

This item is the archived peer-reviewed author-version of:

Editors Choice : the organization of chest pain units : position statement of the Acute Cardiovascular Care Association

Reference:

Claeys Marc J., Ahrens Ingo, Sinnaeve Peter, Diletti Roberto, Rossini Roberta, Goldstein Patrick, Czerw ińska Kasia, Bueno Héctor, Lettino Maddalena, Münzel Thomas,- Editors Choice : the organization of chest pain units : position statement of the Acute Cardiovascular Care Association
European heart journal : acute cardiovascular care - ISSN 2048-8734 - 6:3(2017), p. 203-211
Full text (Publisher's DOI): <https://doi.org/10.1177/2048872617695236>
To cite this reference: <https://hdl.handle.net/10067/1559110151162165141>

The organisation of chest pain units: position paper of the Acute Cardiovascular Care Association

¹Claeys MJ, MD, PhD, ²Ahrens I, MD ³Sinnaeve P, MD, PhD, ⁴Diletti R, MD, ⁵Rossini R, MD, PhD, ⁶Goldstein P, MD, ⁷Czerwińska K, MD, PhD, ⁸Bueno H, MD, PhD, ⁹Lettino M, MD, ¹⁰Münzel *T, MD, ¹¹Zeymer U, MD

* shared senior authorship

¹ Dept of cardiology, Antwerp University Hospital, Belgium

² Cardiology and Angiology I, Heart Center, University of Freiburg, Germany

³ Dept of cardiology, University Hospital of Leuven, Belgium

⁴ Dept of cardiology, Thoraxcentre, Rotterdam, Netherlands

⁵ Dept of cardiology, Papa Giovanni XXIII hospital, Bergamo, Italy

⁶ SAMU and Emerg Dept. Lille University Hospital, France

⁷ Intensive Cardiac Care Unit, American Heart of Poland, Bielsko-Biała, Poland

⁸ Dept of cardiology, University hospital 12th Octubre, Madrid, Spain and Centro Nacional de Investigaciones Cardiovasculares (CNIC)

⁹ Dept of cardiovascular disease, Humanitas Research Hospital, Milano, Italy

¹⁰ Dept of cardiology and intensive care, University hospital Mainz, Germany

¹¹ Dept of cardiology, Germany; Heart Center Ludwigshafen, Germany

Address of correspondence:

Prof dr M Claeys, MD, PhD, FESC

Antwerp University Hospital

Wilrijkstraat 10 2650 Edegem, BELGIUM

Email: marc.claeys@uantwerpen.be

ORCID ID: 0000-0002-6628-9543

Tel: 003238213000

ABSTRACT

Chest pain units (CPUs) are defined as organisational short stay units with specific management protocols designed to facilitate and optimise the diagnosis of patients presenting with chest pain in the emergency department (ED). The present document is intended to standardize and facilitate the installation of CPUs nearby the ED or as an integral part of the ED. Recommendations on organizational structure, physical and technical requirements and on disease management are presented. More standardized installation and implementation of chest pain units will enhance the quality of chest pain units and improve the quality of care of our chest pain patients.

