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Abstract

Female gender and black race have been associated with lower use of cardiac resources however; these patients also have a higher prevalence of obesity. Therefore we determined their relation to cardiac catheterization after stress testing. Clinical characteristics were determined for all patients stress tested over one year at a safety-net, urban, teaching hospital. Subsequent cardiac catheterizations were identified. Univariate and multivariate analyses were performed to determine the factors associated with catheterization. 3644 patients underwent stress testing and 484 (13%) underwent cardiac catheterization. The population was 58% female, 33% black, 53% were obese and 32% lacked insurance. Obese patients were mostly female, disproportionately black and had more CAD risk factors. An ischemic stress test result was similar across all BMI categories. Obesity was not associated with receipt of catheterization. Although univariate analysis showed fewer catheterizations for female and black patients, multivariate analysis adjusting for stress data and clinical risk factors no longer showed this. Neither race, gender, nor obesity was associated with catheterization utilization when stress testing and clinical factors were considered in a center where financial obstacles to testing were minimized.

Keywords

African Americans – Health and hygiene; Cardiac catheterization; Gender; Obesity; Obesity in women; Race; Stress testing; Stress (Physiology) – Testing

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Female gender and black race have been associated with lower use of cardiac resources however; these patients also have a higher prevalence of obesity. Therefore we determined their relation to cardiac catheterization after stress testing. Clinical characteristics were determined for all patients stress tested over one year at a safety-net, urban, teaching hospital. Subsequent cardiac catheterizations were identified. Univariate and multivariate analyses were performed to determine the factors associated with catheterization. 3644 patients underwent stress testing and 484 (13%) underwent cardiac catheterization. The population was 58% female, 33% black, 53% were obese and 32% lacked insurance. Obese patients were mostly female, disproportionately black and had more CAD risk factors. An ischemic stress test result was similar across all BMI categories. Obesity was not associated with receipt of catheterization. Although univariate analysis showed fewer catheterizations for female and black patients, multivariate analysis adjusting for stress data and clinical risk factors no longer showed this. Neither race, gender, nor obesity was associated with catheterization utilization when stress testing and clinical factors were considered in a center where financial obstacles to testing were minimized.

Key words: stress testing, obesity, gender, race

INTRODUCTION

Obesity is a major societal concern with multiple adverse medical and cardiac implications (Berrington de Gonzalez et al., 2010; Flegal, Graubard, & Williamson, 2007; Wilson et al., 2002). In addition to being associated with more cardiac risk factors, obesity poses an increased burden on cardiac investigations with more challenging cardiac imaging, (Finkelhor, Moallem, & Bahler, 2006; Lerakis et al., 2007) greater potential complications of cardiac catheterization (Blankenship et al., 1998; Cox et al., 2004; Ellis et al., 1996; Waksman et al., 1995) as well as obesity-related technical limitations of current cardiac catheterization equipment (Vanhecke, Berman, & McCullough, 2008; Yancy et al., 2005). Further, the influence of race and gender on catheterization use in the majority of studies has demonstrated reduced utilization for black and female populations even after adjusting for other medical and socioeconomic factors (Kressin & Petersen, 2001; Pearte et al., 2008). Since black and female patients are also more often obese (Flegal et al., 2012; MMWR, 2009) and since stress testing is often the initial test in evaluating patients whose symptoms could be due to coronary artery disease, we investigated the relationship of obesity in addition to race and gender in determining the subsequent performance of cardiac catheterization.

METHODS

Between July 1, 2005 and June 30, 2006 all patients referred for cardiac stress testing at an urban safety net, not for profit, university affiliated teaching hospital were identified. Patient characteristics were determined from review of the electronic patient records and stress testing and catheterization databases. Weight was directly measured for all inpatients while for outpatients it and all heights were that proffered by the patient. From this body mass index (BMI, kilograms divided by height in meters squared) was determined. Standard weight categories were used: underweight <18.5 kg/m2, normal 18.5-24.9 kg/m2, overweight 25.0-29.9 kg/m2, obese 30.0-39.9 kg/m2 and morbidly obese ≥40.0 kg/m2. Race was recorded in the stress database by the nurse at the time of testing. Hypertension and hypercholesterolemia were defined by their presence in the electronic medical record (EMR) problem list or by a documented prescription for an antihypertensive or antihyperlipidemic medication on the medication list. Smoking status was dichotomized as current or not smoking. A history of prior coronary artery disease was present if any of the following were documented: a prior myocardial infarction, percutaneous coronary intervention, coronary artery bypass surgery or prior cardiac catheterization demonstrating coronary artery disease. A family history of premature coronary artery disease was noted if this was present in a first degree female or male relative <65 years and <55 years respectively. The type of insurance was obtained from the medical record and divided into commercial, Medicare, Medicaid or uninsured.

