

Differences in diagnostic evaluation and clinical outcomes in the care of patients with chest pain based on admitting service: The benefits of a dedicated chest pain unit

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Background: Chest pain is one of the most common complaints of patients presenting at emergency departments. However, the most appropriate diagnostic evaluation for patients with chest pain but without acute coronary syndrome remains controversial, and differs greatly among institutions and physicians. At our institution, patients with chest pain can be admitted to an internist-run hospitalist service, a private attending service, or a cardiologist-run Chest Pain Unit. The goal of the present study was to compare the management and outcomes of patients admitted with chest pain based on admitting service.

Methods: The charts of 750 patients (250 consecutive patients per service) with a discharge diagnosis of chest pain were studied retrospectively.

Results: Patients admitted to the Chest Pain Unit were younger and had a lower prevalence of known coronary artery disease, hypertension, or diabetes, but a similar prevalence of other risk factors compared with the other groups. Sixty percent of the patients in the Chest Pain Unit underwent stress myocardial perfusion imaging as their primary diagnostic modality (vs 22% and 12% of patients in the hospitalist and private services, respectively; $P < .001$). In contrast, 35% of the patients admitted to the hospitalist service underwent rest echocardiography (vs 8% and 17% of patients in the Chest Pain Unit and private services, respectively; $P < .001$). Finally, 47% of the patients in the private service underwent coronary angiography as their primary diagnostic modality (vs 6% and 10% of patients in the Chest Pain Unit and hospitalist services, respectively; $P < .001$). The length of stay was shortest for patients in the Chest Pain Unit (1.4 ± 1.2 days vs 3.9 ± 3.4 days and 3.5 ± 3.6 days in the hospitalist and private services, respectively; $P < .001$), even when corrected for patient age and number of risk factors. Readmission within 6 months was lowest for patients in the Chest Pain Unit (4.4% vs 17.6% and 15.2% in the hospitalist and private services, respectively; $P < .001$).

Conclusions: The results of this study demonstrate that a highly protocolized chest pain unit, using myocardial perfusion imaging as primary diagnostic modality, results in a decreased length of stay and readmission rate. (*J Nucl Cardiol* 2008;15:186-92.)

Key Words: Chest pain unit • coronary artery disease • myocardial perfusion imaging • chest pain

Chest pain (CP) is a very common presenting complaint, resulting in as many as 8 million emergency

department visits across the United States each year.¹ Approximately 60% (5 million) of these patients are admitted to hospitals, of whom half do not have acute coronary syndrome (ACS) as the cause of their chest pain. Our results showed that approximately 37% of patients presenting with CP but without ACS have coronary artery disease (CAD). Because of this relatively high prevalence of CAD in this population, we adopted a strategy of provocative stress testing before hospital discharge.² It was shown previously that patients who do not undergo diagnostic testing after their index visit for CP have increased rates of return visits for CP and

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adverse events such as myocardial infarction and death, compared with those who undergo diagnostic testing.²

While there are clear guidelines for the evaluation and treatment of patients who present with acute myocardial infarction or unstable angina,³⁻⁸ the evaluation and treatment of patients presenting at an emergency department with CP but without ACS are controversial and differ greatly among medical centers and individual physicians.⁹⁻¹⁸ Many medical centers have established chest pain units (CPUs) to handle the high volume of patients who are admitted to the hospital with chest pain, in an attempt to standardize their approach and expedite and improve the care of these patients. Many CPUs rule out patients for ACS and send them home. Some CPUs perform exercise stress testing after ACS has been ruled out.^{12,18} However, as demonstrated in our previous study, approximately 40% of patients presenting with CP fail to achieve sufficient exercise effort to reach heart-rate or treadmill-time goals, and thus require pharmacologic testing with imaging.² In addition, stress testing combined with myocardial perfusion imaging (MPI) is much more sensitive for the detection of CAD, especially in patients with single-vessel or two-vessel CAD.¹⁹

It was the goal of this study to determine the differences in diagnostic testing strategies used by various hospital services, and to observe whether a dedicated CPU, primarily using stress MPI for the evaluation of these patients, alters the length of stay (LOS) and readmission rates for CP or ACS. An additional goal was to evaluate whether provocative stress testing with MPI is an appropriate strategy for patients with chest pain who have been ruled out regarding ACS but who are at low to intermediate risk for CAD.