BACKGROUND

Chest pain is a common complaint in emergency departments (ED) entailing millions of annual emergency department visits in Europe.(1, 2) Although a great proportion (up to 50%) of these patients do not have life-threatening conditions, clinicians must distinguish between high-risk patients (e.g., acute coronary syndromes, aortic dissection...), who require urgent treatment, and low-risk patients, who do not require admission.(3) Inappropriate discharge of patients with a disregarded acute coronary syndrome is associated with increased mortality and liability, whereas inappropriate admission of patients without an acute and serious disease is neither indicated nor cost-effective.(4) Initial assessment within the emergency department is hampered by suboptimal accuracy of current diagnostic tests on arrival, such as ECG and biomarkers, for identifying patients with acute myocardial infarction.(5, 6) It is against this background that the concept of ED-based chest pain units emerged with the aim to provide high quality and fast medical care for chest pain patients with low probability of an acute coronary syndrome but not sufficiently low to allow discharge. Chest pain units are defined as organisational short stay units with specific management protocols designed to facilitate and optimise the diagnosis of patients with chest pain in whom the diagnosis has not yet been established and who are at too high risk to be discharged immediately. The first chest pain center was set up in 1981 in the United States (St. Agnes Hospital in Baltimore, Maryland, USA), and this concept has been tested in many observational and interventional trials.(7-9) In general, patients admitted to chest pain units receive an accelerated diagnostic protocol consisting of serial electrocardiograms and serial cardiac injury markers to exclude acute coronary syndrome.(1, 10, 11) Documented experience, mainly from the United States and the UK, has demonstrated that chest pain centers manage their patients as effectively as inpatient admission but in a shorter time and at lower cost.(7, 12) Recently, in Germany an almost complete network of 244 certified CPU's has been established (13-16). In Europe, many hospitals have developed elements of chest pain unit care, however, often without establishing a formal chest pain unit.(14) There is evidence that certified chest pain units show better adherence to evidence-based ACS guidelines than institutions without certified units (17). More standardized installation and implementation of chest pain units will enhance the quality of chest pain units and improve the quality of care of our chest pain patients and even improve prognosis in patients with ACS. (18). Until now, no unified European criteria for the set up of CPUs have been defined.

Therefore, a dedicated task force within the Acute Cardiovascular Care Association (ACCA) was established to develop an evidence-based framework for the development of chest pain units. This task force represents a broad spectrum of clinicians with experience and expertise in the evaluation of chest pain patients presenting to emergency departments as well as the German CPU Group. This Task Force has elaborated and edited recommendations on organizational and logistic aspects of chest pain units. These criteria regulate the physical and technical requirements and determine diagnostic and therapeutic strategies for patients with chest pain. As patient volume determines the size and organizational structure of a chest pain unit, it was decided to establish a standard level describing the minimal criteria that all CPUs should fulfil and an advanced level for larger and more specialized chest pain units.

PATIENT EVALUATION

Risk stratification of chest pain patients suspect for ACS begins with the initial clinical assessment, which provides information on the risk of cardiovascular complications and allows to select those patients most appropriate for the chest pain unit (see figure). Low ACS risk patients are those with no haemodynamic instability or severe arrhythmias and without objective evidence of ischaemia (a normal or near-normal ECG, with initial cardiac injury markers below upper limit of normal). (9, 19, 20) Those patients can be admitted to the chest pain unit for further evaluation by means of an accelerated diagnostic protocol consisting of serial electrocardiograms and serial cardiac injury markers obtained over a 3-12 hour period.

Recently, the HEART-score has proven to be an easy, quick and effective risk stratification tool in undifferentiated chest pain patients. (21, 22) Based on the patients' history, ECG, age, cardiovascular risk factors and cardiac Troponin (cTn) measurements, a score between 0-10 points is calculated, representing the patients' risk of developing a major adverse cardiac event (MACE) within 6 weeks after initial presentation. This score is now being evaluated as a key decision-making tool for the initial evaluation of chest pain patients (CPU, CCU, at home) (22, 23). It is essential that criteria for admission to the CPU from the emergency department are locally pre-defined by the cardiologists and the ED physicians.

Echocardiography may reveal regional wall motion abnormalities related to regional myocardial ischaemia. In addition, echocardiography is an important tool to establish a diagnosis of pericarditis, aorta dissection, or pulmonary embolism. Patients with negative findings usually complete the accelerated diagnostic protocol with an exercise or pharmacological stress test to exclude ischaemia.

A negative accelerated diagnostic evaluation allows early discharge, whereas patients with a positive test are admitted for further evaluation and treatment. In case the preferred strategy of pre-discharge testing is unavailable, outpatient stress testing can be proposed, particularly for very low-risk patients (patients with negative serial ECGs, negative cardiac injury markers, and no medical history of ischaemic heart disease).

Organizational structure

Chest pain units occupy a designated area next to the emergency department. Alternatively, the chest pain unit is part of the emergency department primarily comprising personnel and process handling. Successful implementation of a CPU requires close coordination between emergency physicians and cardiologists.

