A CLINICAL TRIAL OF A CHEST-PAIN OBSERVATION UNIT FOR PATIENTS WITH UNSTABLE ANGINA

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ABSTRACT

Background Nearly half of patients hospitalized with unstable angina eventually receive a non–cardiac-related diagnosis, yet 5 percent of patients with myocardial infarction are inappropriately discharged from the emergency department. We evaluated the safety, efficacy, and cost of admission to a chest-pain observation unit (CPU) located in the emergency department for such patients.

Methods We performed a community-based, prospective, randomized trial of the safety, efficacy, and cost of admission to a CPU as compared with those of regular hospital admission for patients with unstable angina who were considered to be at intermediate risk for cardiovascular events in the short term. A total of 424 eligible patients were randomly assigned to routine hospital admission (a monitored bed under the care of the cardiology service) or admission to the CPU (where patients were cared for according to a strict protocol including aspirin, heparin, continuous ST-segment monitoring, determination of creatine kinase isoenzyme levels, six hours of observation, and a study of cardiac function). The CPU was managed by the emergency department staff. Patients whose test results were negative were discharged, and the others were hospitalized. Primary outcomes (nonfatal myocardial infarction, death, acute congestive heart failure, stroke, or out-of-hospital cardiac arrest) and use of resources were compared between the two groups.

Results The 212 patients in the hospital-admission group had 15 primary events (13 myocardial infarctions and 2 cases of congestive heart failure), and the 212 patients in the CPU group had 7 events (5 myocardial infarctions, 1 death from cardiovascular causes, and 1 case of congestive heart failure). There was no significant difference in the rate of cardiac events between the two groups (odds ratio for the CPU group as compared with the hospital-admission group, 0.50; 95 percent confidence interval, 0.20 to 1.24). No primary events occurred among the 97 patients who were assigned to the CPU and discharged. Resource use during the first six months was greater among patients assigned to hospital admission than among those assigned to the CPU ($P=0.003$ by the rank-sum test).

Conclusions A CPU located in the emergency department can be a safe, effective, and cost-saving means of ensuring that patients with unstable angina who are considered to be at intermediate risk of cardiovascular events receive appropriate care. (N Engl J Med 1998;339:1882-8.)

IN the United States, approximately 5 million people annually undergo evaluation in the emergency department for acute chest pain, at a cost of more than $6 billion.[1,2] Most of these patients are admitted to the hospital; their average length of stay is 1.9 days, and the mean hospital charge for their care is $4,135.[3] Of these patients, those with unstable angina present the greatest challenge to clinicians. Approximately 6 to 15 percent of all patients with unstable angina are at low risk for a cardiovascular event in the short term (according to the Agency for Health Care Policy and Research [AHCPR] guidelines for unstable angina[4]), with a 30-day rate of events (death or nonfatal myocardial infarction) of less than 1 percent.[5,6] Observation units, located in the emergency department, have recently become popular for treating such patients.[7-10] In contrast, 54 percent of all the patients with unstable angina have an intermediate risk of an event, with a 30-day event rate of 7 percent.[4,6] Clearly, safe and effective care of patients in this group could have a substantial effect on both the cost and the outcome of this common cardiac condition.

We conducted a community-based, prospective, randomized, controlled clinical trial to compare the safety, efficacy, and use of resources of a chest-pain unit (CPU) with those of routine hospital admission for patients with unstable angina who were at intermediate risk for cardiovascular events in the short term.

METHODS

Patient Population

From November 21, 1995, through March 18, 1997, patients coming to the emergency department of the Mayo Clinic with acute chest pain that met the criteria for unstable angina were prospectively evaluated. All residents of Olmsted County, Minnesota, and the surrounding nine counties who were 18 years old or older were eligible for entry into the study. Unstable angina was defined as one of the following: symptoms of angina at rest, lasting longer than 20 minutes; new-onset angina on exertion,

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meeting the Canadian Cardiovascular Society criteria for class 3 or higher; recent acceleration of preexisting angina to at least Canadian Cardiovascular Society class 3; variant angina; or post–myocardial infarction angina.[4,11] Each patient's assessment in the emergency department included a medical history taking, physical examination, and electrocardiography. On the basis of these baseline data, patients were stratified into groups at low, intermediate, and high risk for short-term cardiovascular events, according to the AHCPR guidelines. Patients whom we determined to be at intermediate risk were considered eligible for study entry (except for those with ST-segment depression in several electrocardiographic leads, who were considered to be at high risk and were excluded). Patients also were excluded if they had ST-segment elevation on the electrocardiogram; an obvious noncardiac cause of the chest pain; unstable angina associated with a low or high risk according to the AHCPR criteria; or a coexisting condition requiring hospitalization.

