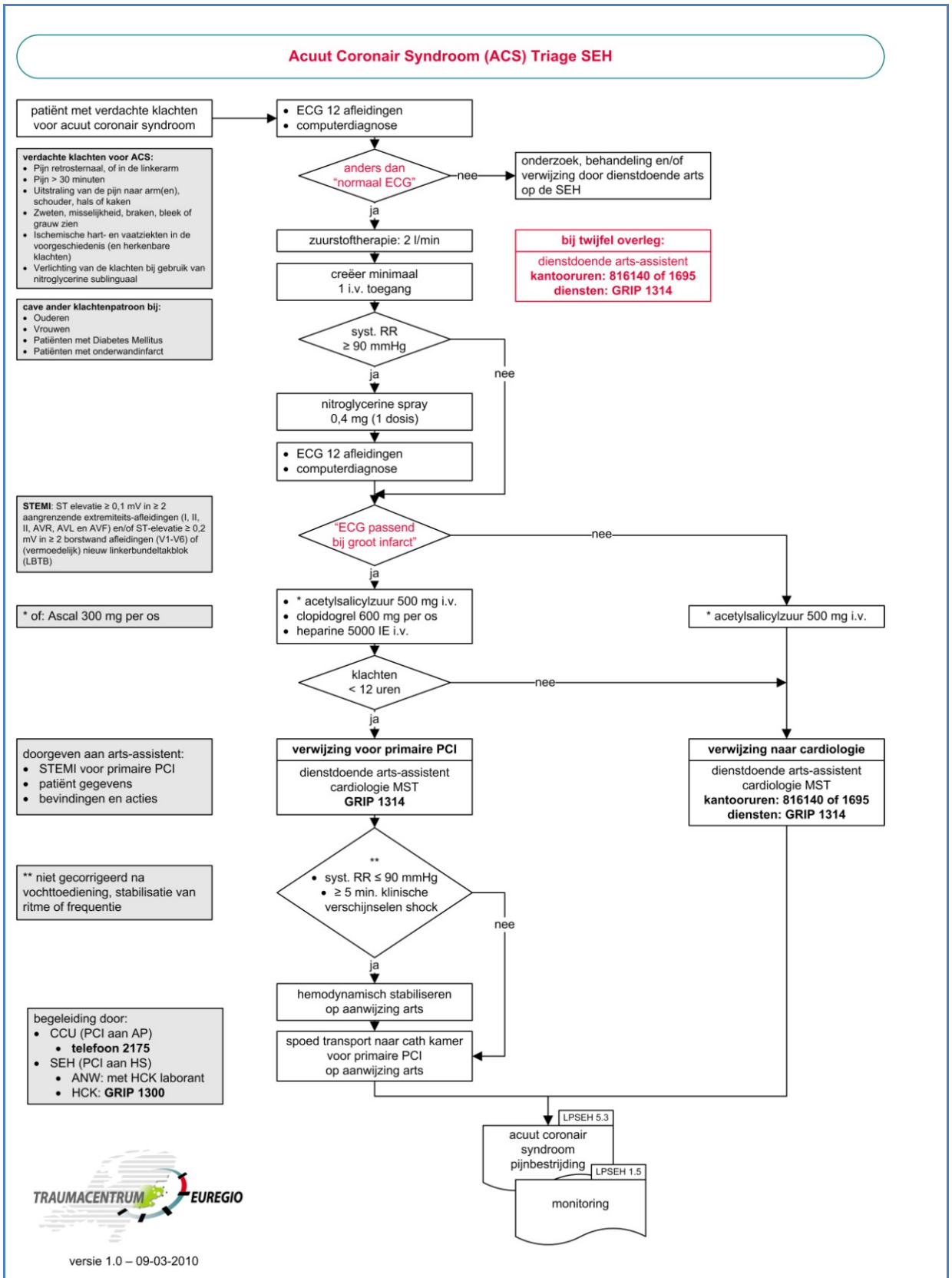

Figure 1. Flowchart from protocol "ACS triage ED" with instructions to assess a patient presenting with chest pain in the emergency department (Dutch version).

Appendix 2. Flowchart sampling.