A standard CPU should be supervised by a cardiologist, which can be in co-direction with an emergency physician, and should be equipped with a qualified doctor (or in training) for internal medicine/emergency medicine (see table 1). The medical staff should be supported by at least one nurse per four beds, who is dedicated to CPU/emergency/CCU. Higher level of quality accreditation requires the permanent presence of a qualified specialist in cardiology or emergency medicine and the supervision of the department by a cardiologist. In addition, dedicated nurses qualified for CPU are required. (24)

To ensure maximal benefits from the CPU concept, regular training (1/year) for all staff members is a prerequisite. Such training should include education and practical implementation of process of care for chest pain patients and should also encompass training in performing and interpreting diagnostic tests, such as ECG, biomarkers and noninvasive tests. Quality monitoring should be organized to measure and evaluate operational performance and adherence to evidence-based guidelines. Predefined quality measures can be extracted from hospital-based patient files. Participation in a specific CPU registry (local or supra-regional) with more continuous quality assessment is recommended for advanced level CPUs. A list of quality indicators for ACS patients has been recently published by the Acute Cardiovascular Care Association. (25)

Physical requirements

Chest pain units can be integrated into an emergency department with predefined continuous availability of 2 to 4 monitoring beds dedicated to chest pain patients. For more advanced CPU settings, a separate department adjacent to the emergency department is advisable. Such a department should contain at least 4 monitoring beds as well as a diagnostic/treatment room and a

waiting room. Permanent access to heart catheterization and PCI facilities should be possible. If a catheterization lab is not present at the hospital, predefined transfer protocols to a hospital with PCI facilities should be present and operational. This protocol includes the permanent availability of an intensive care mobile unit to transfer critically ill patients (cf STEMI) to a PCI hospital.

Technical requirements

Electrocardiogram:

Beyond the clinical status, the initial 12-lead ECG is the most informative tool for early risk stratification, and it should be obtained within 10 minutes of ED presentation.(26) The ECG provides important diagnostic and prognostic information and is pivotal in the triage process. Pre-hospital ECG is strongly recommended if patients attended by the emergency medical system (EMS) as it allows an early triage of the patients. (27) If the initial ECG is negative, repeat ECGs is recommended to unravel evolving myocardial ischaemia or injury. An alternative and more sensitive method is continuous ST-segment monitoring using 12 lead monitoring. Its utility in indicating subclinical ischaemia has been demonstrated during observations of mainly high-risk patients presenting with chest pain, whereas its yield in low-risk patients is limited.(28, 29) For this reason, it is not obligatory in the standard CPU criteria.

Additional ECG leads (posterior leads V7 through V9 and right-sided leads V3R through V4R) have been applied to increase the sensitivity of the ECG for the detection of myocardial ischaemia/injury.(30) (31)

Heart rhythm and blood pressure monitoring:

Myocardial ischaemia or injury may trigger life-threatening (e.g., ventricular tachycardia/fibrillation) or other arrhythmias (atrial fibrillation). For this reason, continuous rhythm monitoring, preferably centralised, is mandatory even in “presumed” low-risk patients until the diagnosis of ACS is ruled out. A resuscitation set with a defibrillator must be available in the chest pain unit. In addition, resuscitation and emergency plans should be in accordance with and integrated into hospital emergency protocols. Beyond tachy-arrhythmias, bradycardia due to atrio-ventricular block has been documented in patients with inferior ischaemia/injury and may require urgent pacing back-up. For this reason, a transcutaneous pacing modality should be available on the external defibrillator .

In addition to rhythm monitoring, blood pressure should be monitored for early detection of spontaneous or drug-induced (e.g., nitrates) blood pressure drops and to evaluate drug-related control of hypertension. Preferably, this can be performed by automatic non-invasive BP measurement at regular time intervals (e.g., every 15-30 minutes).