METHODS

We performed a retrospective chart review of 750 patients (250 consecutive patients in three different services), starting at July 1, 2004, who had an ICD-9 discharge diagnosis of CP (DRG 143). Thus, patients with acute myocardial infarction or unstable angina were not included in the analysis. All patients had normal or nondiagnostic electrocardiograms (ECGs) at 0 and 6 hours after presentation to the Emergency Department, and all had normal serum troponin-I levels at 0 and 6 hours of presentation. All patients were admitted and underwent at least 24 hours of telemetry monitoring. Patients were admitted to one of three services: a hospitalist unit served by eight experienced internists, a private medicine attending service, or a cardiologist-run Chest Pain Unit. Every patient in each service was covered by medicine house staff 24 hours per day.

The decision about admitting particular patients to particular services depended on a number of factors, including whether a patient had a private outpatient physician, whether that physician had privileges to admit patients to the hospital, and whether he or she wanted the patient admitted to his or her

service. Patients who did not have a private physician were admitted to either the hospitalist service or the CPU. This was decided by emergency-medicine attending physicians. Admission to the CPU was predicated on CP as the major complaint of the patient, and on the patient manifesting few other uncontrolled comorbidities.

The CPU at Beth Israel Medical Center is a highly protocolized virtual unit (ie, there are no fixed hospital beds), with twice-daily rounds by an attending cardiologist. Patients who are felt to be at >5% pretest probability of having a coronary event according to the Framingham risk score²⁰ are scheduled for stress testing with MPI, unless they have had previous diagnostic evaluation in the past year or there is a compelling alternative explanation for the patients' symptoms as assessed by the attending cardiologist with a special interest in the area of chest pain. The goal of the CPU is not only to determine whether a patient's CP is cardiac in origin, but to determine the alternative causes of the CP once CAD has been eliminated as the cause. Myocardial perfusion imaging is used liberally in the CPU to detect or rule out significant CAD. The CP pathway at our hospital encourages use of MPI for all such patients, regardless of admitting service.

The use of echocardiography, stress MPI, and coronary angiography in each patient was stratified by each of the three services. In addition to clinical history and risk factors, the length of stay of patients in each service, and the readmission rates for chest pain, shortness of breath, or ACS for a predetermined follow-up period of 6-months, were evaluated.

Statistical Analysis

Data were analyzed using the Statistical Analysis System software. A bivariate analysis was conducted to assess factors associated with readmissions. Categorical variables were analyzed using the chi-square statistic. Continuous variables whose distribution met normality assumptions were analyzed using the *t* test. When normality assumptions were not met, the nonparametric median test was used. Length of stay was compared between units, using the median test. Correlation coefficients were analyzed between pairs of variables using the Spearman correlation coefficient. A logistic regression analysis was conducted to assess predictors of LOS >3 and >4 days. Length of stay was also analyzed as a continuous variable in a multivariate regression analysis. Multivariate logistic regression was also used to assess independent predictors of the dichotomous variable readmission. *P* < .05 was considered statistically significant.

RESULTS

The clinical characteristics of the three groups of patients were similar but not identical (Table 1). Patients in the CPU were younger (52 ± 12 years, SD) compared with patients in the hospitalist (58 ± 15 years, SD) or private (62 ± 15 years, SD) services (*P* < .001). Patients in the CPU also had a lower prevalence of hypertension, diabetes mellitus, and known CAD (previous history of

