Rev Clin Esp. 2014;214(3):113–120

Revista Clínica Española

www.elsevier.es/rce

ORIGINAL ARTICLE

Body mass index and myocardium at risk in patients with acute coronary syndrome

A.L. Arrebola-Moreno[a,b,*], R. Marfil-Alvarez[c], A. Catena[c], R. García-Retamero[c], J.P. Arrebola[c], R. Melgares-Moreno[a], J.A. Ramirez-Hernández[a], J.C. Kaski[b]

[a] *Cardiology Department, Hospital Universitario Virgen de las Nieves, Granada, Spain*
[b] *Cardiovascular Sciences Research Centre, St George's University of London, London, United Kingdom*
[c] *Department of Experimental Psychology, University of Granada, Granada, Spain*

Received 23 September 2013; accepted 1 December 2013
Available online 21 February 2014

KEYWORDS
Obesity paradox;
BARI score;
Acute myocardial infarction;
Acute coronary syndrome

Abstract
Background and objectives: Whilst traditional studies have shown that obese individuals are at a higher risk of cardiovascular events compared to lean subjects, recent studies in patients with acute myocardial infarction (AMI) have suggested that obesity may exert protective effects (the ''obesity paradox''). We sought to assess the relationship between body mass index (BMI) and the BARI score (BARIsc), a validated tool used to assess myocardium at risk, in patients with acute coronary syndrome.
Patients and methods: Participants were 116 consecutive patients (mean age, 60.6 years; 97 men) with AMI (68 ST elevated myocardial infarction, STEMI; 48 non-ST elevated myocardial infarction, NSTEMI). Demographics, BMI, risk factors, biochemistry data, left ventricular function, angiographic data and the BARIsc were assessed in every patient.
Results: Multiple linear regression analyses showed that BMI significantly correlated with BARIsc; $\beta = .23$, $p < 0.02$. This was found only in the overweight/obese patients, $\beta = .27$, $p < 0.01$, but not in patients with normal BMIs, $\beta = 0.08$, $p = 0.71$.
Conclusions: An increased body weight is associated with an increased area of myocardium at risk in patients with ACS.

Abbreviations: CAD, coronary artery disease; ACS, acute coronary syndrome; BMI, body mass index; PCI, percutaneous coronary intervention; BARIsc, BARI score; AMI, acute myocardial infarction; NSTEMI, non-ST elevated myocardial infarction; STEMI, ST elevated myocardial infarction.

Abreviaturas: EAC, enfermedad arterial coronaria; SCA, síndrome coronario agudo; IMC, índice de masa corporal; ICP, Intervención coronaria percutánea; BARIsc, score BARI; IAM, infarto agudo de miocardio; SCACESTs, síndromes coronarios agudos con elevación de ST; SCASESTs, síndrome coronarios agudos sin elevación de ST.

* Corresponding author.
E-mail address: alam_1981@hotmail.com (A.L. Arrebola-Moreno).

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http://dx.doi.org/10.1016/j.rce.2013.12.004

PALABRAS CLAVE
Paradoja de la obesidad;
Puntuación BARI;
Infarto agudo de miocardio;
Síndrome coronario agudo

Índice de masa corporal y miocardio en riesgo en pacientes con síndrome coronario agudo

Resumen
Introducción y objetivos: Algunos estudios han demostrado que los pacientes obesos presentan un mayor riesgo cardiovascular, pero estudios más recientes en pacientes con infarto agudo de miocardio (IAM) han sugerido que la obesidad puede ejercer un efecto protector (efecto conocido como la ''paradoja de la obesidad''). Hemos examinado la relación entre el índice de masa corporal (IMC) y la puntuación ofrecida por el BARI (BARIsc), una herramienta validada para determinar la cantidad de miocardio en riesgo en los pacientes con síndrome coronario agudo.
Pacientes y métodos: Se incluyeron 116 pacientes de forma consecutiva (edad media, 60.6 años; 97% varones) con IAM (68 con un síndrome coronario agudo con elevación de ST [SCACEST], y 48 con síndrome coronario agudo sin elevación de ST [SCASEST]). En todos ellos se determinaron las variables demográficas y analíticas, los factores de riesgo cardiovascular, el IMC, la función ventricular, los datos angiográficos, y el BARIsc.
Resultados: El análisis de regresión lineal múltiple mostró que el IMC se correlacionaba significativamente con el BARIsc, $\beta = ,23$; $p < 0,02$. Esto se demostró únicamente en los pacientes con sobrepeso u obesidad, $\beta = ,27$; $p < 0,01$, pero no en los que presentaban IMC normal $\beta = 0,08$; $p = 0,71$.
Conclusiones: El aumento de peso se asocia a la cantidad de miocardio en riesgo en pacientes que con un SCA.

