

REVIEW ARTICLE

Coronary artery disease in patients with body mass index ≥ 30 kg/m²: a retrospective chart analysis

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Objective: In this study, we evaluated obesity as a single risk factor for coronary artery disease (CAD), along with the synergistic effect of obesity and other risk factors.

Methods: A retrospective study of 7,567 patients admitted to hospital for chest pain from 2005 to 2014 and underwent cardiac catheterization. Patients were divided into two groups: obese and normal with body mass index (BMI) calculated as ≥ 30 kg/m² and < 25 , respectively. We assessed the modifiable and non-modifiable risk factors in obese patients and the degree of CAD.

Results: Of the 7,567 patients who underwent cardiac catheterization, 414 (5.5%) had a BMI ≥ 30 . Of 414 obese patients, 332 (80%) had evidence of CAD. Obese patients displayed evidence of CAD at the age of 57 versus 63.3 in non-obese patients ($p < 0.001$). Of the 332 patients with CAD and obesity, 55.4% had obstructive CAD versus 44.6% with non-obstructive CAD. In obese patients with CAD, male gender and history of smoking were major risk factors for development of obstructive CAD ($p = 0.001$ and 0.01 , respectively) while dyslipidemia was a major risk factor for non-obstructive CAD ($p = 0.01$). Additionally, obese patients with more than one risk factor developed obstructive CAD compared to non-obstructive CAD ($p = 0.003$).

Conclusion: Having a BMI ≥ 30 appears to be a risk factor for early development of CAD. Severity of CAD in obese patients is depicted on non-modifiable and modifiable risk factors such as the male gender and smoking or greater than one risk factor, respectively.

Keywords: coronary artery disease; obesity; body mass index ≥ 30 ; obstructive CAD; dyslipidemia; smoking; hypertension

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Coronary artery disease (CAD) causes approximately one in six deaths in the United States every year and is one of the leading causes of morbidity and mortality worldwide (1). A coronary event will occur approximately every 25 s, and one death every minute. A number of modifiable risk factors (smoking, HLD) and non-modifiable risk factors (gender, age) have well-established association with CAD (2), whereas other potential individual risk factors (such as obesity) are less well established. The estimated prevalence of obesity in the United States is about 32.9% (1), and an increased body mass index (BMI) has been associated with other major health implications including hypertension (HTN), diabetes mellitus (DM), metabolic syndrome (MetS), and

dyslipidemia, all independent risk factors for CAD (2–9). In this study, we describe a cohort of patients with obesity and CAD, and also evaluate the risk factors associated with obstructive CAD (in comparison with non-obstructive CAD) and a gender comparison. This study was approved by IRB institution.

Methods

A retrospective study was made of 7,567 patients admitted to a tertiary hospital for chest pain from 2005 to 2014 and underwent cardiac catheterization. Patients were divided into two groups: obese and normal with BMI calculated as ≥ 30 kg/m² and < 25 , respectively. Patients with BMIs between 26 and 29 were excluded.

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We assessed the modifiable and non-modifiable risk factors in obese patients and the degree of CAD with coronary angiography as obstructive CAD (left main stenosis of $\geq 50\%$ or any stenosis of $\geq 70\%$), non-obstructive CAD (≥ 1 stenosis $\geq 20\%$ but no stenosis $\geq 70\%$), and normal coronaries.

For statistical analysis, we used chi-square, odds ratio, and univariate log regression. The distributions of age, sex, and baseline co-morbidities were compared between the two cohorts. The implication of modifiable risk factors and non-modifiable risk factors were evaluated in those patients including hypertension, diabetes mellitus, obesity, dyslipidemia, tobacco use, cocaine, family history of premature CAD, and gender. Dyslipidemia was defined as low-density lipoprotein cholesterol of 130 mg/dL or greater or total cholesterol > 200 mg/dL. Hypertension was defined as blood pressure 140/90 mm Hg or greater. Lastly, diabetes mellitus was defined as having fasting blood glucose levels greater than or equal to 126 mg/dL or having a hemoglobin A1c level greater than or equal to 6.5%.