Table 1. Baseline characteristics of patients in each service

Characteristics	Hospitalist (n = 250)	Private (n = 250)	Chest Pain Unit (n = 250)	P value
Age, mean (SD), y	58 (15)	62 (15)	52 (12)	<.001
>60 y, n (%)	102 (41)	124 (50)	47 (19)	
Gender				
Female, n (%)	132 (53)	126 (50)	122 (49)	.67
Male, n (%)	118 (47)	124 (50)	128 (51)	
History of HTN, n (%)	155 (62)	161 (64)	114 (46)	<.001
History of DM, n (%)	77 (31)	69 (28)	39 (16)	<.001
History of increased cholesterol, n (%)	84 (33)	107 (43)	92 (37)	.10
Previous history of CAD, n (%)	73 (29)	106 (42)	29 (12)	<.001
History of smoking, n (%)	110 (44)	105 (42)	104 (42)	.84
Family history of MI, n (%)	49 (20)	49 (20)	68 (27)	.06

Demographics and risk factors for all patients in the three services are listed. Patients admitted to the Chest Pain Unit were younger and had a lower prevalence of diabetes mellitus and known coronary artery disease.

CAD, Coronary artery disease; DM, diabetes mellitus; HTN, hypertension; MI, myocardial infarction.

P value for age was calculated using the *t* test. All other P values were calculated using the chi-square test.

myocardial infarction, coronary angioplasty or stent placement, angiographic or imaging evidence of obstructive lesions, or a coronary artery bypass graft). Patients in the three services were similar in terms of gender and other risk factors, including a family history of myocardial infarction, smoking, and dyslipidemia (Table 1).

It was observed that patients admitted to the three services underwent different diagnostic evaluations. Stress MPI was utilized much more by the CPU, where 60% of patients in that service underwent stress MPI, compared with 22% and 12% in the hospitalist and private services, respectively ($P < .001$). Thirty-five percent of patients on the hospitalist service underwent two-dimensional echocardiography as their primary diagnostic modality, compared with 17% and 8% in the private service and CPU, respectively ($P < .001$). Coronary angiography was used much more in the private service, with 47% of those patients undergoing angiography, compared with 10% and 6% of hospitalist and CPU patients, respectively ($P < .001$) (Figure 1).

Length of stay was shortest in the CPU, with a mean LOS of 1.4 ± 1.2 days, whereas the LOS in the hospitalist and private groups was 3.9 ± 3.4 days and 3.5 ± 3.6 days, respectively ($P < .001$) (Figure 2). Readmission to the hospital within 6 months of the index visit with further episodes of CP or shortness of breath thought to be secondary to cardiac causes, or ACS, was lowest in the CPU, with a rate of 4.4%, whereas the readmission rate of patients in the hospitalist and private groups was 17.6% and 15.2%, respectively ($P < .001$) (Figure 2).

Although the population groups were not identical in terms of risk factors for CAD, a low correlation between

risk factors and LOS was observed ($r = 0.139$, $P < .001$). Length of stay was shortest in the CPU, irrespective of number of risk factors ($P < .001$) (Figure 3). The data were also analyzed by subgroups to account further for these differences. Patients were stratified according to CAD status and age (Table 2). Patients in the CPU had a shorter LOS, regardless of their CAD status or age ($P < .001$). A lower readmission rate was observed in the CPU in patients without CAD or patients ≤ 60 years of age ($P = .003$ and $P < .001$, respectively). Similar findings were observed in patients with CAD and patients aged >60 years (Table 2). The lack of significance in these two analyses was likely secondary to smaller population sizes.

Results obtained from both sets of multivariate analyses conducted for LOS predictors were very similar. Variables in the model included male gender, age >60 years, hypertension, diabetes mellitus, dyslipidemia, CAD, a family history of myocardial infarction, smoking, and admission to the CPU. After controlling for these variables, patients admitted to the CPU were still found to have a significantly shorter LOS compared with the other two services (odds ratio [OR] = 0.04, 95% confidence interval [CI] = 0.014-0.139, $P < .001$). A logistic regression analysis was also conducted to assess independent predictors of the dichotomous variable "readmission." The variables noted above were included in this model as well. The only variables remaining in the final model were CAD and admission to the CPU. Overall, patients with a history of CAD were more likely to have a readmission than patients without CAD (OR = 2.00, 95% CI = 1.27-3.16, $P = .003$), but after controlling for CAD, patients admitted to the CPU were still less