Introduction

Obesity has reached epidemic proportions both in adults and children in recent years[1,2] and it has been suggested to have adverse effects on the cardiovascular system. Prospective studies[3,4] have indicated that obesity is an independent risk factor for major coronary artery disease (CAD) events, especially in women. A large 10-year follow up study with more than 527,000 participants aged 50–71 years found a significant association between high body weight during midlife and increased risk of death.[5]

Although the above-mentioned studies showed obesity to be a powerful risk factor for cardiovascular disease, several recent studies have reported a paradoxical finding, the so-called ''obesity paradox''. In a systematic review of 40 cohort studies involving 250,000 cardiovascular disease patients, Romero-Corral et al.[6] found that overweight patients (BMI 25–29.9 kg/m^2), paradoxically, were at a lower risk for total cardiovascular mortality than normal BMI patients. In contrast, patients with severe obesity (BMI $\geq$35 kg/m^2) were at the highest risk for cardiovascular mortality. In a meta-analysis of patients undergoing both surgical and percutaneous coronary revascularization, Oreopoulos et al.[7] also showed similar results.

There is no clear explanation for the contradictory findings in the literature about the ''obesity paradox.'' Importantly, most of the research investigating whether BMI is related to the area of myocardium at risk used cardiac computed tomography.[8] This research suggests that BMI is a predictor of the presence, but not severity of CAD. However, coronary angiography is now considered the standard method for assessing injury of coronary arteries. To the best of our knowledge, there is no published research assessing the relationship between BMI and the area of myocardium at risk by using such technique. To fill this gap in the literature, in the present cross-sectional study we investigated this relationship by calculating the Bypass Angioplasty Revascularization Investigation score (BARIsc) in patients admitted to hospital with ACS.

Methods

Patients

Study participants were 116 consecutive patients (average age 60.6 years, range 33–82; 97 (83%) males) who had been referred to coronary angiography for acute myocardial infarction to the Virgen de las Nieves University Hospital (Granada, Spain). Patients were recruited between July 2010 and December 2010. Both patients with ST elevation myocardial infarction (STEMI) and non-ST elevation myocardial infarction (NSTEMI) were considered to be eligible for the study. All had typical ECG changes and elevated cardiac troponin I. Patients were excluded if they had a history of previous coronary revascularization (PCI or bypass) or had recently experimented a substantial weight change (more than 10 kg in the last year), to avoid false modification of the BMI and BARIsc scores. The study protocol was approved by the Ethics Committee of the Virgen de las Nieves University Hospital (Granada, Spain). All participants signed written informed consent prior to study entry.

Study protocol

Patient demographics, anthropometric, and biochemistry laboratory data, including fasting lipid profile, renal and liver function and serum glucose, were measured at baseline. Patients' height and weight were specifically measured in hospital, fasting, at 7 a.m. and three days after

What we know?

Some studies have suggested that obesity may exert a protective effect (the ''obesity paradox'') on the myocardium at risk following an acute coronary syndrome. This study aimed to assess the relationship between body mass index (BMI) and the BARI score (BARIsc), a validated tool used to assess myocardium at risk, in patients with acute coronary syndrome.

What this article provides?

In 116 consecutive patients with acute coronary syndrome (ST elevated and non-elevated myocardial infarction) increased body weight was associated with an increased area of myocardium at risk.

The Editors

the coronary event, using calibrated devices. Standardized questionnaires were used to determine participants' past medical history, medications that were taken, and cardiovascular risk factors. Patients were classified as hypertensive if they (a) had an average systolic blood pressure of >140 mm Hg or a diastolic blood pressure of >90 mm Hg at rest, (b) had previous history of hypertension, or (c) were taking antihypertensive drugs. Diabetes was diagnosed in the presence of one of the following: fasting blood glucose >126 mg/dL, previous history of diabetes mellitus, or treatment with insulin and/or oral hypoglycemic drugs. Fasting venous samples were collected in all patients for the assessment of total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL), cholesterol, and triglyceride levels, which were all assessed using standard enzymatic methods. Hyperlipemia was defined as total cholesterol >220 mg/dL or LDL cholesterol >140 mg/dL, or treatment with hypolipemic drugs.