Cardiac biomarkers

Current guidelines recommend measurement of cardiac injury markers, which should include a highly sensitive and specific troponin assay for all patients with suspected myocardial ischaemia.(26) Cardiac troponins are more sensitive and specific markers of cardiomyocyte injury than creatine kinase (CK), its MB isoenzyme (CK-MB) and myoglobin. If the clinical presentation is compatible with myocardial ischemia, then a dynamic elevation (rise and fall) of cardiac troponin above the 99th percentile of healthy individuals indicates myocardial infarction.(32) With the use of the highly sensitive troponin,

serial troponin measurements at 3-hour intervals (0 h/3 h algorithm) have been shown to accurately rule in or rule out myocardial infarction. (26, 33) This requires the presence of a 24-hour emergency laboratory with turnaround time of <90 min (<60 minutes at advanced CPUs). If this cannot be achieved, point-of-care methods should be considered. However, the currently used point-of-care assays have lower diagnostic accuracy and are less thoroughly evaluated than the automated assays located in central laboratories.(34) With the development of more accurate troponin assays, shorter (0-1 h) rule in/rule out algorithms have been suggested. It should be stressed that for these shorter algorithms, the cut-off values are assay-specific and differ from the standard cut-off-values of 0 h/3 h algorithms.. Those short algorithms should always be integrated with a detailed clinical assessment and 12-lead ECG, and repeat blood sampling is mandatory in case of ongoing or recurrent chest pain. Those more recent techniques should be reserved for advanced level CPUs, but pending on growing expertise and on the development of more accurate assays, these short algorithms could be expanded to all CPUs in the future.

The utility of B-type natriuretic peptide has been demonstrated across a broad spectrum of ACS patients as a powerful prognostic risk indicator and as marker of heart failure. However, its diagnostic value for detecting ischaemia is limited.(35)

Beyond cardiac biomarkers, a general laboratory set containing electrolytes, renal and liver function, CRP and D-dimer should be available with turn-around times of <60 min.

Chest X-ray

Most patients with uncomplicated ACS have a normal chest X-ray. However, chest X-rays may reveal diagnostic clues for some other diseases related to the chest pain, such as aortic dissection, pericardial effusion, pleural effusion, pneumonia, and pneumothorax. Hence, chest X-ray should be available preferably within 30 min.

Transthoracic echocardiography

Regional wall motion abnormalities (RWMA) induced by ischaemia can be detected by rest echocardiography, but the extent of RWMA is highly dependent on the extent and duration of ischaemia/injury.(36, 37) Although normal rest echocardiography in chest pain patients is an indicator of low clinical risk, it may be insufficiently sensitive for the detection of subtle RWMAs that may reflect ischaemia in troponin-negative patients with unstable angina.(37) In addition, pre-existing wall motion abnormalities mitigate the diagnostic accuracy of detecting ischaemia. The diagnostic capability of echocardiography can be enhanced by the use of stress echocardiography (see later). In the absence of significant wall motion abnormalities, impaired myocardial perfusion detected by contrast echocardiography or reduced regional function using strain and strain rate imaging might improve the diagnostic and prognostic values of conventional echocardiography.(38, 39) Beyond evaluation of RWMA, transthoracic echocardiography is highly useful for detecting alternative pathologies associated with chest pain, such as pericardial effusion, ascending aortic syndromes, aortic valve stenosis, hypertrophic cardiomyopathy or right ventricular dilatation suggestive of acute pulmonary embolism.

Hence, this technique should be standard and available within 30 minutes. For advanced CPU settings, the permanent presence of an ultrasound equipment is required.

Specific instrumental requirements

Although pulse oxymetry is a standard test for each ED patient, more complete blood gas analysis might be highly useful in patients suspected of having a pulmonary embolism or suffering from hyperventilation. This test should be standard and available within 15 min. For advanced CPUs, a blood gas analysis machine should be integrated into the CPU department.

In some patients with respiratory insufficiency in the setting of an ACS, non-invasive ventilation may be required and should be available within 30 minutes. The permanent presence of non-invasive ventilation equipment is recommended for advanced CPUs.

In case the patient needs to be transported for additional examinations (e.g., catheterization lab), transport monitoring/ventilating systems should be available within 30 min. Those transport systems should be permanently present in the advanced CPU setting.