Stress tests were stratified as negative or positive for ischemia or indeterminate if ischemic markers were equivocal, imaging was technically unacceptable or findings were negative for ischemia but the patient did not reach 85% of age predicted maximal heart rate on either exercise or dobutamine/atropine stress testing.

All patients undergoing cardiac catheterization within the subsequent 6 months of stress testing in the absence of an intervening cardiac event were determined.

Statistical analyses were performed using Statistica software version 8 (StatSoft, Tulsa, Oklahoma, USA) and SAS software Version 9.2 of the SAS System for Windows (SAS InstituteInc., Cary, North Carolina). Categorical data concerning demographics and stress testing

characteristics were compared using Chi squared analysis. Continuous variables were compared using ANOVA. The Bonferroni correction was used when comparing results for individual weight categories with normal. Comparisons between those undergoing and not undergoing catheterization used Chi square for discrete data and the Student's t-tests for continuous data. Logistic regression analysis was used to investigate the associations between obesity, race, gender and cardiac catheterization after adjustment for other patient characteristics. Statistical significance threshold was $p<0.05$.This study was approved by the institutional review board.

RESULTS

3692 patients underwent stress testing of which 48 were excluded from analysis: four due to missing BMI data and 44 with a low BMI (<18.5 kg/m2, 1.2%) as the influence of excess weight on test utilization was the main focuses of this study. Thus, the study population consisted of 3644 patients. The mean age was 55.4±12.6 years, 57.9% were female, 51.1% were white, 33% black, and 9% Hispanic. The mean BMI was 31.9±8.0 kg/m2 (range 18.5 to 80.1 kg/m2), and 53% were obese or morbidly obese (BMI ≥ 30 kg/m2). A total of 24.6% of patients had Medicare, 16.9% had Medicaid, 26.6% private insurance, and 31.9% were uninsured.

The patient demographics broken down by BMI category are listed in Table 1. As seen in prior studies black and female patients were more likely to be obese: 60.2% of black patients versus 49.7% of white patients ($p<0.001$) and 58.0% of females versus 45.1% of males ($p<0.001$). Obese patients were also younger, had more coronary artery disease risk factors (diabetes, hypertension and elevated cholesterol) but were less likely to be smokers or have previously documented coronary artery disease.

The stress results are listed in Tables 2 and 3. Treadmill exercise was performed in 56.8%, pharmacologic testing using either dobutamine/atropine in 29.7% or adenosine in 13.3% and paced stress testing in 0.2%. The vast majority of stress tests were performed using imaging (90.1%) most often stress echocardiography (76.9% of imaging tests). In order to optimize the echo wall motion assessment each increased BMI category required a significantly greater utilization of left heart echocardiographic contrast. The only testing indication significantly different between groups was a proportionately greater testing for dyspnea in the morbidly obese population. Despite their younger age, those obese patients able to exercise had markedly worse functional capacities.