Coronary angiograms and BARI scores: All patients underwent diagnostic coronary angiography and BARIsc were calculated in all coronary angiogram images by an experienced interventional cardiologist (Arrebola-Moreno AL) blinded to all clinical information. Coronary stenosis $\geq$50% diameter reduction was considered to be significant. Myocardium at risk was assessed with the BARIsc, a myocardial jeopardy index that encompasses both the severity of a coronary artery lesion and the volume of myocardium subtended by a stenosis.[9] BARIsc were computed from an anatomical representation of the size and distribution of the coronary arteries. Distal segments of the left anterior descending artery, the circumflex coronary artery, and the right coronary artery received a score from 1 to 3 on the basis of their length and size. Major branch vessels, i.e., diagonals, obtuse marginals, ramus, posterior descending, and left ventricular branches received a score following the same procedure. Units jeopardized by $\geq$50% stenosis were summed up and divided by total left ventricular territory units to define the extent of jeopardy.[9] Examples of BARIsc calculations are shown in Figs. 1 and 2.

Table 1 Acronyms.

Acronyms	
ACS	Acute coronary syndrome
AMI	Acute myocardial infarction
BARIsc	Bypass Angioplasty Revascularization Investigation score
BMI	Body mass index
CAD	Coronary artery disease
CV	Cardiovascular
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
NSTEMI	Non-ST elevation myocardial infarction
PCI	Percutaneous coronary intervention
STEMI	ST elevation myocardial infarction

BARIsc has been shown to be a reliable predictor of 1-year mortality (especially when patients are treated medically or with a PCI) in patients with CAD,[10] and has been correlated with the myocardial area-at-risk estimated by cardiovascular magnetic resonance.[11–13] In other words, mortality tends to rise with incremental increases in myocardial jeopardy.

Body mass index

A standard definition of body mass index was used,[14] defined as the individual body mass divided by the square of their height, with the value universally being given in units of kg/m^2. Following the World Health Organization definition[15] we considered a BMI of less than 18.5 as underweight, while a BMI greater than 25 was considered overweight, and above 30 obese.

Statistical analysis

Statistical analyses were performed using SPSS 15.0 statistical software (SPSS, Chicago, IL). The statistical analyses were performed using multiple linear regression models. BARIsc was considered the dependent variable, and BMI the independent variable. We considered the following potential confounders: the classical CAD risk factors (smoking habits, hypertension, diabetes mellitus, and dyslipidemia), sex, age, type of acute myocardial infarction (AMI) and previous AMI.[16] In addition, we stratified the analyses according to the participants' BMI ($<25\ kg/m^2$ or $\geq 25\ kg/m^2$). The unstandardized coefficients (β) are the regression coefficients of the estimated linear model. Standardized coefficients can be useful for comparing the weight of each independent variable on the prediction model. Partial correlation measures the linear correlation between the dependent and a single independent variable after adjusting for the remaining independent variables. The R^2 coefficient was calculated as the proportion of variance of the dependent variable explained by the set of independent variables. The significance level was set at $p \leq 0.05$. Linear regression diagnostics included graphical methods to test normality of the model residuals, homoscedasticity and outliers detection (Table 1).