Management

Clinical risk scores

A useful approach to risk stratification has been the development of risk scores. Besides the Heartscore (see section patient evaluation), The Global Registry of Acute Coronary Events (GRACE) scoring system has been reported to accurately predict risk in patients presented with acute coronary syndromes. (40). Favourable (low risk) scores allow consideration for CPU management. Whereas the GRACE score provides information on ischaemic risk, specific risk scores have been developed to assess bleeding risk. The Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA guidelines (CRUSADE) bleeding risk score was developed from a cohort of NSTEMI-ACS patients undergoing invasive evaluation to estimate the patient's likelihood of an in-hospital major bleeding event. (41, 42) In patients being medically treated or on oral anticoagulants, the predictive value of these scores is not established.

Ischemic and bleeding risks need to be weighed in the individual patient, although many of the predictors of ischemic events are also associated with bleeding complications.

Non-invasive testing

In low-risk patients with normal baseline ECG and able to exercise, exercise ECG testing is frequently used as part of the CPU diagnostic protocol. The validity and safety of symptom-limited exercise ECG within 12 h after negative observation has been documented by multiple studies. (29, 43) To optimize the safety, the stopping rules are stricter, e.g., stop at onset of minimal criteria for ischemia (0.1 mV of ST-segment shift). Exercise ECG testing is however hampered by suboptimal sensitivity (68%) and specificity (77%) at detecting coronary artery disease and requires a (near) normal baseline ECG and maximal exercise (85% of age-predicted maximum heart rate). (44) The rationale of performing this easily-available test in the CPU setting is to risk stratify patients to a very low probability of ACS if the

exercise ECG test is negative and to allow early discharge with eventual out-patient cardiac re-evaluation. (43)

Stress imaging either pharmacologically- or exercise-induced is more sensitive and specific than ECG stress testing and is recommended in recent guidelines due to its greater diagnostic accuracy.(44) Echocardiography reveals stress-induced wall motion abnormalities whereas scintigraphy evaluates stress-induced perfusion defects. Resting myocardial scintigraphy, by detecting fixed perfusion defects suggestive of myocardial necrosis, can also be helpful for initial triage of patients presenting with chest pain without ECG changes or without elevated cardiac troponins. (45)

Multidetector computed tomography (MDCT) allows visualization of the coronary arteries. Recent studies have reported overall high negative predictive values for excluding ACS (by excluding CAD) and excellent outcomes in patients presenting to the emergency department with low to intermediate pre-test probability for ACS and a normal coronary CT angiogram.(26, 46, 47). Patients with high probability of CAD are not good candidates as MDCT does not allow an accurate assessment of stenosis severity. In addition, CT imaging can effectively exclude other causes of acute chest pain, such as pulmonary embolism, aortic dissection, pneumonia, and tension pneumothorax. (48)

Cardiac magnetic resonance (CMR) can assess both perfusion and wall motion abnormalities, and patients presenting with acute chest pain with a normal stress CMR have an excellent short- and midterm prognosis. CMR also permits detection of scar tissue (using late gadolinium enhancement) and oedema and may facilitate the differential diagnosis between infarction and myocarditis or Takotsubo cardiomyopathy.(49)

All of these imaging tests require more expertise and equipment than the standard exercise ECG and are also less likely to be available as a 24 h service.

When pre-discharge stress testing is unavailable, outpatient testing can be performed shortly after discharge in a selected group of patients. Those patients should be without further discomfort and with negative serial troponin and should receive an appointment schedule at the time of discharge.

Treatment

Patients with chest pain of unknown origin should be treated initially only with aspirin (or clopidogrel if contraindicated).

Once a specific diagnosis has been obtained, treatment should follow recommendations by the specific guidelines for the different diseases (STEMI, NSTEMI-ACS, unstable angina, pericarditis, acute pulmonary embolism, aortic dissection, hypertensive crisis, arrhythmias, cardiogenic shock, pneumonia, pneumothorax).

For STEMI patients, an urgent invasive evaluation is recommended **with target door-in-door-out time < 30 min if the patient needs to be transferred to a PCI centre and with target door-to-balloon time of < 60 min if a cathlab is present on site.** (25,50)

For NSTEMI-ACS patients, an invasive evaluation should be performed within 24 h for high-risk patients and within 72 h for moderate-risk patients. (26)

A discharge policy from the CPU to home or a hospital ward should be available.