Table 1

Population Characteristics by BMI Category, n=3644

	Normal	Overweight	Obese	Morbidly Obese
BMI (kg/m^2)	18.5-24.9	25.0-29.9	30-39.9	≥40.0
N	651 (17.9)	1078 (29.6)	1368 (37.5)	547 (15.0)
Age, years	56.4±13.8	57.0±13.0	55.0±11.8	52.1±11.6*
Gender, female	355 (54.5)	531 (49.3)	806 (58.9)	417 (76.2)*
Race/Ethnicity				
White	370 (56.8)	567 (52.6)	698 (51.0)	227 (41.5)*
Black	174 (26.7)	309 (28.7)	473 (34.6)	259 (47.0)*
Hispanic	45 (6.9)	117 (11.0)	125 (9.1)	40 (7.3)
Asian	18 (2.8)	20 (1.9)	3 (0.2)	0
Other	44 (6.8)	64 (5.9)	69 (5.0)	21 (3.8)
Number of risk factors	1.7±1.3	2.0±1.3†	2.2±1.3*	2.3±1.3*
Smoking	194 (29.8)	289 (26.8)	330 (24.1)‡	91 (16.6)*
Diabetes	81 (12.4)	198 (18.4)	361 (26.4)*	200 (36.6)*
Hypertension	282 (43.3)	564 (52.3)†	856 (62.6)*	373 (68.2)*
High Cholesterol	251 (38.6)	538 (49.9)*	787 (57.5)*	304 (55.6)*
FH of CAD	287 (44.1)	532 (49.4) ‡	705 (51.5)‡	268 (49.0)
Known prior CAD	123 (18.9)	254 (23.6) ‡	291 (21.3)	88 (16.1)
MI	74 (11.4)	136 (12.6)	169 (12.4)	33 (6.0) †
CABG	38 (5.8)	94 (8.7) ‡	101 (7.4)	28 (5.1)
Insurance				
Private	164 (25.2)	290 (26.9)	383 (28.0)	131 (23.9)
Medicare	165 (25.4)	293 (27.2)	327 (23.9)	112 (20.5) ‡
Medicaid	100 (15.4)	135 (12.5)	222 (16.2)	158 (28.9)*
Uninsured	222 (34.1)	360 (33.4)	436 (31.9)	146 (26.7) †

()=percent, BMI=body mass index, CAD=coronary artery disease, CABG=coronary artery bypass grafting, FH=family history, MI=myocardial infarction

*$p<0.001$ versus normal, †$p<0.01$ versus normal, ‡$p<0.05$ versus normal

Table 2

Stress Test Demographics by BMI Category

	Normal	Overweight	Obese	Morbidly Obese
BMI (kg/m^2)	18.5-24.9	25.0-29.9	30-39.9	≥40.0
N	651 (17.9)	1078 (29.6)	1368 (37.5)	547 (15.0)
Stress Indication				
Chest pain	415 (63.8)	698 (64.8)	930 (68.0)	354 (64.7)
Dyspnea	76 (11.7)	124 (11.5)	191(14.0)	104 (19.0)‡
Misc.	160 (24.6)	256(23.8)	247 (18.1)	89 (16.3)
Exercise Stress	411 (63.1)	676 (62.8)	764 (56.0)‡	220 (38.2)*
Dobutamine/atropine	167 (25.6)	254 (23.6)	427 (31.3)	233 (42.6)*
Adenosine	73 (11.2)	147 (13.6)	172 (12.6)	93 (17.0)‡
ECG Alone	73 (11.2)	123 (11.4)	126 (9.2)	37 (6.8)‡
Stress Echo	461 (70.8)	736 (68.3)	948 (69.3)	379 (69.3)
Echo contrast	222 (48.0)	483 (65.5)*	764 (80.8)*	344 (90.8)*
Stress Nuclear	117 (18.0)	218 (20.2)	294 (28.8)	131 (24.0)

()=percent, Misc. included: abnormal ECG, arrhythmias, evaluation of known CAD, preoperative evaluation.

*p<0.001 versus normal, †p<0.01 versus normal, ‡p<0.05 versus normal

Table 3

Stress Test Results

	Normal	Overweight	Obese	Morbidly Obese
BMI (kg/m^2)	18.5-24.9	25.0-29.9	30-39.9	≥40.0
N	651 (17.9)	1078 (29.6)	1368 (37.5)	547 (15.0)
Baseline LVEF, %	58.3±10.2	58.6±10.0	59.5±8.7	58.5±9.5
Resting HR, bpm	78.8±16.0	78.3±14.7	80.2±14.3	84.4±14.2*
Resting SBP, mmHg	127±13	130±18	131±18*	133±17*
Resting DBP, mmHg	70.1±12.1	71.7±12.6	73.0±12.9†	71.2±14.9
METs (exercise only)	11.4±4.1	10.6±3.5†	9.4±3.2*	7.7±3.1*
%APHR (exercise and dobutamine/atropine)	92.1±13.0	92.4±12.1	90.7±11.0†‡	89.0±10.4*
Abnormal (ischemia)	33 (5.1)	53 (4.9)	82 (6.0)	29 (5.3)
Indeterminate	101 (15.5)	182 (16.9)	250 (18.3)	101 (18.5)
Inadequate HR	76 (75.2)	125 (68.7)	189 (75.6)	69 (68.3)
Inadequate imaging	25 (24.8)	57 (31.3)	61 (24.4)	32 (31.7)