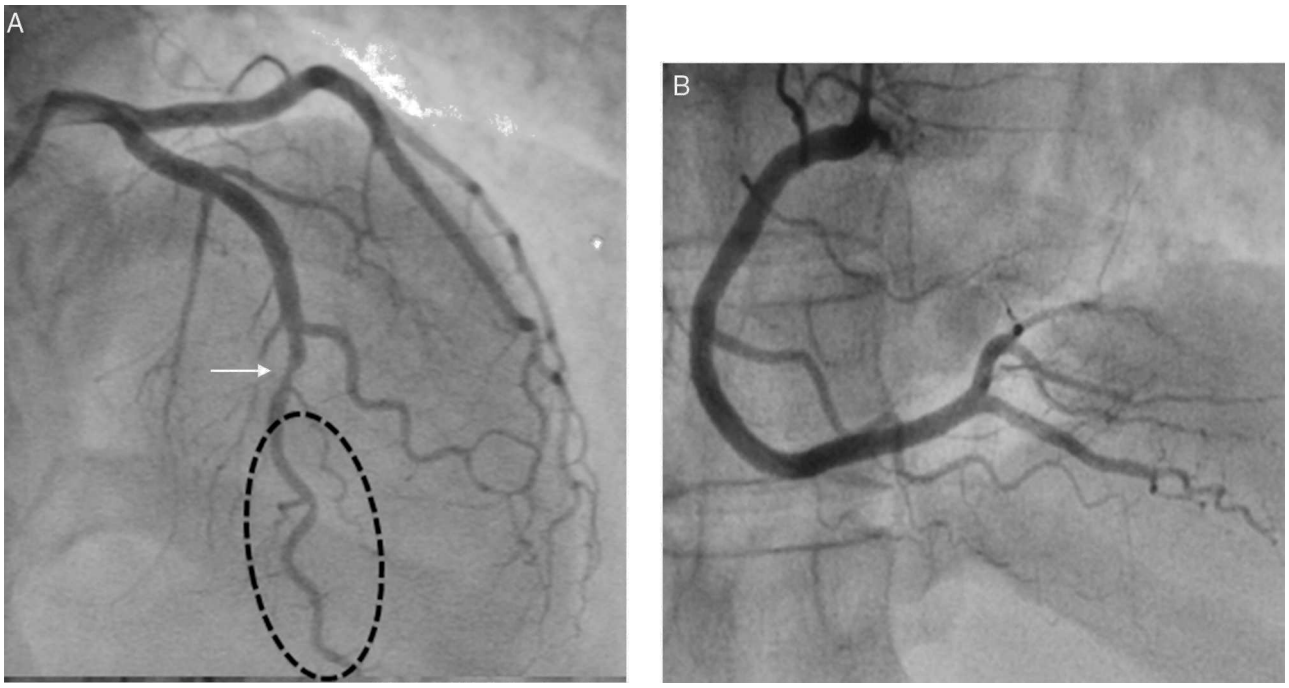

Figure 1 Coronary angiography in a patient with a normal BMI (24.0 kg/m^2). The left (A) and right (B) coronary arteries (A) are shown. The arrow points to a $\geq$50% coronary stenosis. The dashed circle shows the myocardium volume beyond the $\geq$50% coronary stenosis. In this case, based on the length and size of the coronary vessels, 2 points were given to the vessel beyond the $\geq$50% stenosis, and 16 points to the whole coronary tree. Therefore a $2/16 \times 100 = 12.5\%$ of the whole myocardium was considered at risk.

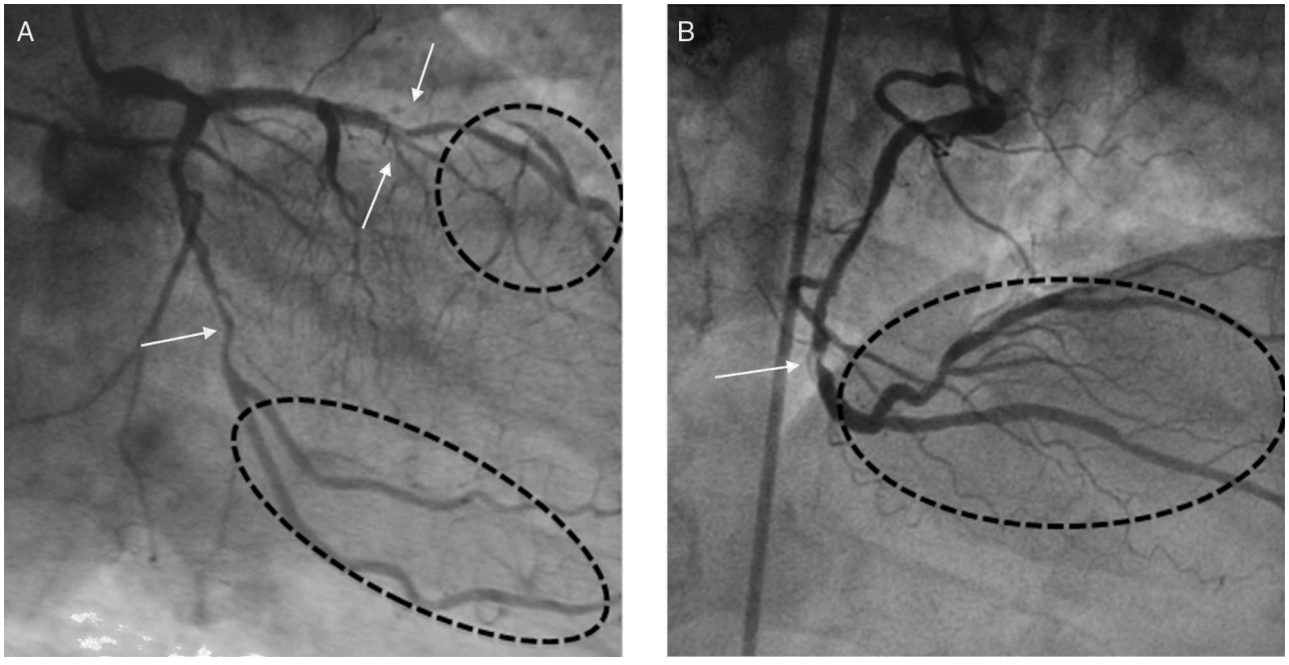

Figure 2 Coronary angiography in an obese patient (BMI, 34.0 kg/m^2). The left (A) and right (B) coronary arteries (A) are shown. The arrow points to a $\geq$50% coronary stenosis. The dashed circles show the myocardium volume beyond the $\geq$50% coronary stenosis. In this case, based on the length and size of the coronary vessels, 14 points were given to the vessels beyond the $\geq$50% stenoses, and 18 points to the whole coronary tree. Therefore a $14/18 \times 100 = 77\%$ of the whole myocardium was considered at risk.