Randomization and Intervention

After patients gave written informed consent, they were randomly assigned to routine hospital admission or to observation in the CPU with stratification according to age, sex, whether they had had a previous myocardial infarction, and whether they had previously undergone a revascularization procedure.

The CPU consisted of four beds in a separate area of the emergency department. It was equipped with event monitors and continuous ST-segment monitoring and was staffed by a full-time nurse. In patients randomly assigned to the CPU, the total level of creatine kinase MB isoenzyme (CK-MB)[12,13] was measured at the time of randomization (time zero) and two and four hours after randomization. The isoenzyme was measured with a two-site fluorogenic enzyme immunoassay (Opus Plus, Behring Diagnostics, San Jose, Calif.), standardized to match measurements obtained with a chemiluminescent immunoassay (ACS-180, Chiron Diagnostics, Norwood, Mass.). Results were considered positive if at any time during the stay in the CPU the total CK-MB level exceeded 9.6 ng per milliliter (the upper limit of normal in our laboratory). If the results were positive, the patient was admitted to a monitored bed under the care of the cardiology service or to the coronary care unit with a presumptive diagnosis of myocardial infarction. Patients were also admitted from the CPU to the hospital if they had symptoms of recurrent chest pain consistent with recurrent unstable angina or important ventricular dysrhythmia or had another medical condition warranting admission. All the patients randomly assigned to the CPU were observed for a minimum of six hours, and all received 325 mg of aspirin. The decision whether to administer heparin intravenously was made by the emergency department physician according to clinical criteria.

For all patients who "passed" (completed) the observation period in the CPU, a cardiac-function study was performed at the end of the observation period. A treadmill exercise test was performed if the patient was judged to be able to walk on a treadmill at a rate of at least 2.5 miles per hour and if there was no electrocardiographic evidence of left ventricular hypertrophy, ventricular paced rhythm, left bundle-branch block, or the Wolff–Parkinson–White syndrome. Otherwise a nuclear stress test (with thallium or sestamibi imaging) or echocardiographic stress test (with exercise or a pharmacologic agent) was performed. Treadmill and nuclear stress studies were routinely available between 7 a.m. and 10:30 p.m., on both weekdays and weekends. All the results of the cardiac-function studies were interpreted by staff cardiologists. The Duke treadmill scoring system was used to score the performance on the treadmill exercise test[14]; a score of 5 or more was considered negative. The results of imaging studies were classified as negative, equivocal, or positive. All the patients with negative results on a treadmill or imaging study were discharged to their homes. Patients with a treadmill score of less than 5 or equivocal or positive results on an imaging study were admitted to the hospital. All those who were discharged from the CPU returned to the outpatient clinic within 72 hours for a follow-up evaluation with a staff cardiologist.

In contrast, patients who were randomly assigned to "usual care" were admitted to a monitored bed under the care of the cardiology service. This service consists of a team of internal-medicine residents or cardiology fellows under the supervision of a staff cardiologist. Although the medical therapy provided by this service was frequently similar to the care given in the CPU, it was not standardized, and the care of individual patients varied in diagnostic approach and details of therapy. The typical duration of hospitalization was one to three days.

Monitoring for Safety

The study was approved by the Mayo Foundation Institutional Review Board. A safety-monitoring committee consisting of two senior cardiologists and two internists not involved in study design, data collection, or analysis reviewed all the data on clinical outcomes and patient safety. This committee had full authority to stop the study in the event that serious questions about safety arose. An O'Brien–Fleming adjustment for two interim analyses and one final analysis was used to set the alpha levels for analyzing the primary end points.

