Published in final edited form as:

Crit Pathw Cardiol. 2016 June ; 15(2): 56–59. doi:10.1097/HPC.0000000000000071.

Utility of the Diamond-Forrester classification in stratifying acute chest pain in an academic chest pain center

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Abstract

Background—Because the Diamond-Forrester (DF) model is predictive of obstructive coronary artery disease (CAD), it is often used to risk stratify acute chest pain patients. We sought to further evaluate the clinical utility of the DF model within a chest pain evaluation center (CPEC).

Methods—Consecutive patients with chest pain and no known CAD or evidence of active ischemia were asked to participate in a prospective registry. Patients were classified based on cardiovascular risk factors, age, and DF classification. We compared data from the ED course, Duke Activity Status Index (DASI) and Seattle Angina Questionnaire (SAQ), hospitalization rates, and results of testing between patients with typical angina versus all others. Multivariate logistic regression was also used to assess for predictors of CAD by CTCA or positive ETT.

Results—Among 209 patients, 163 had atypical/noncardiac and 46 had typical chest pain. The SAQ and DASI scores were lower in the typical chest pain group (indicating more severe impairment), which were not statistically significantly different. There were no significant differences in risk factors or the results of CTCA, ETT, or cardiac catheterization. In the regression analysis, SAQ score, DASI score, and DF classification were not predictive of CAD by CTCA. Worsening angina frequency scores on the SAQ were marginally associated with positive ETT (OR 1.04, $p=.04$).

Conclusion—In a contemporary low-risk acute chest pain population, typical angina, as defined by the DF classification was not predictive of CAD or useful for identifying patients with higher symptom burden.

Keywords

Chest pain; Diamond Forrester; Duke Activity Status Index; Seattle Angina Questionnaire

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Data were presented at the American College of Cardiology meeting, March 2015, San Diego, CA

Conflict of Interest: none declared

Introduction

Chest pain is an exceedingly common presenting symptom in the emergency department (ED). In order to risk stratify patients presenting with acute chest pain, multiple standardized tools have been developed, including the GRACE, TIMI, and HEART risk models.^{1–3} These strategies are good for identifying high risk patients, but the management of low to intermediate risk patients remains controversial. Furthermore, while the negative predictive values of these tools may be useful for ruling out ACS, their positive predictive value is poor and can result in unnecessary admissions. Many institutions have created chest pain observation units, in which patients undergo extended observation with laboratory testing, serial electrocardiograms, and some form of ischemic testing for coronary artery disease (CAD).

For the past 30 years, the Diamond Forrester classification (DF) has been used to estimate the pretest probability of coronary artery disease in patients with chest pain and been validated prospectively in numerous trials.^{4–6} The DF was developed in an outpatient setting and has not been well studied in acute chest pain observation center (CPEC) patients.⁷ A notable advantage of the DF model is its simplicity, using only age, gender, and chest pain details to estimate the likelihood of obstructive CAD, which could represent a low-cost alternative for further risk-stratifying low-risk patients.

To better define the utility of the DF classification system in low-risk acute chest pain patients, we applied it to a sample of patients from a single CPEC. We hypothesized that patients with symptoms typical of angina, based on the DF assessment, would be more likely to have a positive test for CAD than patients with less typical symptoms.

Methods

At our facility, patients with low to intermediate CV risk are evaluated in a CPEC. The design of this physical unit and an example of the triage decision tool used to stratify risk has been previously described.⁸ In brief, patients presenting to the ED with chest pain are immediately triaged to a bed in the main ED where they receive an ECG and point of care troponin. Patients having ischemic ECG changes, positive cardiac biomarkers, hemodynamic instability, or a history of CAD are not referred to the CPEC. Those included in the CPEC are then evaluated for potential CAD.

The CPEC is staffed by a physician assistant or nurse practitioner trained in the assessment of chest pain and supervised by an ED physician. The decision on further clinical testing is based on a custom decision support tool, with decision making based on patients' perceived risk. The two primary testing modalities were exercise treadmill testing (ETT) and computed tomography coronary angiography (CTCA).