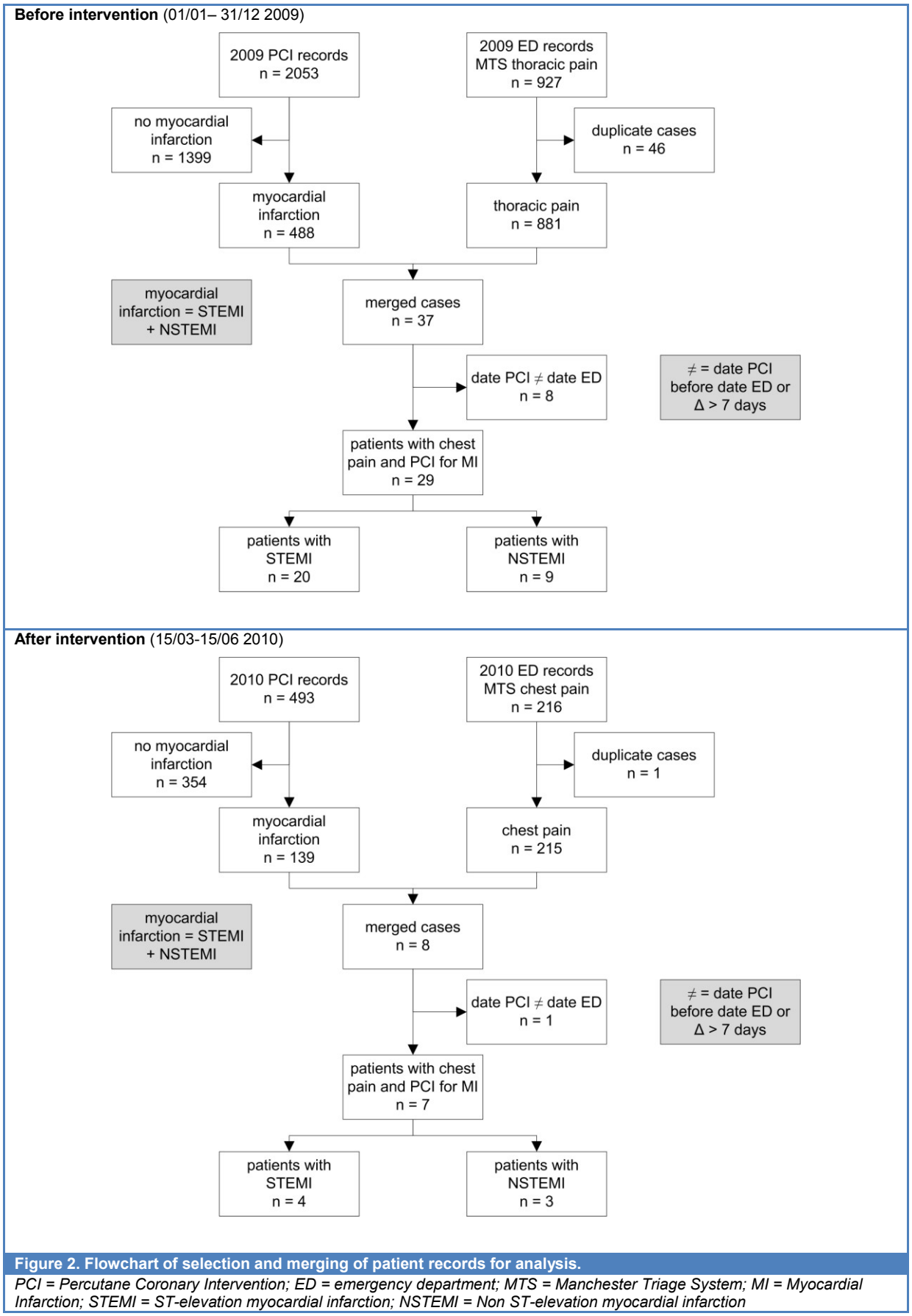

Figure 2. Flowchart of selection and merging of patient records for analysis.

PCI = Percutane Coronary Intervention; ED = emergency department; MTS = Manchester Triage System; MI = Myocardial Infarction; STEMI = ST-elevation myocardial infarction; NSTEMI = Non ST-elevation myocardial infarction

Appendix 3. Detailed description of the patients in the after group.

Table 6. Details of the seven cases in after group.