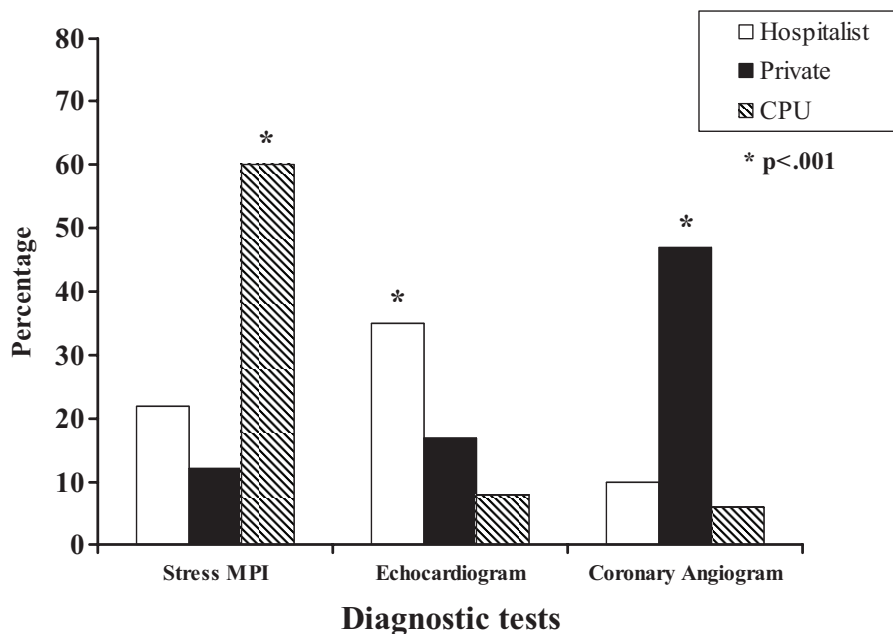


Figure 1. Utilization of diagnostic tests among the different services. *CPU*, Chest Pain Unit; *MPI*, myocardial perfusion imaging.

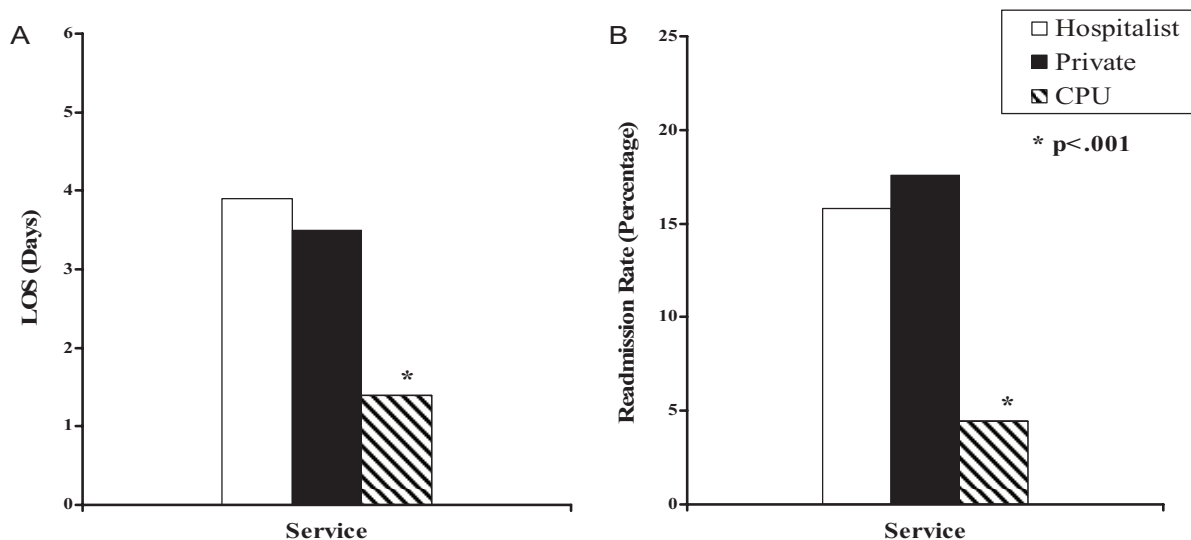


Figure 2. A, Hospital length of stay (LOS) in days for all patients in each service. The length of stay was found to be shortest in patients admitted to the Chest Pain Unit (CPU). **B,** Histogram of readmission rates within 6 months. The readmission rate was lowest in patients admitted to the CPU.

likely to have a readmission (OR = 0.28, 95% CI = 0.145-0.545, $P < .001$).