APHR=age predicted maximum heart rate, DBP=diastolic blood pressure, HR=heart rate, METs=metabolic equivalents, SBP=systolic blood pressure, ()=percent

Table 4

Cardiac Catheterization Demographics

	Cardiac Catheterization	No Catheterization	p-value
N	484 (13.3)	3160 (86.7)	
Age	57.4±11.4	55.1±12.7	<0.001
Gender, female	235 (48.6)	1874 (59.2)	<0.001
BMI, kg/m^2	32.2±7.6	31.9±8.1	0.46
Obese (BMI ≥30 kg/m^2)	268 (14.0)	216 (12.5)	0.18
Race			
White	280 (57.8)	1588 (50.2)	0.002
Black	125 (25.8)	1094 (34.6)	<0.001
Hispanic	39 (8.1)	289 (9.2)	0.44
Asian	7 (1.4)	34 (1.1)	0.13
Other	33 (6.8)	155 (4.9)	0.078
Smoking	131 (27.1)	771 (24.4)	0.21
Diabetes	158 (32.6)	681 (21.6)	<0.001
Hypertension	361 (74.6)	1713 (54.2)	<0.001
High cholesterol	353 (72.9)	1527 (48.3)	<0.001
FH of CAD	258 (53.3)	1537 (48.6)	0.056
Known prior CAD	264 (54.6)	292 (9.2)	<0.001

()=percent

A sizable proportion had indeterminate stress test results (17.4 %). Inadequate imaging was relatively uncommon accounting for only 4.8% of all tests and did not significantly differ across BMI categories. The major reason for an indeterminate test was the inability to achieve at least 85% of age predicted heart rate in the absence of an ischemic marker (12.6% of the total study population). Inadequate heart rate response was significantly more common with exercise testing (21.6%) than with high dose dobutamine/atropine stress testing up to 40 mcg/kg/min and 1.0 mg respectively (14.1%, $p<0.001$). These results were most likely due to beta-blockade as an inadequate heart rate response without ischemic markers occurred in 12.5% without beta-blockers versus 33.7% on them ($p<0.001$), which are not routinely held prior to testing in our lab. Beta-blocker use was relatively constant between the BMI groups.

Cardiac catheterization was performed in 13.3% of the total population: 62.6% of those with an ischemic response, 25.4% of those with an indeterminate response and in 7.1% of those with negative tests. Broken down by gender, race and BMI (dichotomized at 30 kg/m2) a significantly greater percentage of those undergoing catheterization were male (16.2% versus 11.1%, $p<0.001$) and white (15.0% versus 10.2%, $p<0.001$) but there was no significant difference for obesity (14.0% versus 12.5%, $p=0.18$). As expected, multiple cardiac risk factors were also significantly different between groups. Multivariate analysis showed that race, gender and BMI were not associated with catheterization after the stress test results, standard CAD risk factors and prior known CAD were included (Table 5). Repeating this analysis only for those without known prior CAD showed similar results.

Table 5

Logistic Regression Analysis of Predictors for Undergoing Catheterization

Beyond Stress Test Results

Characteristic	Adjusted OR	95% CI	p-value
Age (per year)	0.99	0.98-1.00	0.05
BMI (per kg/m^2)	1.0	0.99-1.02	0.75
Female	0.91	0.69-1.3	0.44
Black Race	0.81	0.52-1.08	0.1
Uninsured	1.35	1.00-1.82	0.002
CAD Risk Factors			
Smoking	1.01	0.8-1.3	0.91
Diabetes	1.35	1.04-1.74	0.02
Hypertension	1.4	1.01-1.8	0.04
High cholesterol	1.73	1.3-2.2	<0.001
Known Prior CAD	4.4	3.4-5.6	< 0.001

DISCUSSION

In a population of patients referred for cardiac stress testing at one urban safety-net hospital, obese patients differed in many ways from non-obese patients including a younger age, greater proportion of blacks, females, diabetes, hypertension and hypercholesterolemia but fewer smokers. Obese patients also required more pharmacologic stress testing and those undergoing echocardiographic imaging required more use of left heart intravenous contrast. Despite these differences obese patients had similar rates of ischemic stress test response and indeterminate test results due to either inadequate imaging or the inability to reach the minimal heart rate threshold for an adequate negative test. Although univariate analysis suggested an association between catheterization and race and gender, but not BMI, this association vanished when standard cardiac risk factors were included in multivariate analysis.