Case	Age (yr)	Gender	Priority (MTS)	Mode of referral	Time of arrival	Type of myocardial infarction	Door-to-balloon time (minutes)	LOS ED (minutes)
1	53	Male	Orange	GP	Off-hours	STEMI	134	18
2	64	Male	Orange	Self-referral	Off-hours	STEMI	139	30
3	68	Female	Orange	GP	Off-hours	NSTEMI	198	96
4	53	Male	Red	Other †	Off-hours	STEMI	93	75
5	66	Male	Yellow	Ambulance	Off-hours	NSTEMI	5236	95
6	70	Female	Orange	GP	Off-hours	NSTEMI	277	20
7	58	Male	Orange	Other ‡	Off-hours	STEMI	105	67

MTS = Manchester Triage System; D2B = door-to-balloon; LOS ED = Length of stay emergency department; GP = General practitioner; STEMI = ST-elevation myocardial infarction; NSTEMI = Non ST-elevation myocardial infarction

† = transfer from other facility; ‡ = physician (internally)

Case 1 was a 53 year old male with a > 12 hours existing STEMI, referred by a general practitioner on a Saturday morning. Patient was transferred to the CCU for further analysis within 18 minutes after arrival at the ED, 73 minutes later the patient arrived at the catheterization laboratory. Door-to-balloon time was 134 minutes. Maximum CK value 1936 ng/ml and Troponin T level at arrival 1.34 ng/ml. This patient arrived almost simultaneously with the patient of case 6.

Case 2 was a 64 year old male who came to the ED by himself in the night. The automated ECG report of the LIFEPAK©12 monitor showed a normal ECG, but because of the classic clinical symptoms the patient was transferred to the CCU to be evaluated by the cardiology resident, where a STEMI was diagnosed for which he underwent primary PCI. Door-to-balloon time was 139 minutes; length of stay in the ED was 30 minutes. Maximum CK value 980 ng/ml, Troponin T level at arrival 0.07 ng/ml.

Case 3 was a 68 year old female, brought to the ED in the evening, by ambulance after referral by general practitioner. Automated ECG report in the ambulance showed a normal ECG, in the ED an abnormal ECG was registered with the LIFEPAK©12 monitor. Patient was evaluated by the cardiology resident and based on a Troponin T level of 0.05 ng/ml at arrival and ongoing chest pain, the patient was diagnosed with a NSTEMI. After premedication the patient was transferred to the CCU from which she later that evening underwent primary PCI. Door-to-balloon time was 198 minutes; length of stay in the emergency department was 93 minutes. Maximum CK level was 532 ng/ml.

Case 4 was a 53 year old male, brought to the ED by ambulance (transfer from other facility) in the night. This patient was in cardiac arrest and cardiogenic shock and was assessed by the resuscitation team. After stabilizing, the patient was directly transferred to the catheterization laboratory. Maximum CK level 9169 ng/ml and Troponin T level at arrival

<0.01 ng/ml. The door-to-balloon time registered was 93 minutes; length of stay in the ED was 75 minutes.

Case 5 was a 66 year old male, referred to the ED by ambulance at 9.30 pm, with ongoing chest pain without ST-elevation on the automated ECG report. This patient stayed in the ED for 95 minutes before transfer to the CCU. 4 days after arrival at the ED patient underwent primary PCI, door-to-balloon time was 5236 minutes. Maximum CK level 386 ng/ml and Troponin T level at arrival 0.05 ng/ml.

Case 6 was a 70 year old female, referred by a general practitioner on a Saturday morning and was transported to the CCU for further analysis within 20 minutes after arrival at the ED, 241 minutes later the patient arrived at the catheterization laboratory.Patint was diagnosed with a NSTEMI, based on an elevated Troponin T level of 0.07 ng/ml at arrival. Maximum CK level 1551 ng/ml. Door-to-balloon time was 277 minutes. This patient arrived almost simultaneously with the patient of case 1 but had lower priority due to the presence of ST-elevation in case 1.

Case 7 was a 58 year old male, referred by physician inside the hospital (after referral by a general practitioner) to the ED in the evening, with chest pain and respiratory distress. This patient had a myocardial infarction (STEMI) based on a ruptured papillary muscle and was haemodynamic unstable. He was transported from the ED to the thoracic intensive care unit, where he was further stabilized before he underwent primary PCI. Door-to-balloon time was 105 minutes. Length of stay in the ED was 67 minutes. Maximum CK level 642 ng/ml and Troponin T level at arrival 0.82 ng/ml.