

Fast Track Evaluation of Patients with Acute Chest Pain: Experience in a Large-Scale Chest Pain Unit in Israel

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ABSTRACT: **Background:** Many patients present to the emergency department with chest pain. While in most of them chest pain represents a benign complaint, in some patients it underlies a life-threatening illness.

Objectives: To assess the routine evaluation of patients presenting to the ED with acute chest pain by means of a cardiologist-based chest pain unit using different non-invasive imaging modalities.

Methods: We evaluated the records of 1055 consecutive patients who presented to the ED with complaints of chest pain and were admitted to the CPU. After an observation period and according to the decision of the attending cardiologist, patients underwent myocardial perfusion scintigraphy, multidetector computed tomography, or stress echocardiography.

Results: The CPU attending cardiologist did not prescribe non-invasive evaluation for 108 of the 1055 patients, who were either admitted (58 patients) or discharged (50 patients) after an observation period. Of those remaining, 444 patients underwent MDCT, 445 MPS, and 58 stress echocardiography. Altogether, 907 patients (86%) were discharged from the CPU. During an average period of 236 ± 223 days, 25 patients (3.1%) were readmitted due to chest pain of suspected cardiac origin, and only 8 patients (0.9%) suffered a major adverse cardiovascular event.

Conclusions: Utilization of the CPU enabled a rapid and thorough evaluation of the patients' primary complaint, thereby reducing hospitalization costs and occupancy on the one hand and avoiding misdiagnosis in discharged patients on the other.

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For Editorial see page 377

Over the past decade major advances have occurred in the triage and evaluation of patients presenting with chest pain. Nevertheless, considerable time and effort are still devoted to the diagnosis of patients presenting to the emergency department with chest pain, particularly since misdiagnosis of acute coronary syndrome can lead to dire consequences. Two-thirds of patients presenting to the ED with chest pain are admitted, and of these only 15% are ultimately diagnosed with ACS; of the remaining third who are discharged from the ED 5% eventually suffer an ACS [1-3]. In recent years chest pain units have provided thorough and rapid evaluation of patients presenting to the ED with chest pain [4,5], and studies have proved their cost effectiveness [6,7]. Accordingly, the recent American Heart Association/American College of Cardiology guidelines have emphasized the effectiveness of the CPU in the evaluation of patients with acute chest pain [8].

We present here our experience with the first large-scale CPU in Israel, which has implemented the current AHA/ACC guidelines and uses various contemporary non-invasive tests.

PATIENTS AND METHODS

We observed 1055 consecutive patients with chest pain who presented to the ED of the Sheba Medical Center and were admitted to the CPU between May 2006 and January 2008. Inclusion criteria for CPU admission included:

- age > 20 years
- chest pain that was a) considered by the attending physician to be suggestive of cardiac origin or required admission in order to rule out ACS, or b) not explained by local trauma
- absence of baseline electrocardiographic changes suggesting acute ischemia or infarction
- absence of elevated cardiac troponin T or I during evaluation in the ED.

ACS = acute coronary syndrome

AHA/ACC = American Heart Association/American College of Cardiology

ED = emergency department

CPU = chest pain unit

MDCT = multidetector computed tomography

MPS = myocardial perfusion scintigraphy

Exclusion criteria included conditions requiring intravenous medications or chronic nursing care. The CPU consists of five beds in an observation area adjacent to the ED. Patients are monitored and observed for a minimum of 12 hours after which a repeat ECG is performed and cardiac troponin is reassessed. Each patient in the CPU is monitored continuously by a monitor with an ST-segment analyzer. Patients are evaluated by a cardiologist who then decides on further management in the CPU. Patients who demonstrate ischemic ECG changes, repeated elevated troponin levels, ST changes or ongoing chest pain assumed by the treating cardiologist to be ischemic are admitted for further evaluation.

Patients without any of the above are referred to 64-slice multidetector computed tomography, stress (exercise, dipyridamole or dobutamine), single-photon emission computed tomography myocardial perfusion scintigraphy with thallium-201, or stress echocardiography. Exclusion criteria for MDCT are:

- age > 70 years
- prior history of coronary artery disease
- weight > 120 kg
- absence of sinus rhythm
- documented allergy to iodine contrast material
- abnormal renal function (serum creatinine \geq 1.4 mg/dl)
- use of metformin.