Results

Of the 7,567 patients who underwent cardiac catheterization, 414 (5.5%) had a BMI ≥ 30 . Of 414 obese patients, 332 (80%) had evidence of CAD. Obese patients displayed evidence of CAD at the age of 57 versus 63.3 in non-obese patients ($p < 0.001$). Of the 332 patients with CAD and obesity, 55.4% had obstructive CAD versus 44.6% with non-obstructive CAD. In obese patients with CAD, male gender and history of smoking were major risk factors for development of obstructive CAD ($p = 0.001$ and 0.01 , respectively) while dyslipidemia was a major risk factor for non-obstructive CAD ($p = 0.01$). Additionally, obese patients with more than one risk factor developed obstructive CAD compared to non-obstructive CAD ($p = 0.003$). See Table 1.

Approximately 40% presented with ST elevation myocardial infarction (STEMI), 30% with non-ST-segment elevation myocardial infarction (NSTEMI), and 30% had stable angina as a primary diagnosis. Of the 332 obese patients with CAD, 24% received medical treatment, 58% underwent percutaneous coronary intervention (PCI), and 18% obtained coronary artery bypass grafting (CABG). In a gender comparison, average age of CAD in obese males was 55 years compared to 59 in females ($p < 0.001$). Approximately 67% of males underwent PCI (OR: 2.4, 95% CI: 1.5–3.6, $p < 0.001$) and 24% obtained CABG (OR: 3, 95% CI: 1.6–5.6, $p < 0.001$), whereas in obese females 43% received medical therapy (OR: 9, 95% CI: 5–17, $p < 0.001$). See Table 2.

Discussion

Obesity is associated with more morbidity than smoking, alcoholism, and poverty, and may soon become the

Table 1. Baseline characters of patients with BMI > 30 and diagnosed with obstructive CAD and non-obstructive CAD

	Obstructive CAD <i>n</i> = 184	Non-obstructive CAD <i>n</i> = 148	Odds ratio (OR) 95% Confidential interval (CI) <i>P</i> -value
M:F	115/69	66/82	OR: 2.07 95% CI: 1.3–3.2 <i>P</i> = 0.001
Smoking	32 (17.4%)	12 (8.1%)	OR: 2.4 95% CI: 1.2–4.8 <i>P</i> = 0.01
Hyperlipidemia	75 (40.8%)	41 (27.7%)	OR: 1.8 95% CI: 1.1–2.9 <i>P</i> = 0.01
Diabetes mellitus	40 (21.7%)	11 (11.4%)	OR: 3.5 95% CI: 1.7–7 <i>P</i> < 0.001
Hypertension	78 (42.4%)	29 (19.6%)	OR: 3 95% CI: 1.8–5 <i>P</i> < 0.0001
>1 Risk factor	117 (63.6%)	70 (47.3%)	OR: 1.9 95% CI: 1.3–3 <i>P</i> = 0.003

leading cause of preventable death in the United States, especially given the increased prevalence of morbid obesity from 1 to 6% (4, 7). Obesity increases the risk for HTN, DM, dyslipidemia, obstructive sleep apnea, MetS, and cardiovascular diseases (5–9). MetS has been associated with up to threefold increase in coronary heart disease (CHD) alone and is defined by abdominal obesity, atherogenic dyslipidemia, high blood pressure, insulin resistance, a proinflammatory state, and a prothrombotic state (3, 5, 8–10). Given that many of these same risk factors from obesity increases the development of CAD, excess body fat appears to be deleterious for patients with a history of coronary disease (7, 11). Excess adiposity has been strongly related to first NSTEMI occurring at a younger age (4), and during autopsy studies, the

Table 2. The difference outcomes among male and female groups who had CAD and BMP ≥ 30 kg/m²

	Male <i>n</i> = 181	Female <i>n</i> = 151	<i>P</i>
Age (years old)	55 (SD: 53.2, 56.1)	59 (SD: 58–60)	<0.001
Medical	14 (7.7%)	65 (43%)	<0.001
PCI	122 (67.4%)	71 (47%)	0.0002
CABG	45 (24.9%)	15 (10%)	<0.0001

extent of coronary atherosclerosis has been associated with the extent of obesity (10). Obesity alone can be a risk factor for atherosclerosis. Studies have shown that obese young men, aged 15 to 34 years, have accelerated coronary atherosclerosis (7). The type of obesity plays an important role in development of CAD. Android obesity (upper body and abdominal obesity), which is more typical in men, is associated with DM and CHD, than gynoid obesity (lower body, gluteal, or femoral obesity), which tend to be metabolically less active (3, 7, 8).