Study Outcomes

The primary study outcome was defined as the first occurrence of one of the following: nonfatal myocardial infarction, death, acute congestive heart failure, stroke, or out-of-hospital cardiac arrest. Secondary outcomes included additional visits to the emergency department for chest pain or the use of any of the following tests and procedures: cardiac revascularization (including percutaneous transluminal coronary angioplasty and coronary-artery bypass grafting), cardiac diagnostic tests (including angiography, nuclear cardiology studies, and echocardiography), and any hospitalization for cardiac care during the six months after randomization.

We developed an approach to comparing the use of resources related to cardiovascular care between the two patient groups. First, resource-based relative-value units for each of the cardiac tests and procedures were obtained from published sources. For items without published resource-based relative-value units (such as hospital days), an estimate was made by calculating the cost (not the charges) associated with one hospital day that included cardiovascular care, dividing this cost by the average cost attributed to one relative-value unit ($34.62), and multiplying by the number of days that resource was used. For example, the number of resource-based relative-value units assigned to cardiac bypass would include the value published for the bypass procedure and that calculated for the associated hospital days. Next, a relative weight for each procedure, test, or admission was computed by dividing the cost in resource-based relative-value units by that of a standard treadmill test (see the Appendix). With these weights, a total score was then computed for each patient by adding together the weighted frequencies of procedures, tests, and hospital admissions for that patient during the first six months after random group assignment. Hospitalizations for cardiac care (both the initial and any subsequent admissions) were given a relative weight based on the length of stay for each separate hospital admission during the first six months after randomization.

Statistical Analysis

In the main analysis we examined the first occurrence of one or more of the primary outcomes within the first 30 days after the index visit to the emergency department as well as survival without a primary event within the first 6 months after the visit. The sample size provided a power of 80 percent to detect differences of 8 to 10 percentage points in the rates of adverse events. A logistic-regression analysis was used to assess the risk of a primary event during the first 30 days. An odds ratio for patients randomly assigned to the CPU as compared with those randomly assigned to regular hospital admission was estimated after adjustment for the stratification factors (age, sex, whether there had been previous myocardial infarction, and whether there had been a previous revascularization procedure). A Cox proportional-haz-

ards regression model was used to analyze survival without a primary cardiac event during the first six months. The CPU:hospital hazard ratio was estimated from the model, again after adjustment for the stratification factors. A similar analysis examined survival free of the following cardiovascular events: myocardial infarction, acute congestive heart failure, stroke, cardiac arrest, revascularization, or arrhythmia. Wilcoxon's rank-sum test was used to compare the standardized scores for use of health care services between patients randomly assigned to the CPU and those assigned to hospital admission.

RESULTS

We evaluated 2517 patients who came to the emergency department with chest pain (Table 1). Of these, 2012 patients were excluded for the following reasons: residency outside the nine-county region (308 patients), transfer from another hospital (285), non–English speaking (13), serious coexisting condition (214), other cardiac diagnoses (195), a noncardiac explanation for the chest pain (408), high risk according to AHCPR criteria[4] (199), low risk according to the criteria (216), and the clinical judgment of the emergency department physician (174). In addition, 81 patients who were eligible refused to participate. Therefore 424 eligible patients remained available for randomization. With the exception of those who were at low risk for a cardiac event and those who presented with noncardiac chest pain, the patients who were excluded typically were older and more likely to have had a myocardial infarction or a previous revascularization procedure than those who underwent randomization. Overall, the randomly assigned patients were approximately 58 years old, and 56 percent were men. There were no significant differences in base-line variables between the patients randomly assigned to hospital admission and those assigned to the CPU (Table 2).

Of the 212 patients assigned to the CPU, 60 met the criteria for hospitalization before stress testing. In the cases of another 55 patients, the results of the cardiac-function study performed in the CPU (treadmill exercise test or nuclear stress study) were positive or indeterminate. These patients were also hospitalized. The remaining 97 patients in the CPU had an uneventful observation period and a negative result on the functional study and were discharged, with cardiologic follow-up to be performed on an outpatient basis. Thus, assuming that all patients with intermediate risk would have been admitted routinely to the hospital, 45.8 percent of hospital admissions (97 of 212) were prevented. The median length of stay in the CPU was 9.2 hours. Patients who were admitted during the night tended to have a longer observation period because of the reduced availability of stress tests at night.