DISCUSSION

There are no universally accepted guidelines for the evaluation and treatment of patients presenting with CP but without ACS. The optimal diagnostic approach for these

patients is controversial, and differs greatly between medical centers, individual physicians, and different CPUs.⁹⁻¹⁸ Many patients are sent home after ACS has been ruled out, for follow-up with their primary medical doctors. These patients' outcomes are not well-known, but previous studies showed that the prevalence of CAD in patients such as these at other institutions is quite low, ie, in the range of 5%-15%.²¹⁻²⁴ Patients in our setting were shown to have as

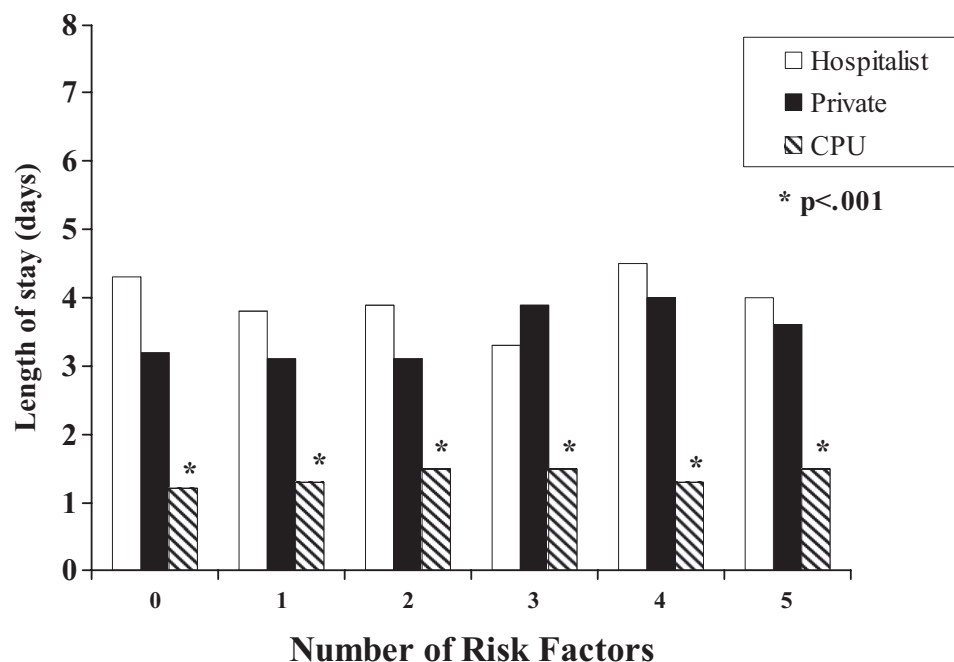


Figure 3. Hospital length of stay for all patients, adjusting for number of coronary risk factors. Regardless of the number of risk factors, patients admitted to the Chest Pain Unit (CPU) had a significantly shorter length of stay.

high as a 37% prevalence of CAD, which may reflect the urban location of our medical center and the lack of outpatient care that these patients receive.²

This was a single-center study, conducted at a tertiary-care medical center in the Lower East Side of

New York City. The patient population that is seen at such an institution is diverse. All patients included in this study presented with CP and underwent the same initial workup, including two negative serum cardiac biomarkers, and two negative or nondiagnostic ECGs. In this