Table 2 Patient characteristics.

Demographics	Sample structure			*p*-Value
	All patients ($N = 122$)	Normal weight ($N = 22$)	Overweight ($N = 94$)	
Age, years	60.62 ± 9.2	61.5 (10.9)	60.4 (9.0)	0.38
Male, %	97 (83.6)	16.0 (84.2)	81.0 (83.5)	0.99
BMI, kg/m^2	28.50 ± 4.2	23.31 (1.6)	29.7 (3.7)	<0.01*
Medical history				
Number of risk factors				0.30
0	6 (5.2)	2 (9.1)	4 (4.3)	
≥1	110 (94.8)	20 (90.9)	90 (95.7)	
≥2	80 (69.0)	13 (59.1)	67 (71.3)	
≥3	40 (34.5)	7 (31.8)	33 (35.1)	
≥4	8 (6.9)	2 (9.1)	6 (6.4)	
Smoking (current), %	53 (45.7)	10 (45.5)	43 (45.7)	0.30
Family history of CAD, %	55 (47.4)	12 (54.6)	43 (45.7)	0.21
Hypertension, %	69 (59.5)	12 (54.5)	57 (60.6)	0.31
Hyperlipidemia, %	60 (51.7)	12 (54.5)	48 (51.1)	0.99
Diabetes mellitus, %	36 (31.0)	6 (27.3)	30 (31.9)	0.79
AMI: SCACEST	68 (56.9)	12 (54.5)	54 (57.5)	0.99
Previous AMI, %	22 (18.9)	4 (18.2)	18 (19.1)	0.22
BARIsc	57.6 (26.7)	56.9 (30.2)	57.7 (26.1)	0.59
Ventricular function	51.8 (10.9)	50.4 (12.3)	52.2 (10.6)	0.96
Troponin-I	38.4 (38.7)	44.6 (39.4)	37.0 (38.6)	0.55
Myoglobin (ng/ml)	639.7 (903.9)	891.9 (1086.8)	578.8 (849.6)	0.21
Colesterol (g/dL)	181.8 (53.8)	174.6 (37.2)	183.5 (57.3)	0.72
Creatinine (mg/dL)	1.0 (0.6)	1.3 (1.3)	1.0 (0.2)	0.07
Platelets (×1000/μl)	232.1 (75.9)	232.1 (99.6)	232.2 (69.8)	0.52
Urea (mg/dL)	37.0 (16.3)	39.3 (22.9)	36.5 (14.4)	0.51
Hemoglobin	14.7 (1.5)	14.2 (2.0)	14.8 (1.3)	0.28

BMI = body mass index; CAD = coronary artery disease; AMI = acute myocardial infarction. BARIsc = Bypass Angioplasty Revascularization Investigation score.
* $p < 0.01$.

Results

The prevalence of different cardiovascular risk factor is described in Table 2. Most patients (94.8%) had at least one risk factor for CAD and 69% had two or more. The distribution of the patients depending on the number of cardiovascular risk factors is described in Table 2. All the 36 diabetes mellitus patients were type II. The average BMI was 28.50 ± 4.22 kg/m^2. Forty-eight and 68 patients suffered a NSTEMI and a STEMI, respectively. NSTEMI and STEMI patients showed similar results in the coronary angiogram (see Table 3). Overall, 45 patients had single-vessel coronary artery disease, 34 patients had two-vessel disease, 35 patients had three-vessel disease, and only 2 patients had non-significant coronary lesions. The average BARIsc was 55.89 (±25.38).

The simultaneous multiple linear regression analysis performed on the whole data set (Table 4) showed that BARIsc was significantly associated with BMI ($\beta = 0.22$, $p < 0.02$). The whole set of predictors accounted for 23% of the variability in BARIsc, $F(9, 106) = 3.51$, $p = .001$. The association between BMI and BARIsc remained significant after partialling out the effect of the remaining predictors, $r_{part} = 0.23$, $p < 0.02$ (Fig. 3). We did not observe any evidence favoring violations of the linear model assumptions.