The mean age of the patients who were discharged

TABLE 1. BASE-LINE CHARACTERISTICS OF 2517 PATIENTS WHO CAME TO THE EMERGENCY DEPARTMENT WITH CHEST PAIN, NOVEMBER 1995 THROUGH MARCH 1997.*

STATUS IN STUDY	NO. OF PATIENTS	MEDIAN AGE	MALE SEX	PREVIOUS MYOCARDIAL INFARCTION	PREVIOUS REVASCULARIZATION
		yr	percent		
Exclusion					
Residence out of area	308	66 (57–74)	64	31†	45†
Pain of noncardiac origin	408	54 (42–71)	52	13‡	13‡
Serious coexisting condition or frailty	214	82 (71–88)	44	37	23
First language not English	13	72 (60–80)	31	31	38
Evolving or recent myocardial infarction, recent coronary-artery bypass grafting, or death in the emergency department	199	68 (56–76)	66	33	27
Direct admission or transfer to hospital	285	66 (55–74)	63	38§	36§
Other cardiac conditions	195	71 (59–79)	55	29	30
Low risk of cardiac event according to AHCPR criteria	216	53 (41–67)	46	11	9
Decision of emergency-department physician	174	70 (58–76)	56	34	43
Refusal to participate	81	66 (52–75)	53	35	33
Random assignment after entry					
Chest-pain unit	212	57 (46–68)	56	14	14
Hospital admission	212	59 (48–70)	56	15	14

*Values in parentheses are the interquartile range. AHCPR denotes the Agency for Health Care Policy and Research.

†Value is estimated from a sample of 160 of the 308 out-of-area patients.

‡Value is estimated from a sample of 263 of the 408 patients with noncardiac pain.

§Value is estimated from a sample of 183 of the 285 directly admitted or transferred patients.

TABLE 2. BASE-LINE CHARACTERISTICS OF PARTICIPATING PATIENTS ACCORDING TO STUDY GROUP.*

CHARACTERISTIC	CHEST-PAIN UNIT (N=212)	HOSPITAL ADMISSION (N=212)	P VALUE†
Age (yr)	57.7±1.0	59.2±1.0	0.20
Male sex (%)	56.1	55.7	0.97
Previous myocardial infarction (%)	13.7	15.1	0.66
Previous revascularization procedure (%)	13.7	13.7	0.98
Diabetes mellitus (%)	7.6	10.8	0.22
Family history of congestive heart disease (%)	35.4	39.1	0.37
History of hypertension (%)	36.3	41.0	0.30
Smoking status (%)‡			0.35
Current smoker	17.0	13.7	
Former smoker	37.3	38.7	
Never smoked	45.8	46.2	
Initial electrocardiogram (%)§			0.73
Normal	49.5	49.5	
Abnormal¶	45.3	43.9	
ST-segment depression ≥1 mm	0.9	1.9	
Left bundle-branch block	3.8	2.5	
T-wave inversion	8.0	11.3	
Indeterminate	5.2	6.6	
Highest median cholesterol level (mg/dl)‖	239	232	
Lowest median high-density lipoprotein cholesterol level (mg/dl)‖	40	41	

*Plus–minus values are means ±SE.

†P values are based on logistic-regression analysis.

‡For smoking status, any smoking was compared with never having smoked.

§For the initial electrocardiogram, abnormal results were compared with normal and intermediate results.

¶Values are percentages of the total number of patients assigned to the respective groups.

‖To convert values for cholesterol to millimoles per liter, multiply by 0.02586. For total cholesterol, data were available for 172 patients assigned to the chest-pain unit and 188 patients assigned to hospital admission, and for high-density lipoprotein cholesterol data were available for 155 and 168 patients, respectively.

after evaluation in the CPU was 53 years, as compared with 62 years for those who later required hospital admission. However, after adjustment for age, electrocardiographic results, and smoking status, no other base-line variable, including previous myocardial infarction, previous revascularization, diabetes mellitus, or hypertension, was a significant predictor of the disposition of a patient (discharge to home or admission to the hospital).