All consecutive patients in our CPEC were asked to participate in a prospective registry. As part of inclusion in the registry, patients were self-administered standardized, validated clinical instruments including the Duke Activity Status Index (DASI) and Seattle Angina Questionnaire (SAQ). The DASI is a 12-item questionnaire used to measure patient functional capacity, in which each item represents an activity of daily living weighted for its

known metabolic equivalent. Scores range from zero to 58.2, with higher numbers representing better functional capacity.⁹ The SAQ measures quality of life in patients with angina and is measured across 5 different scales: angina severity, angina frequency, physical limitation, treatment satisfaction, and quality of life. Higher scores represent better quality of life and lower symptom burden.¹⁰ The treatment satisfaction scale was not included in this study as patients had not yet been treated at the time of the survey. Data on patient demographics, symptoms, medications, risk factors, comorbidities, and results of testing and CPEC course were recorded in a central database using REDcap software.¹¹

All subjects in the CPEC registry provided written documentation of informed consent and our research protocol was approved by our Institutional Review Board. Using Diamond and Forrester's criteria, we created two cohorts of patients: those with typical angina symptoms, and those with atypical or noncardiac symptoms. Between these groups, we compared data from the ED course, DASI and SAQ scores, hospitalization rates, and results of testing between patients with typical angina versus all others.

All ETTs were interpreted by an attending physician using standard criteria for ischemia: horizontal or downsloping ST depression 1mm in contiguous leads, exercise induced hypotension, or ventricular arrhythmias. Results of each ETT were used to calculate a Duke treadmill score.¹² CTCA was performed on an Aquilion One CT scanner (Toshiba, Tustin, California) with 320 detectors and images reviewed on a Vital workstation (Vitrea, Minnetonka, Minnesota) by an interdisciplinary team of trained radiologists and cardiologists. Results were classified as normal if the calcium score was zero and there were no coronary lesions, nonobstructive if all lesions were < 50%, or obstructive if at least 1 lesion was ≥ 50%.

The primary outcome of our analysis was to compare the rate of positive CAD testing between the two cohorts. Multivariate logistic regression using a forward conditional method was also used to assess for predictors of CAD by CTCA and positive ETT. Proportions were compared by the chi-square test and continuous data by the Student's *t* test. Statistical analyses were performed using SPSS, version 21 (IBM, Armonk, New York).

Results

A total of 209 low to intermediate risk patients were included in the study, with 163 classified as having atypical or noncardiac chest pain and 46 as having typical chest pain. Demographic information is shown in table 1. Subjects were predominantly female and middle-aged in both groups. Patients with typical angina by DF classification were more likely to have had a prior stroke (3.2% vs. 0.6%, *p*=0.03), hyperlipidemia (32.6% vs. 14.1%, *p*=0.004), and to be treated with a statin (13% vs. 4.9%, *p*=0.05).

Clinical characteristics of patients stratified by DF classification are shown in Table 2. The DASI score and SAQ scores across four scales were lower in the typical chest pain group (indicating more severe impairment), but the difference was not statistically significant (see Figure 1). For the primary outcome analysis, there were no statistically significant

differences in the presence of CAD by CTCA or coronary angiography or in positive ETTs between patients with typical angina versus all others.

In the logistic regression analysis, SAQ score, DASI score, and DF classification were not predictive of CAD by catheterization or CTCA. Worsening angina frequency score on the SAQ was marginally associated with a positive ETT (OR=1.04, p=.04).

Discussion

In this single center observational cohort study of low risk acute chest pain patients, symptoms typical of angina were not associated with detection of obstructive CAD. The clinical relevance of this finding is that in populations such as the one studied, symptoms alone may not be suitable for making decisions about who should undergo further testing for CAD.

Other contemporary studies of low risk acute chest pain patients have demonstrated similarly low diagnostic yield.^{13–15} The resulting challenge is that both clinicians and researchers have attempted to develop strategies that accurately identify patients at acceptably low risk to facilitate safe discharge from the ED. An approach that has demonstrated favorable results is the HEART score. This risk score consists of five clinical elements: history (i.e. symptoms), electrocardiogram, age, risk factors, and troponin.³ A score of <4 using this system is associated with a less than 2% risk of adverse cardiac events within 6 weeks of discharge.¹⁶

When applying the HEART score, clinicians are asked to rate the patients symptoms as slightly suspicious (0 points), moderately suspicious (1 point), or highly suspicious (2 points). The lack of precision for this component of the score makes some clinicians wary to apply it. Furthermore, the HEART score has been adapted as a means of identifying risk of ACS downstream and not at the time of presentation. The DF system has not yet been applied within the HEART scoring system, but may be a viable option for a future prospective trial.

Ongoing arguments exist about how to manage these low risk patients. In the United Kingdom, the National Institute for Health and Care Excellence (NICE) published guidelines to assess patients with chest pain of recent onset.¹⁷ Patients at low risk for CAD, which includes those with noncardiac chest pain by DF, are not advised to undergo further cardiac testing. In a retrospective study by Patterson et al. of patients presenting to chest pain centers, they found that 10% of patients who would have been excluded from further testing by the NICE guidelines went on to have significant CAD within 6 months.¹⁸ Thus, despite the low event rate relating to noninvasive testing in chest pain units, ongoing research aimed at properly risk stratifying these patients is critical.