MDCT is the preferred modality for ruling out pulmonary embolism or an aortic source as the cause of chest pain ("triple rule out" protocol). All other patients undergo MDCT, MPS or stress echocardiography according to the discretion of the treating cardiologist and test availability (when more than one approach was potentially adequate). Patients with positive results (i.e., narrowing of the coronary arteries > 50% by MDCT, moderate-severe ischemia by MPS, or the appearance of regional wall motion abnormality by stress echocardiography) are admitted for further evaluation and undergo coronary angiography. Discharged patients are followed either by visiting the cardiac outpatient clinic or by telephone. Recurrent episodes of chest pain, repeated hospitalizations for chest pain or ACS, coronary angiography, percutaneous coronary intervention, coronary artery bypass grafting, and death were documented. For patients whose follow-up was not available we reviewed the Ministry of Interior's records to ascertain their vital status.

STATISTICAL ANALYSIS

All data were analyzed using SPSS software (version 12). Categorical variables were compared using the chi-square test. Student's independent *t*-tests were used for comparison of continuous variables. $P < 0.05$ was considered statistically significant.

The positive predictive value of each imaging modality was calculated as the percent of positive findings on coronary

angiography in patients who had either significant disease based on the MDCT or positive findings on MPS.

RESULTS

The study included 1055 consecutive patients presenting to the ED with acute chest pain who were evaluated in the CPU. Baseline characteristics of patients evaluated in the CPU are shown in Table 1. Following a clinical evaluation period of \geq 12 hours, 50 patients (5%) were discharged without further workup. Fifty-eight patients (5.5%) were hospitalized due to ECG or ST segment analyzer changes (N=18; ECG changes in 13 patients, ST analyzer changes in 6 patients), elevated cardiac troponin levels (N=16), ongoing chest pain episodes suggestive of angina (N=18), or other medical causes (N=12). The remaining 947 patients (89.5%) underwent MDCT (N=444, 42%), MPS (N=445, 42%) or stress echocardiography (N=58, 5.5%) as the initial non-invasive test. Patients undergoing MDCT were younger and less likely to have diabetes, hypertension, dyslipidemia, or a history of prior coronary artery disease compared to those who underwent MPS [Table 1]. None of the patients died during the evaluation period in the CPU.

Of the 444 patients who underwent MDCT, 266 (60%) had no evidence of CAD, 115 patients (26%) had findings of non-

CAD = coronary artery disease

Table 1. Baseline characteristics of entire population evaluated in the chest pain unit, and subgroups of the two major non-invasive modalities

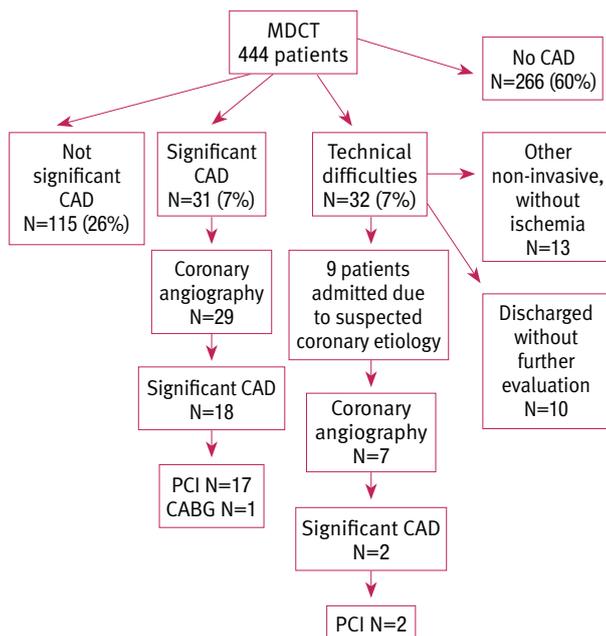
	CPU population (N=1055)*	MDCT (N=444)	MPS (N=445)	P**
Age (yrs)	54 \pm 12	50 \pm 10	57 \pm 12	< 0.001
Males	70%	66%	74%	0.016
Smoking	35%	34%	35%	0.78
Hypertension	40%	28%	50%	< 0.001
Diabetes mellitus	16%	9%	22%	< 0.001
Dyslipidemia	53%	41%	64%	< 0.001
Family history	27%	30%	25%	0.085
Known CVD	24%	7%	36%	< 0.001
Prior angiogram	21%	4%	33%	< 0.001
Prior PCI	16%	1%	26%	< 0.001
Prior CABG	3.7%	0.2%	5.8%	< 0.001
Prior stroke	2.6%	1.5%	2.7%	0.25
PVD	1%	0.2%	1.5%	0.07

* Entire patient population includes those admitted and discharged without non-invasive evaluation, and those undergoing stress echocardiography.