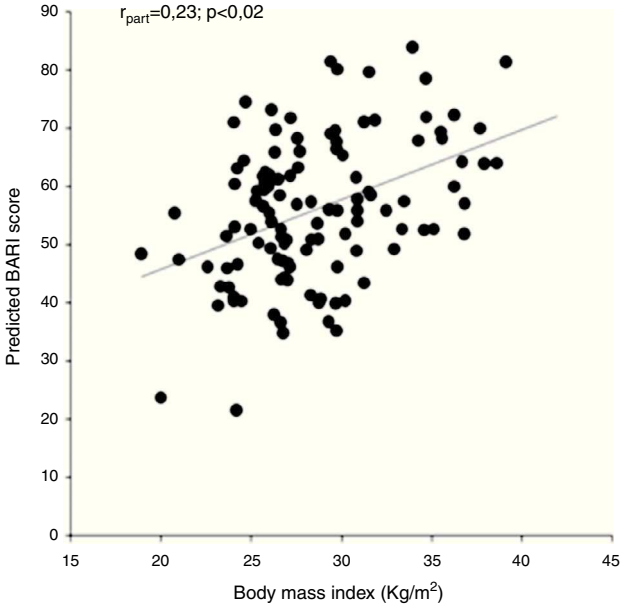

Figure 3 Correlation chart showing the association between BMI and BARI score. BMI = body mass index, BARI = Bypass Angioplasty Revascularization Investigation.

Table 3 Coronary event and coronary angiography data.

	Total ($n = 116$)	NSTEMI ($n = 48$)	STEMI ($n = 68$)	P value
CAD (number of vessels)	1.85	1.77	1.90	0.48
No coronary stenosis	2 (1.72)	2	0	NC
One vessel	45 (38.79)	17	28	0.10
Two vessels	34 (29.31)	13	21	0.17
Three vessels	35 (30.17)	16	19	0.61
BARIsc	55.89 (25.4)	56.92 (28.1)	55.16 (23.5)	0.72

BARIsc = Bypass Angioplasty Revascularization Investigation score; CAD = coronary artery disease; NSTEMI = non-ST elevation myocardial infarction; STEMI = ST elevation myocardial infarction.

Table 4 Multiple linear regression model.

	Regression coefficients	p	Partial correlation
BMI, kg/m^2	0.22	0.02	0.23
Age, years	0.14	0.14	0.14
Sex	−0.12	0.18	−0.13
Smoking	0.05	0.61	0.05
AMI type	−0.03	0.69	−0.04
Previous AMI	0.16	0.08	0.17
Hypertension	−0.18	0.08	−0.19
Diabetes mellitus	0.23	0.01	0.24
Dyslipidemia	−0.22	0.10	−0.24

BMI = body mass index; AMI = acute myocardial infarction.

The simultaneous multiple linear regression performed on the group of 94 overweight/obese patients showed that BMI and age were significantly associated with BARI ($\beta = 0.28$, $p < 0.01$, $\beta = 0.26$, $p < 0.02$, respectively). The whole set of predictors accounted for the 23.5% of the variability in BARIsc ($F(9, 84) = 2.87$, $p < 0.01$). The BARI–BMI partial correlation was also significant, $r_{part} = 0.29$, $p < 0.01$. In contrast, when the same lineal model was applied to normal BMI patients ($n = 22$), diabetes mellitus was significantly associated with BARI ($\beta = 0.60$, $p < 0.01$), and smoking was only marginally associated with BARI ($\beta = -0.42$, $p = 0.06$). No other independent variable was associated with BARIsc, especially BMI ($\beta = 0.08$, $p = 0.71$). The whole model accounted for 69.8% of the variability of BARIsc ($F(9, 12) = 3.08$, $p < 0.04$).

Discussion

This study shows that obesity, defined on the basis of an increased BMI, is associated with BARIsc. In other words, obesity correlates with the myocardial jeopardy index that encompasses both the severity of the coronary artery stenosis responsible for the acute event and the area of myocardium subtended by the stenosis. The relationship between BMI and BARIsc found in this study was robust and remained significant after controlling for classical cardiovascular risk factors, including hypertension, diabetes mellitus, and dyslipidemia. The novelty of our study relies on the fact that for the first time we have established a relationship between obesity and a validated coronary angiography score that reflects both CAD extension and prognosis. The fact that this relationship was only evident in overweight/obese patients but not in normal-weight patients shed light on the pathophysiology of obesity and the so called ''obesity paradox'' found in previous studies, as it means that obesity would express its harmful cardiovascular effect mainly among the most obese patients.