Event rates for the primary outcomes according to study group are summarized in Table 3. During hospitalization, the 212 patients in the hospital-admission group had 13 nonfatal myocardial infarctions and 2 episodes of acute congestive heart failure, whereas the 212 patients in the CPU group had 5 nonfatal myocardial infarctions, 1 death from cardiovascular causes, and 1 episode of acute congestive heart failure (Table 3). Logistic-regression analysis demonstrated that after adjustment for age, sex, presence or absence of a previous myocardial infarction, and presence or absence of a previous revascularization procedure, the risk of a primary outcome event in the first 30 days did not differ significantly between patients assigned to the CPU and those assigned to hospital admission (odds ratio, 0.50; 95 percent confidence interval, 0.20 to 1.24). The total number of primary events during the first six months was similar in the two groups; there were 23 events among 18 patients (8.5 percent) in the hospital-admission group and 18 events among 14 patients (6.6 percent) in the CPU group (P=0.94; hazard ratio, 0.98; 95 percent confidence interval, 0.49 to 1.95). Only two patients (less than 1 percent; one admitted to the hospital after random assignment to the CPU and one randomly assigned to hospital admission) were lost to follow-up during the first six months.

The Kaplan–Meier curve for survival without any primary cardiovascular events is shown in Figure 1. Most of the events that did occur happened within the first several days after randomization, with essentially no differences between the two groups after the first few weeks of observation. All the primary events that occurred in the CPU group were in the subgroup of 114 patients who were eventually admitted to the hospital because they met the criteria for hospital admission during the observation period or because the results of a treadmill exercise test or a nuclear stress study were positive or indeterminate. No primary events occurred among the patients who were initially assigned to the CPU and then discharged.

There was no significant difference in the proportions of patients in the two groups who had any of the secondary outcomes over the six-month follow-up. However, the proportion of patients who made return visits to the emergency department was higher in the CPU group than in the hospital-admission group (8.0 percent vs. 4.2 percent, P=0.14).

Two additional analyses examined survival free of the following cardiovascular events: myocardial infarction, acute congestive heart failure, stroke, cardiac arrest, revascularization, and arrhythmia. Overall, event-free survival did not differ significantly (P=0.72) between patients in the CPU group and those in the hospital-admission group (Fig. 2A). The Kaplan–Meier curves for event-free survival during the six-month follow-up period are shown in Figure 2B for three groups (direct hospital admission, CPU and discharge to home, and CPU and hospital admission). These results clearly illustrate that most of the events occurred within the first month after randomization and that the majority of events in the CPU group occurred in the subgroup of patients who were later admitted to the hospital.

The use of selected cardiac tests and procedures and of hospitalization for cardiac care during the first six months of follow-up was significantly greater in the

TABLE 3. RATES OF INITIAL PRIMARY OUTCOMES ACCORDING TO STUDY GROUP.*

TIME OF EVENT	HOSPITAL ADMISSION (N=212)	CHEST-PAIN UNIT (N=212)	P VALUE	ODDS OR HAZARD RATIO (95% CI)
	no. (%)			
Early events				
During hospital stay	15 (7.1)†	7 (3.3)‡	0.15	0.50 (0.19–1.29)
Within 30 days after discharge from hospital	2 (0.9)§	1 (0.5)¶		
Total within 30 days	17 (8.0)	8 (3.8)	0.13	0.50 (0.20–1.24)
Late events (after 30 days and within 6 mo)‖	1 (0.5)**	6 (2.8)††		
Total events	18 (8.5)	14 (6.6)	0.94	0.98 (0.48–1.95)

*P values were based on logistic regression or proportional-hazards regression, incorporating age, sex, previous myocardial infarction, and previous revascularization procedures. CI denotes confidence interval.

†Events were myocardial infarction in 13 patients and congestive heart failure in 2.

‡Events were myocardial infarction in five patients, congestive heart failure in one, and death in one.