** P value for comparison between the MDCT and MPS groups.

CVD = cardiovascular disease, PVD = peripheral vascular disease.

Figure 1. Outcome of patients evaluated by multi-detector computed tomography (MDCT)



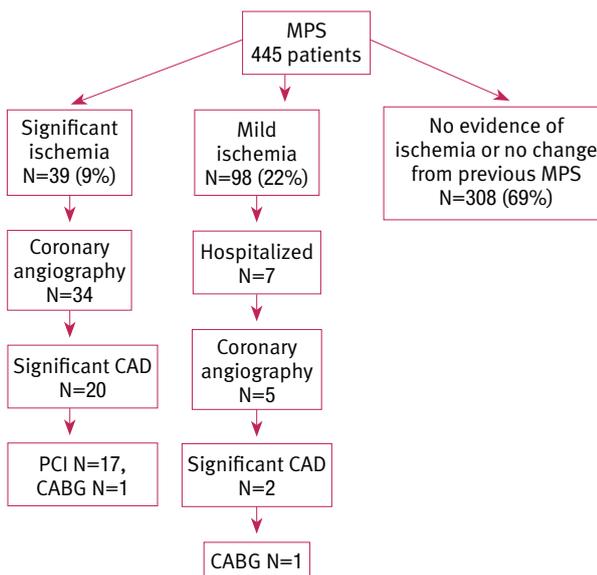
CAD = coronary artery disease, CABG = coronary artery bypass grafting, PCI = percutaneous coronary intervention

significant CAD, and 31 (7%) had significant CAD [Figure 1]. MDCT was interpreted as non-diagnostic in 32 patients (7%) due to a breathing artifact, arrhythmia and accelerated heart rate, blooming artifacts due to gross coronary calcifications, or body habitus. Patients with normal or non-significant CAD were discharged, except for five patients who were hospitalized for further investigation of non-cardiac causes.

All 31 patients with significant CAD on MDCT underwent coronary angiography, except for two: one patient had significant coronary disease in one small distal branch and was discharged with conservative treatment; the other self-discharged against medical advice. Of the remaining 29 patients in whom coronary angiography was performed, significant CAD was confirmed in 18, resulting in a positive predictive value of 62%. PCI was performed in 17 of them and CABG in one. Of the 32 patients with non-diagnostic MDCT, 13 underwent an alternative non-invasive evaluation (12 MPS, 1 stress echocardiography), which was interpreted as normal and they were discharged. Seven patients underwent coronary angiography, two of whom had significant CAD and underwent PCI accordingly. Three patients were hospitalized for further observation, and nine were discharged without further investigation, according to the decision of the attending cardiologist.

PCI = percutaneous coronary intervention
CABG = coronary artery bypass grafting

Figure 2. Outcome of patients evaluated by myocardial perfusion scintigraphy (MPS)



CABG = coronary artery bypass grafting, CAD = coronary artery disease, PCI = percutaneous coronary intervention

Significant extracardiac findings warranting further investigation or accounting for a cause of chest pain were demonstrated in 103 patients (23%), including pulmonary emboli (N=1), large hiatal hernia (N=9), aortic dilatation (aortic diameter exceeding 35 mm) (N=17), coronary anomalies (N=3), pulmonary nodules necessitating further follow-up (N=28), and mediastinal mass (N=1). Ultimately, of the 444 patients who underwent MDCT, 403 (91%) were discharged. Forty-one patients (9%) were hospitalized, 38 of them due to a suspected coronary etiology.

Of the 445 patients who underwent MPS as the primary strategy, 308 (69%) had either no evidence of ischemia or no change from a previous abnormal MPS scan, 98 (22%) had mild ischemia, and 39 (9%) had significant ischemia [Figure 2]. All patients with no evidence of new ischemia were discharged except for two who were hospitalized for non-cardiac causes. All patients with mild ischemia were discharged, except for seven who were hospitalized for further evaluation: five underwent coronary angiography that demonstrated significant CAD in two (one underwent CABG). Of the patients with significant ischemia 34 underwent coronary angiography. The diagnosis of significant CAD was confirmed in 20 patients, resulting in a positive predictive value of 59%. PCI was performed in 17 of them and CABG in 1. Ultimately, of the 445 patients who initially underwent MPS, 400 (90%) were discharged and 46 (10%) were hospitalized, of whom 44 had a suspected coronary etiology.