Table 2. Outcomes stratified by CAD status and age

	Hospitalist	Private	Chest Pain Unit	P value
Length of stay (days), mean \pm SD, and median*				
All patients	3.9 \pm 3.4, 3	3.5 \pm 3.6, 2	1.4 \pm 1.2, 1	<.001
Patients without CAD	3.8 \pm 3.4, 3	2.9 \pm 3, 2	1.4 \pm 1.2, 1	<.001
Patients with CAD	4.1 \pm 3.5, 3	4.3 \pm 4, 3	1.4 \pm 0.7, 1	<.001
Patients aged \leq 60 y	3.6 \pm 3.4, 3	3.1 \pm 3.2, 2	1.3 \pm 1.1, 1	<.001
Patients aged >60 y	4.3 \pm 3.4, 3	3.9 \pm 3.8, 3	1.7 \pm 1.1, 1	<.001
Readmissions, % (n) [†]				
All patients	17.6 (44)	15.2% (38)	4.4% (11)	<.001
Patients without CAD	14.1% (25)	11.1% (16)	4.1% (9)	.003
Patients with CAD	26% (19)	20.8% (22)	6.9% (2)	.099 (.048) [‡]
Patients aged \leq 60 y	19.6% (29)	14.3% (18)	3.9% (8)	<.001
Patients aged >60 y	14.7% (15)	16.1% (20)	6.4% (3)	.25 (.10) [‡]

CAD, Coronary artery disease.

*P values were calculated using median test.

[†]P values were calculated using chi-square test.

[‡]Because the hospitalist and private attending services had comparable readmission rates, the two units were combined, and the two analyses were conducted again, with the respective P values shown in parentheses.

study, our goal was to determine the differences in diagnostic testing strategies used by different hospital services, to observe whether there were differences in LOS and readmission rates, and whether provocative stress testing with MPI is an appropriate strategy for patients with CP in whom ACS is ruled out.

Although it was shown that it may be safe for patients with CP but without ACS to undergo an outpatient stress test within 72 to 96 hours after discharge,²⁵ the population seen at an urban medical center such as ours often does not keep appointments. If referred for outpatient diagnostic testing, appointments are likely to be missed. It was previously demonstrated that patients who are ruled out for an acute coronary syndrome without definitive diagnostic testing have an increased rate of myocardial infarction and death.² It is therefore important to know if a patient has CAD, because that information will change the management significantly.

The difference in diagnostic testing among the three services was striking despite uniform guidelines in our hospital. The internist-run hospitalist service used echocardiography significantly more than the other services, even though this modality, without stress, does not have a high yield for the diagnosis of CAD in patients without infarction. Patients in the private attending service were known to their physicians and had a higher rate of known CAD. This likely played a role in the decision to perform coronary angiography. However, a diagnosis of CAD does not mean that the patients' presenting CP was secondary to myocardial ischemia. A functional test such as stress MPI can help determine whether there is significant ischemia associated with the CP in patients with known CAD, which can further guide therapy and determine the need for cardiac catheterization.²⁶

Length of stay was significantly shorter in patients admitted to the CPU, irrespective of age, the presence of CAD, or number of risk factors. This decrease was largely due to twice-daily attending rounds with prompt decision-making, as opposed to the more traditional work-flow in standard services.

Although risk-factor analysis suggests that patients admitted to the hospitalist or private services should have an increased incidence of CAD, there was no statistically significant difference in the diagnosis of CAD as a cause for patient admissions among the three services (CPU, 14%; hospitalist, 9%; private, 10%; $P = .27$).

Regarding the limitations of this study, patients were not randomized to one of the three services. Therefore, it may be argued that the groups compared in the study were not similar, and that LOS was shorter and the readmission rate was lower for patients in the CPU because they were younger and had a lower prevalence of CAD than patients in the other two services. However, this group represents a large por-

tion of the patients who present with CP. To account for these differences, the data were also analyzed by subgroups, and the findings remained consistent (Table 2). Furthermore, no correlation was found between the number of risk factors and LOS, and patients admitted to the CPU still had a shorter hospital LOS, regardless of the number of risk factors ($P < .001$) (Figure 3). No relationship was found between readmission rate and number of risk factors.

CONCLUSION

The results of this single-center observational study suggest that a highly protocolized CPU results in decreased LOS and readmission rate to the hospital, and that the use of provocative stress MPI in patients with a low to intermediate risk for CAD is an appropriate strategy for patients who present with CP but without ACS.

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