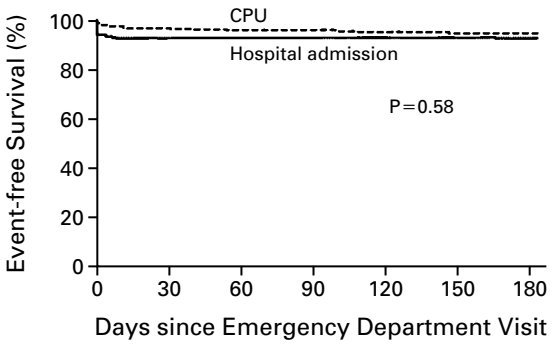
§Events were myocardial infarction in one patient and congestive heart failure in one.

¶The single event was death.

‖One patient in each group was lost to follow-up during the first six months.

**The single event was congestive heart failure.

††Events were myocardial infarction in two patients, congestive heart failure in three, and death in one.



NO. AT RISK

CPU	203	200	200	198	197
Hospital admission	194	194	194	194	194

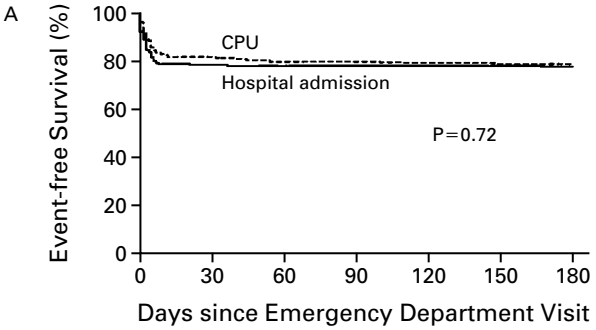
Figure 1. Kaplan–Meier Curves for Survival Free of a Primary Cardiovascular Event in the Hospital-Admission Group and the Chest-Pain Unit (CPU) Group.

The primary outcome was defined as the first occurrence of one of the following: nonfatal myocardial infarction, death, acute congenital heart failure, stroke, or out-of-hospital cardiac arrest.

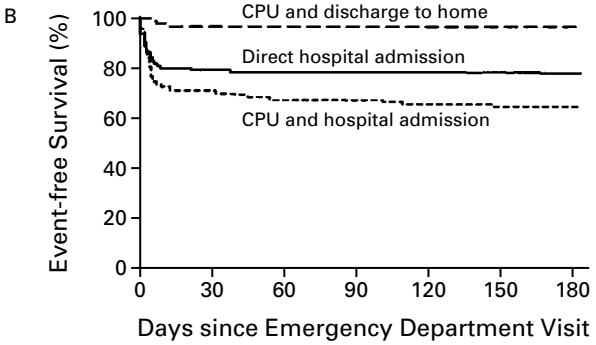
hospital-admission group (P=0.003 by the rank-sum test). On the basis of the difference in (log-transformed) standardized scores, a patient in the hospital-admission group would incur, on average, approximately 61 percent more costs related to cardiac care during the six months, including the index visit to the emergency department, than a patient in the CPU group. Resource use was lowest among the 97 patients in the CPU group who were discharged to their homes. In fact, 91 of these 97 patients (94 percent) had scores for resource use that were lower than the minimal score among all the patients in the hospital-admission group.

DISCUSSION

Using the methods of a randomized, controlled clinical trial, we demonstrated that a CPU located in the emergency department can be used to identify patients with intermediate-risk unstable angina who can be safely discharged rather than admitted to the hospital. Our results indicated that there is a 45.8 percent reduction in the rate of hospital admission for patients with intermediate-risk unstable angina and no increase in the rate of adverse events after a median stay in the CPU of 9.2 hours. Thus, we have demonstrated that the CPU intervention, including the use of a stress test for patients at intermediate risk, is both safe and effective. Our analyses also suggest that this intervention can save resources. Resource use was significantly greater in the hospital-admission group than in the CPU group. This difference was attributable primarily to the relatively low use of resources by the subgroup of patients in the CPU group who were discharged to their homes. This finding demonstrates the capability of a CPU intervention to classify patients with intermediate-risk unstable angina into subgroups at high and low risk for a cardiac event as well as into subgroups associated with high and low levels of resource use.