Our results contradict reports in the literature that support this ''obesity paradox,'' i.e. obesity has a protective rather than a harmful effect both in healthy individuals and in patients with cardiovascular disease.[6,7] No clear reasons, however, have been documented to explain this phenomenon. In contrast to these studies, we used a more direct way to evaluate the influence of obesity on coronary artery disease, as we assessed the relationship between BMI and the amount of myocardium at risk using the validated coronary angiographic BARIsc.[9] By looking at the relation among obesity, and coronary artery disease and jeopardized myocardium using the BARIsc, we minimized the effects of confounding factors such as weight loss due to underlying debilitating diseases and smoking commonly present in lean patients, treatments with beta adrenergic receptor blockers, antithrombotic drugs, coronary interventions, and bypass grafting or increased bleeding rates,[17] that could have affected the interpretation of results in some of the follow-up studies supporting the ''obesity paradox''.[6,7]

The negative effects of obesity on the cardiovascular system, as reported in the present study, are also supported by another recently published study in AMI patients.[18] In this study, obesity, defined as a BMI >30 was associated with an increased likelihood of death and longer-term mortality in patients who suffered an AMI,[18] and higher risk of functional limitations after the onset of a coronary heart disease.[19] Similarly, the case–control study ''INTERHEART'',[20] which included 15,152 patients with AMI and 14,820 controls from 52 different countries, showed that BMI is significantly related to risk of myocardial infarction. A study from Rossi et al.[21] failed to shown an association between BMI and coronary atherosclerotic burden as assessed by Gensini score. The authors, however, found higher incidence of coronary events in obese patients, a finding that was partly explained by conventional associated risk factors and suggest that other unknown (or not considered) pathways were involved. In our study the area of myocardium at risk was determined, which do not need to correlate with the atherosclerotic burden. When coronary lesions are placed in a more proximal part of the coronary artery the amount of jeopardized myocardium increases. In our study, obese patients, defined on the basis of BMI, had an increased area of myocardium

at risk. Probably, obese patients tend to develop coronary lesions in more proximal part of the vessels, increasing the myocardium at risk, and therefore worsening the cardiovascular prognosis.

Interestingly, in our study the relationship between BMI and myocardium at risk was stronger among overweight/obese patients than in those with normal BMIs. These results can be explained by the small sample size in the group of patients with normal weight. However, studies in the literature[6,22] offer an alternative, more plausible, explanation, i.e. that obesity is most harmful among patients with severe obesity and only in these patients increases in BMI go hand in hand with harmful effects on the coronary vessels and correlate with a larger amount of myocardium at risk. All in all, this research converges to suggest that the harmful cardiovascular effects of obesity increase in parallel with BMI values.

Obesity correlates with classic cardiovascular risk factors[23] as well as the metabolic syndrome.[24] There is a pathophysiological link between obesity and coronary atherosclerosis that probably goes beyond the concomitant occurrence of traditional risk factors in obese patients. In recent years, several studies suggested that obesity may cause cardiovascular disease via multiple mechanisms including subclinical inflammation, endothelial dysfunction, increased sympathetic tone, atherogenic lipid profiles, enhanced thrombogenic factors, and obstructive sleep apnea.[25] Recent evidence also suggested that adiponectines might play an important role in obese patients developing CAD.[26] Thus, in the presence of high adipokine concentrations, patients like the ones recruited in our study should fall in a high risk category as per findings in other clinical studies,[26] which is consistent with our results. All in all, these above mentioned studies support our findings in patients with a first episode of acute coronary syndrome, that obesity is associated with more severe coronary heart disease. Therefore, obesity should be taken into account when assessing a patient global cardiovascular risk.

Limitations of the study

In our study, obesity was defined on the basis of patients' BMI. This index does not discriminate between intra- and extra-abdominal fat, which may differ in how they affect patients' prognosis.[27,28] In addition, the relatively small number of patients comprising the normal BMI group might limit our conclusions. The findings reported here, however, deserve further investigation in larger patient cohorts. Finally, BARIsc was performed by one interventional cardiologist and inter-observer variability may exist. However, we believe that it would be minimal due to his large experience.

Conclusions

This study demonstrates, for the first time, that obesity, as defined by BMI >25 kg/cm^2 is independently and significantly associated with the amount of myocardium at risk in patients with a first episode of ACS, even after adjusting for traditional CV risk factors. Of interest, the relationship between BMI and myocardium at risk was significant in overweight and obese patients but not in patients with a BMI within normal ranges. Our results are in contrast with previous clinical studies supporting the ''obesity paradox'' and agree with recent studies[5,19,20] suggesting that obesity is related to worse prognosis in AMI patients.