Conclusion

CPUs are facilities with specific management protocols designed to facilitate and optimise the diagnosis of patients consulting with chest pain in the ED. The present document is intended to standardize and facilitate the installation of a CPU nearby the emergency department or as an integral part of the ED to improve the quality of care of our chest pain patients. In the future, these criteria can be applied in the certification process of chest pain units both at a standard and an advanced level.

Funding: none

Declaration of interests

Dr Ingo Ahrens

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Bayer Healthcare - Anticoagulants - <10 k€/year ; Daiichi Sankyo - Anticoagulants - <10 k€/year ; Astra Zeneca - Antithrombotic Therapy - <10 k€/year ; Sanofi Aventis - PCSK9 Inhibitors - <10 k€/year ; Bristol Myers Squibb - Anticoagulants - <10 k€/year ; Stealth Biotherapeutics - Mitochondrial Targeted Therapy - <10 k€/year

Prof dr H Bueno

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Astra Zeneca - Ticagrelor - <10 k€/year ; Bayer Healthcare - Aspirin - <10 k€/year ; Daiichi Sankyo - Prasugrel - <10 k€/year ; Eli Lilly - Prasugrel - <10 k€/year ; Novartis - Serelaxin, LCZ696 - <10 k€/year ; Bristol Myers Squibb - Apixaban - <10 k€/year ; Sanofi Aventis - Clopidogrel - <10 k€/year ; Pfizer - Apixaban - <10 k€/year ; Servier - ivabradine - <10 k€/year ; Ferrer Internacional - Trinomia (polypill) - <10 k€/year

- Payment to your Institution: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Astra Zeneca - Ticagrelor - <10 k€/year

Prof dr Marc Claeys

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Abbott Vascular - coronary interventions-mitraclip - <10 k€/year ; Astra Zeneca - Antithrombotic Therapy - <10 k€/year ; Daiichi Sankyo - Anticoagulants - <10 k€/year ; Bayer Healthcare - Anticoagulants - <10 k€/year ; ; Eli Lilly - antithrombotic therapy - <10 k€/year

Dr Roberto Diletti

- Payment to your Institution: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Abbott Vascular - coronary interventions - <10 k€/year

Dr Patrick Goldstein

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Astra Zeneca - ticagrelor - <10 k€/year ; Boehringer-Ingelheim - Thrombolytic - <10 k€/year ; Daiichi Sankyo - Prasugrel - <10 k€/year ; Bayer - rivoraxaban - <10 k€/year ; Daiichi Sankyo - endoxaban - <10 k€/year ; Boehringer-Ingelheim - praxbind - <10 k€/year ; Pfizer - apixaban - <10 k€/year

Dr Maddalena Lettino

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Astra Zeneca - Antithrombotic agents, statins - <10 k€/year ; Bayer Healthcare - Antithrombotic agents, anticoagulants - <10 k€/year ; Bristol Myers Squibb - Antithrombotic agents, anticoagulants - <10 k€/year ; Boehringer-Ingelheim - Anticoagulants - <10 k€/year ; Daiichi Sankyo - Antithrombotic agents, anticoagulants - <10 k€/year ; Eli Lilly - Antithrombotic agents - <10 k€/year ; Pfizer - Anticoagulants, statins - <10 k€/year ; Sanofi Aventis - Antithrombotic agents, anticoagulants, lipid lowering drugs (PCK9 inhibitors) - <10 k€/year ; Merck Sharp & Dohme - Statins, ezetimibe - <10 k€/year ; Aspen - Anticoagulants - <10 k€/year

Dr Thomas Munzel

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Bayer Healthcare - Xarelto - <10 k€/year ; Boehringer Ingelheim - Pradaxa - <10 k€/year ; Daiichi Sankyo - Edoxaban - <10 k€/year

- Payment to your Institution: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Abbott Vascular - Mitraclip, Absorb Stent - 10-50 k€/year

Dr Roberta Rossini

- Direct Personal payment: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Bayer - rivaroxaban - <10 k€/year ; Boehringer-Ingelheim - dabigatran - <10 k€/year ; Astra Zeneca - ticagrelor - <10 k€/year ; Daiichi Sankyo - edoxaban - <10 k€/year

- Research funding (departmental or institutional).