No. at Risk					
CPU	173	169	169	167	166
Hospital admission	166	165	165	165	165



No. at Risk					
CPU and discharge to home	93	93	93	93	93
Direct hospital admission	166	165	165	165	165
CPU and hospital admission	80	76	76	74	73

Figure 2. Kaplan–Meier Curves for Survival Free of Specific Cardiovascular Events.

This analysis considered the first occurrence of death, nonfatal myocardial infarction, acute congestive heart failure, stroke, out-of-hospital cardiac arrest, revascularization, or arrhythmia. Panel A shows the survival of patients randomly assigned to the chest-pain unit (CPU) and those assigned to hospital admission. Panel B shows the survival of the patients randomly assigned to the CPU and then discharged to their homes, assigned to the CPU and subsequently admitted to the hospital, and assigned initially to hospital admission.

Previous studies have documented the effectiveness of a CPU intervention in the care of patients with unstable angina who are at low risk for a cardiac event.[7,8,10,12,15-20] However, the usefulness of these studies is limited because the low-risk subgroup comprises only 15 percent of patients with unstable angina and because the studies were conducted in referral centers, raising questions about the extent to which the results can be generalized.[5] Our study was a randomized, controlled clinical trial of a CPU intervention in a population-based cohort of patients at intermediate risk. Whereas previous reports attempted to subdivide patients according to whether they had a cardiac diagnosis, we devised a strategy, based on clinical observation, cardiac monitoring, selected laboratory tests, and a cardiac-function study, that can safely and effectively distinguish patients who can be treated as outpatients from those requiring hospital care.

Our study has some potential limitations. Although the stratified, randomized, controlled design provided excellent internal validity, we cannot ensure its external validity — that is, that the patients who entered the study were representative of the general population of patients with intermediate-risk unstable angina who come to our emergency department. Although our study population was limited to residents of the local community (10 counties in Minnesota), the study was conducted in a large, referral-based center with access to expertise in interventional and noninterventional cardiology. The feasibility of this strategy in smaller hospitals is unknown. In addition, the population of this 10-county region is approximately 95 percent white and generally middle class. Therefore, the results cannot be generalized to the management of unstable angina in other racial or socioeconomic groups.

In summary, our results indicate that a CPU based in the emergency department can identify patients with intermediate-risk unstable angina who can be safely discharged to their homes and can save resources. Nonetheless, we emphasize the importance of clinical judgment in determining a patient's suitability for admission to a CPU and the need for early cardiovascular follow-up for all patients discharged to their homes.

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APPENDIX

RESOURCE-BASED RELATIVE-VALUE UNITS AND WEIGHTED SCORES FOR CARDIAC TESTS AND PROCEDURES IN THE ANALYSIS OF RESOURCE USE.

TEST OR PROCEDURE	RESOURCE-BASED RELATIVE-VALUE UNIT	NORMALIZED WEIGHTED SCORE*
Treadmill exercise test, all protocols	3.3	1.0
Multiple gated acquisition scanning		
Resting	7.1	2.1
Exercise	10.6	3.2
Thallium imaging		
Resting	9.0	2.7
Adenosine	14.2	4.3
Dobutamine	14.2	4.3
Dipyridamole	14.2	4.3
Exercise	14.2	4.3
Sestamibi imaging		
Resting	14.2	4.3
Adenosine	14.2	4.3
Dobutamine	14.2	4.3
Exercise	14.2	4.3
Echocardiography		
Resting	5.8	1.8
Dobutamine	8.0	2.4
Exercise	8.0	2.4
Vectorcardiography	1.6	0.5
Cine computed tomography	7.7	2.3
Admission to chest-pain unit and discharge†	23.3	7.1
Direct admission to monitored bed and discharge†	82.9	25.1
Admission to chest-pain unit, to monitored bed, and discharge	103.7	31.4
Angiography, including ancillary vessels†	88.7	30.6
Percutaneous transluminal coronary angiography, including ancillary vessels†	273.0	94.3
Coronary-artery bypass grafting, including ancillary vessels†	595.7	205.7

*Weighted scores were normalized according to the resource-based relative-value unit for the treadmill exercise test.

†Resource-based relative values were imputed from the actual costs of services for typical patients.

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