Table 2. Outcome of patients in the chest pain unit and follow-up of discharged patients

Patient outcome in the CPU	N = 1055
Hospitalized	152 (14%)
Angiography	122 (12%)
Significant CAD/ACS	88 (8.3%)
Percutaneous intervention	63 (5.9%)
Coronary artery bypass grafting	4 (0.4%)
Death	0
Follow-up of discharged patients	N = 907
Completed follow-up	821 (91%)*
Days (mean \pm SD, days)	236 \pm 223
Recurrent chest pain	226 (28%)
Readmission due to chest pain	44 (5.8%)
Readmission due to cardiovascular chest pain	25 (3.1%)
Angiography	27 (3.6%)
Percutaneous intervention	11 (1.5%)
MACE	8 (0.9%)

*Of the remaining 86 patients (9%) for whom complete follow-up data were not available, after reviewing the Ministry of Interior's records for 84 patients; all were alive after an average follow-up of 2 years.

MACE = major adverse coronary events (i.e., death, recurrent ACS)

Fifty-eight patients underwent stress echocardiography, 55 of whom were negative for ischemia, 1 had a non-conclusive test, and 2 had a positive test. All patients with negative findings were discharged. One patient with an inconclusive finding was hospitalized for further evaluation. Both patients with positive results were hospitalized, one of whom underwent coronary angiography without evidence of significant CAD.

We were able to obtain a complete follow-up for 821 (91%) of the 907 patients discharged from the CPU. The average follow-up period was 236 \pm 223 days. Patient outcome during follow-up is presented in Table 2. During the follow-up period 226 patients (28%) continued to complain of chest pain, but only 44 (5.8%) were readmitted for recurrent chest pain. Moreover, the number of patients admitted for chest pain suspected to be of cardiovascular etiology was even smaller and 11 patients (1.5%) underwent PCI during follow-up. The number of patients suffering major adverse coronary events (i.e., acute coronary syndrome and/or death) was very small (8 patients, 0.9%). Four of them had an adverse event within one month of discharge.

Of the remaining 86 patients (9%) for whom complete follow-up data were not available, after reviewing the Ministry of Interior's records we were able to verify the records for 84 patients who were all alive after an average period of at least 2 years. The remaining two patients were not Israeli citizens and thus follow-up data were not available for them.

DISCUSSION

In the present study we summarize our experience in the evaluation of a large cohort of consecutive patients who presented to the ED with acute chest pain and were admitted to a CPU. Evidence of myocardial damage or ischemia was present in 4.4% (N=46) of the patients during the observation period, in accordance with reports on ACS leading to erroneous ED discharge [1-3]. Ninety percent of the cohort (N=947) underwent further evaluation using non-invasive modalities. In 60% of patients with a positive non-invasive test, coronary angiography revealed severe CAD necessitating coronary intervention, with no significant differences between the non-invasive modalities used. These results are in accord with previous research of patients with acute chest pain; however, a high degree of caution is warranted in the interpretation of non-invasive studies [9-13]. Of the 907 patients discharged from the CPU (86% of the entire cohort), very few had major adverse coronary events during an average follow-up period of at least 6 months.

The two main imaging modalities we used to determine the existence of symptomatic CAD – namely, MDCT and MPS – differed in their baseline patient characteristics mainly due to the MDCT exclusion criteria. However, it should be stated that our goal was not to compare these various modalities but rather to demonstrate their role in the daily evaluation of patients with acute chest pain. While for some patients MDCT might be a reasonable or even preferred alternative to MPS or stress echocardiography (i.e., patients with suspicion of pulmonary embolism or dissecting aortic aneurism), it might not be so for others.

Utilization of the CPU enabled patients with acute chest pain to receive a comprehensive evaluation. Those in need of further evaluation, mainly by coronary angiography, eventually underwent the procedure early during their hospital course, while those without evidence of CAD or with a non-significant disease were discharged, thereby limiting hospitalization costs and bed occupancy while avoiding misdiagnosis of discharged patients with acute chest pain.

LIMITATIONS

The lack of randomization introduces an unwanted bias. However, the main purpose of this study was to describe the day-to-day reality and routine use in the CPU of different modalities in a large unselected population with acute chest pain. Modality availability was an issue that resulted in a relatively small number of patients undergoing stress echocardiography. Our study was not designed to assess either the management of the entire ED population evaluated for chest pain or the cost effectiveness of the utilization of the CPU. Further studies are needed regarding this issue.

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