The lack of a multivariate race and gender effect on testing is concordant with recent data suggesting progress, in part due to a greater national awareness of treatment disparities and a push for institutional quality and accountability (Cohen et al., 2010; Lewis et al., 2009). Serial trends for the AHA Get with the Guidelines benchmark therapies for acute coronary syndromes have shown continued improvement in participating hospitals, attenuating race and gender differences with time (Lewis et al., 2009). We have been a participant in this program and were included in these reports. Even though stress testing was not one of the items they assessed it is possible that the push for evidence based care such a program fosters extends beyond those benchmarks being addressed.

Fewer patient or physician financial concerns could also explain our results. Prior studies have shown that black patients were more often uninsured than white, which we also found (33.6% black versus 23.5% white patients were uninsured, p=0.002). Paradoxically uninsured status was associated with greater cardiac catheterization utilization in the multivariate analysis (Table 5). As a county owned entity, patients that do not have insurance are rated to pay only a scaled amount of the testing costs based on their income. Further, at the time of this study all physicians were salaried hospital employees. These could reduce patient financial barriers and reluctance to undergo expensive but indicated testing as well as removing any subconscious physician disincentive for underinsured patients.

Little prior information exists regarding potential biases after stress testing which might influence subsequent cardiac catheterization utilization. Shaw et al examined a selected population of patients undergoing nuclear stress testing in the late 1980's for gender differences in subsequent test utilization, including cardiac catheterization. They found a similar high rate of positive stress tests for female (20%) and for male patients (22%) but a significant disparity in subsequent testing in these positive tests (38% for female and 62% for males). Further, the lack of additional investigation was associated with worse subsequent cardiovascular outcomes (Shaw et al., 1994). We are unaware of similarly derived information concerning race or obesity or in a more contemporary practice environment.

As stress testing may occur early in the diagnostic cascade, race and/or gender inequities may exist at this point. Such disparities have been demonstrated for gender in Olmsted County (Roger et al., 1998), and for both race and gender using an ambulatory care national database (Cohen, Stafford, & Misra, 1999), and the Medicare database (Lucas et al., 2007). Further, Lucas et al reported the temporal trends for stress testing and cardiac catheterizations from this Medicare database. Stress tests and in particular those with imaging, increased at a faster rate than cardiac catheterizations over time across race and gender but rose less rapidly for females and blacks

than non-blacks and males. They were unable to infer what proportion of patients undergoing stress testing went on to catheterization as an unknown amount of the catheterizations bypassed stress testing (Lucas et al., 2006).

We are unaware of any information on how obesity might affect any race or gender differences in the evaluation process. Practical equipment weight limitations remain an issue as our catheterization table's maximum capacity is 450 pounds (204 kg). Despite the large number of morbidly obese patients in our study only three exceeded the catheterization table weight limit, none of whom had an ischemic stress test.

Our study had an appreciable number of stress tests that were reported as indeterminate (17.4%). This was not due to obesity as there was no trend to more of these with increasing BMI. Further, inadequate imaging was not more common with increasing BMI, mostly due to our primary reliance on echocardiographic imaging and a greater protocol guided utilization of echocardiographic contrast with increasing BMI (Finkelhor et al., 2000). The major reason for an indeterminate test was failure to achieve at least 85% of age predicted heart rate in the absence of an ischemic marker. This too was not related to BMI but may be more a function of beta-blocker utilization. In an asymptomatic population undergoing exercise stress testing and not taking beta-blockers only 7% would fail to reach 85% of traditional age predicted maximal heart rate (Gulati et al., 2010). Our practice was not to withdraw beta-blockers prior to testing (Fletcher et al., 2001).

This study has several limitations. It was retrospective and from a single institution. We were unable to infer what biases, if any, may have occurred prior to stress test referral. Despite our study's modest size it may have lacked power to detect a small effect of race or gender on the rate of post-stress test catheterization. We did not categorize ischemic stress test results into degrees of abnormality which might further differentiate single vessel from multi-vessel disease and may have further influenced progression on to cardiac catheterization.

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