Despite reporting exertional symptoms, the patients in our typical angina cohort had neither lower self-reported exercise tolerance (DASI) nor lower quality of life (SAQ) compared to the remainder of patients. The lack of differences with neither DASI nor SAQ retained in our regression model suggests that these instruments may not be clinically applicable in the low risk acute chest pain population.

Limitations

Not all patients in our investigation underwent definitive angiography, and thus obstructive CAD may have been underdetected. The overall detection of CAD was low and sample size relatively small and as such, our study was inadequately powered to detect small differences between our symptom-based cohorts. Our institution applied a custom protocol to select patients for our observation unit, and thus results may not be generalizable to that of other chest pain units.

Conclusion

In a contemporary low-risk acute chest pain population, typical angina, as defined by the DF classification was not predictive of CAD or useful for identifying patients with higher burden of symptoms. DASI and SAQ scores were similarly not predictive of CAD. These tools appear to have limited utility in this selected population at low likelihood of CAD.

Acknowledgments

Funding: Supported by the Gatorade Trust through funds distributed by the University of Florida, Department of Medicine. Data collection was supported in part by the Clinical and Translational Science Institute (NIH Grants UL1TRR029890; UL1TR000064).

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Figure 1. DASI score and Seattle Angina Scores by Diamond-Forrester Classification

The mean DASI scores for atypical/noncardiac vs. typical chest pain patients are on the far left, followed by the four components of the Seattle Angina Questionnaire used in this study.

Table 1

Baseline demographics by Diamond-Forrester classification

	Diamond-Forrester Classification		p-value
	Atypical/Non-cardiac (n=163)	Typical (n=46)	
Age - years	45 ± 9.9	46 ± 8.3	0.55
Female	103 (63.2)	32 (69.6)	0.43
Diabetes mellitus	17 (10.4)	5 (10.9)	0.93
Hypertension	60 (36.8)	19 (41.3)	0.58
Stroke	1 (0.6)	3 (6.5)	0.03
Peripheral vascular disease	0	1 (2.2)	0.22
Hyperlipidemia	23 (14.1)	15 (32.6)	0.004
Tobacco use	40 (24.5)	10 (21.7)	0.69
Family history of CAD	76 (46.6)	27 (58.7)	0.15
GERD	33 (20.2)	15 (32.6)	0.08
Depression	31 (19)	10 (21.7)	0.68
Anxiety	39 (23.9)	12 (26.1)	0.76
Chronic pain	17 (10.4)	6 (13)	0.62
Aspirin	9 (5.5)	5 (10.9)	0.20
Statin	8 (4.9)	6 (13)	0.05
Beta blocker	9 (5.5)	4 (8.7)	0.43

All data expressed as no. (%) or mean ± standard deviation.

Table 2

Characteristics of low-intermediate risk chest pain patients by Diamond-Forrester classification

	Diamond-Forrester Classification		
	Atypical/Non-cardiac (n=163)	Typical (n=46)	p-value
DASI Score	49.1 ± 12.4	44.5 ± 17.2	0.10
SAQ Scores			
Physical Limitation	83.2 ± 21.3	80.4 ± 21.1	0.45
Angina Stability	45 ± 37.7	43.6 ± 34.5	0.83
Angina Frequency	77.2 ± 20.8	74.1 ± 26	0.41
Quality of Life	46 ± 21.4	45.6 ± 25	0.93
Number of episodes in previous week	4 ± 4.9	4.6 ± 11.4	0.66
Severity	6.7 ± 2.4	7 ± 2.4	0.55
Risk factors	1.3 ± 0.9	1.7 ± 1.3	
Duke Treadmill Score	6.8 ± 4.1	5.8 ± 5.8	0.51
Coronary Calcium Score	41.9 ± 108	51.4 ± 96.9	0.75
Exercise Treadmill	94 (57.7)	23 (50)	0.35
Cardiac CT angiography	53 (32.5)	16 (34.8)	0.77
Admitted to the hospital	12 (7.4)	3 (6.5)	0.85
Return visits to ED	5 (3.1)	0	0.38
Obstructive CAD by CTCA	5 (3.1))	1 (2.2)	0.74
Obstructive CAD by coronary angiography	1 (0.6)	1 (2.2)	0.50

All data expressed as no. (%) or mean ± standard deviation.