Adipose cells are endocrine in nature and have a pivotal role in body metabolism homeostasis. They can release proinflammatory cytokines (IL-6, CRP, tumor necrosis factor- α) and fat-related hormones (leptin, adiponectin), which actively lead to the atherosclerotic process (3, 4, 8, 12). A number of inflammatory responses including increased clotting factors (fibrinogen, von Willebrand factor, factors VII and VIII), increase plasminogen activator inhibitor type I, decreases endogenous fibrinolysis and a increases prothrombotic state, can leading to CAD (8, 12). One of the adipokines, leptin, controls food intake and energy metabolism, but may be particularly related with CV disease (4). Leptin has been associated with perpetuating inflammation and endothelial dysfunction via cholesterol uptake by macrophages, triggering formation of foam cells resulting in atheromatic lesions (3). Chronically elevated leptin levels have also been related to negative CAD outcomes and increase in stent restenosis (12). Adiponectin, on the other hand, may enhance insulin sensitivity and reduce glucose levels, as seen in animal models, and may play a protective role in atherogenesis (8).

There, however, appears to be an obesity paradox, where patients with BMI in the range of 30–34 have a protective effect against cardiovascular diseases. Research has shown obesity in this range had lower mortality rate with STEMI (7) and had better to no difference in survival after coronary revascularization and CABG when compared to normal weight individuals (3, 5, 9, 12, 13). Those with severe obesity (BMI > 35 kg/m²) were at increased cardiovascular mortality risk (5). Interestingly, the low BMI group (BMI < 18) had the highest mortality risk, even after adjustment for confounders such as age, sex, and cardiovascular risk factors (5, 9, 12). The relationship of obesity to CHD mortality appears to be U-shaped (2, 7). Multiple explanations have been used to try and answer this paradox. One possible explanation for the lack of expected association between BMI and adverse cardiac outcomes in patients with CAD could be due to poor association of BMI to discriminate between body fatness and lean body mass, which are associated with opposite outcomes in cardiovascular disease (11). A person with increased muscle mass or gynoid distribution of fat would have the same BMI as a person with increased fat percentage or android distribution of fat.

Therefore, waist to hip ratio (WHR) or waist circumference (WC) has been suggested instead of BMI, which was thought to clear up this paradox, but results are inconclusive thus far (7, 14). Alternatively, part of the obesity paradox could come from a subset of patients who, with the help of diet and exercise, lose weight, improve cardiorespiratory fitness (CRF), and alter their prognosis as compared to non-obese individuals, who have less room for improvement (7). Finally, obese patients tend to have a more aggressive treatment course as compared to the leaner counterpart. A study showed obese patients under the age of 65 had higher rate of target vessel revascularization (5, 7).

Our study encompasses several limitations, one of which is the small sample size. To further strengthen our findings, a multi-centered study may yield stronger findings. Also, this is a univariate log regression analysis, not multivariate. Also, we evaluated the patients who presented with chest pain only.

Conclusion

BMI \geq 30 is a risk factor for early development of CAD. Severity of CAD in obese patients is depicted on non-modifiable and modifiable risk factors such as the male gender and smoking or greater than one risk factor, respectively. Early lifestyle modification including increasing CRF and muscular strength had up to a 35% reduction in all-cause mortality (12,14–16), by reducing arterial pressure, preventing LVH, decreasing insulin resistance, and increasing HDL (17). Mortality was decreased not only in obese patients but also in normal weight individuals. Weight loss also proved to significantly lower the rate of adverse outcomes even after adjustment for age, sex, smoking, dyslipidemia, DM, HTN, MI, depression, and obese status (16). Therefore, it is prudent for patients with BMI of greater than 30 to increase exercise and lose weight. Education on these principles may provide benefit in striving to aid decreasing incidents of CAD and possibly lowering cardiovascular events.

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