Bayer - rivaroxaban - <10 k€/year Pfizer - apixaban - <10 k€/year

Prof dr Peter Sinnaeve

- Payment to your Institution: Speaker fees, Honoraria, Consultancy, Advisory Board fees, Investigator, Committee Member, etc.

Astra Zeneca - ACS, trials - 10-50 k€/year ; Bayer - ACS & AF - <10 k€/year ; Boehringer-Ingelheim - ACS & AF - <10 k€/year ; GlaxoSmithKline - ACS & CAD, trials - <10 k€/year ; Duke University - trial management - 10-50 k€/year ; Merck Sharp & Dohme - CAD & ACS - <10 k€/year ; Sanofi Aventis - trials, consultancy - 10-50 k€/year Novartis - trials - <

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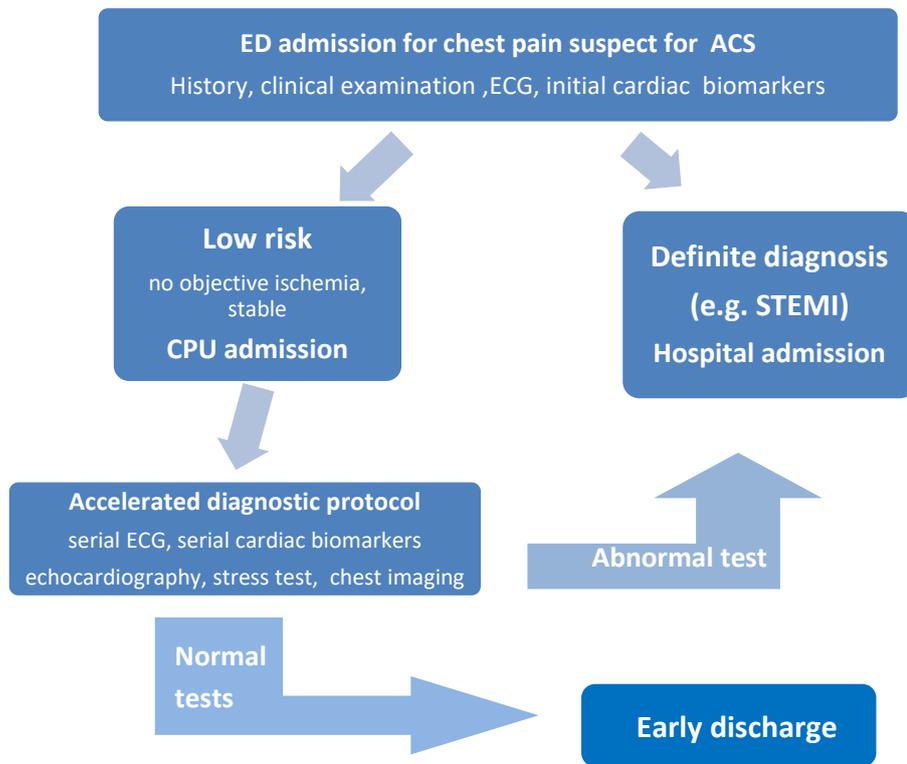
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Figure



ACS: acute coronary syndrome; CPU: chest pain unit STEMI; ED: emergency department; STEMI: ST segment elevation myocardial infarction.

Figure legend:

Flowchart depicting the evaluation of chest pain patients admitted in the emergency department.

Table 1 Organizational structure

	Standard criteria	Advanced criteria
Head of the unit	Cardiologist	Cardiologist
Medical personnel 365/24 h	Assistant doctor/resident under close supervision of cardiologist	Permanent specialist present
Nurse	Permanent presence, dedicated to CPU/emergency/CCU One nurse/4 beds.	Permanent presence, dedicated to CPU One nurse/4 beds
CPU training (at least 1/y)	Yes (1/year/person)	Yes (2/year/person)
Quality assessment	Yes (hospital based patient files)	Yes (hospital based patient files and participation in CPU registry)

CPU: chest pain unit

Table 2: Spatial requirements

	Standard criteria	Advanced criteria
Location	Integration in an emergency room unit with continuous availability of defined bed capacity.	Separate space (monitoring room, waiting room, treatment room, meeting room)
Bed capacity/availability	2-4 monitoring beds/ 365 d/24 h	≥4 monitoring beds/365 d/24 h
Catheterisation lab with PCI capacity	Available in hospital (365d/24h) or with pre-defined transfer protocol to hospital with PCI facilities	Available in the hospital /365 d/24 h

PCI: percutaneous coronary intervention

Table 3: Technical requirements

	Standard criteria	Advanced criteria
ECG with 12 lead monitoring	Yes (within 10 min after admission)	Yes (within 10 min after admission)
Rhythm monitoring	Yes	Yes
Blood pressure monitoring	Non-invasive BP	Non-invasive BP monitoring
Pulse oxymetry	Yes	Yes
Thorax X-ray	Available preferably within 30 min	Available within 30 min
Transthoracic echocardiography	Available preferably within 30 min	Ultrasound equipment present in the CPU
Resuscitation set including defibrillator/transcutaneous pacing	yes	Yes
Emergency plan	Yes	Yes
Laboratory	24-hour emergency laboratory, "turn-around time <90 min. Point of care tests (optional)	24 hour emergency laboratory "turnaround-time" <60 min, Point of care tests (optional)
Cardiac biomarkers	Serial trop I or T BNP/NT-proBNP yes	Serial High sensitive troponin I or T BNP/NT-proBNP
General (electrolyte, creatine, CRP, liver enzymes, D-dimer on indication)		yes
Blood gas analysis	Available preferably within 15 min	Integrated in the CPU
Transport monitoring	Available preferably within 30 min.	Equipment present in the CPU
Non-invasive ventilation	Available preferably within 30 min	Equipment present in the CPU
Transport ventilator	Available preferably within 30 min.	Equipment present in the CPU

BNP: brain natriuretic peptide, BP: blood pressure, CPU: chest pain unit, ECG: electrocardiogram, GRACE: Global Registry of Acute Coronary Events, Trop: troponin.

Table 4: Management

	Standard criteria	Advanced criteria
Clinical risk scores	Formally reported risk stratification, using preferable established ischaemic and bleeding risk scores such as Heartscore, GRACE score, CRUSADE	Formally reported risk stratification using established ischaemic and bleeding risk scores such as Heartscore, GRACE score, CRUSADE
Non-invasive testing for low-risk patients exercise test/ stress imaging coronary CT scan, CT thorax CMR	Available within reasonable time period	Available within reasonable time period
Medical treatment	According to evidence-based protocols (STEMI, NSTEMI, unstable angina, stable angina, pericarditis, acute pulmonary embolus, aorta dissection, hypertensive crisis, cardiogenic shock, arrhythmia's, pneumonia, pneumothorax)	According to evidence-based protocols (STEMI, NSTEMI, unstable angina, stable angina, pericarditis, acute pulmonary embolus, aorta dissection, hypertensive crisis, cardiogenic shock, arrhythmia's, pneumonia, pneumothorax)
Invasive evaluation STEMI Time delays	Transfer to PCI centre, with door-in-door-out time < 30 min	On site activation system at the cathlab with door-to-balloon time < 60 min
Invasive evaluation non-STEMI	<24 h for high risk (GRACE>140) <72 for moderate risk	<24 h for high risk (GRACE>140) <72 for moderate risk
CPU/hospital discharge policy	Available	Available

CMR: Cardiac magnetic resonance, CPU: chest pain unit, CRUSADE: Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA guidelines, FMC: first medical contact, MRI: magnetic resonance imaging, NSTEMI: non ST elevation myocardial infarction, PCI: percutaneous coronary intervention, STEMI: ST elevation myocardial infarction