Conflict of interest

No conflict of interests to declare.

Acknowledgements

A.L. Arrebola-Moreno has received a grant from the Spanish Society of Cardiology. J.P. Arrebola is under contract with the PTA-MICINN program (Spanish Ministry of Science and Innovation). None of the authors have any actual or potential competing financial interests. The results would not have been achieved without the collaboration of the staff from the University Hospital Virgen de las Nieves and the patients who took part in the study.

References

1. Bray GA, Ryan DH. Medical therapy for the patient with obesity. Circulation. 2012;125:1695–703.
2. Poirier P, Giles TD, Bray GA, Hong Y, Stern JS, Pi-Sunyer FX, et al., American Heart Association. Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association Scientific Statement on Obesity and Heart Disease from the Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2006;113:898–918.
3. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. Circulation. 1983;67:968–77.
4. Manson JE, Colditz GA, Stampfer MJ, Willett WC, Rosner B, Monson RR, et al. A prospective study of obesity and risk of coronary heart disease in women. N Engl J Med. 1990;322:882–9.
5. Adams KF, Schatzkin A, Harris TB, Kipnis V, Mouw T, Ballard-Barbash R, et al. Overweight, obesity, and mortality in a large prospective cohort of persons 50 to 71 years old. N Engl J Med. 2006;355:78–63.
6. Romero-Corral A, Montori VM, Somers VK, Korinek J, Thomas RJ, Allison TG, et al. Association of bodyweight with total mortality and with cardiovascular events in coronary artery disease: a systematic review of cohort studies. Lancet. 2006;368:78–666.
7. Oreopoulos A, Padwal R, Norris CM, Mullen JC, Pretorius V, Kalantar-Zadeh K. Effect of obesity on short- and long-term mortality postcoronary revascularization: a meta-analysis. Obesity. 2008;16:442–50.
8. Dores H, de Araújo Gonçalves P, Carvalho MS, Sousa PJ, Ferreira A, Cardim N, et al. Body mass index as a predictor of the presence but not the severity of coronary artery disease evaluated by cardiac computed tomography. Eur J Prev Cardiol. 2013.
9. Graham MM, Faris PD, Ghali WA, Galbraith PD, Norris CM, Badry JT, et al. APPROACH investigators (Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease. Validation of three myocardial jeopardy scores in a population-based cardiac catheterization cohort. Am Heart J. 2001;142:254–61.
10. Alderman EL, Stadius M. The angiographic definitions of the Bypass Angioplasty Revascularization Investigation. Coron Artery Dis. 1992;3:207–1189.

11. Moral S, Rodríguez-Palomares JF, Descalzo M, Martí G, Pineda V, Otaegui I, et al. Quantification of myocardial area at risk: validation of coronary angiographic scores with cardiovascular magnetic resonance methods. Rev Esp Cardiol. 2012;65:1010–7.
12. Ortiz-Pérez JT, Lee DC, Meyers SN, Davidson CJ, Bonow RO, Wu E. Determinants of myocardial salvage during acute myocardial infarction: evaluation with a combined angiographic and CMR myocardial salvage index. JACC Cardiovasc Imaging. 2010;3:491–500.
13. Ortiz-Pérez JT, Meyers SN, Lee DC, Kansal P, Klocke FJ, Holly TA, et al. Angiographic estimates of myocardium at risk during acute myocardial infarction: validation study using cardiac magnetic resonance imaging. Eur Heart J. 2007;28:1750–8.
14. Eknoyan G. Adolphe Quetelet (1796–1874) – the average man and indices of obesity. Nephrol Dial Transplant. 2007;23:47–51.
15. WHO Expert Consultation Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157–63.
16. Kennedy LM, Dickstein K, Anker SD, James M, Cook TJ, Kristianson K, et al. Weight-change as a prognostic marker in 12,550 patients following acute myocardial infarction or with stable coronary artery disease. Eur Heart J. 2006;23:2755–62.
17. Andreotti F, Rio T, Lavorgna A. Body fat and cardiovascular risk: understanding the obesity paradox. Eur Heart J. 2009;30:752–4.
18. Simpson CR, Buckley BS, McLernon DJ, Sheikh A, Murphy A, Hannaford PC. Five-year prognosis in an incident cohort of people presenting with acute myocardial infarction. PLoS ONE. 2011;6.
19. Britton A, Brunner A, Kivimaki E, Shipley MMJ. Limitations to functioning and independent living after the onset of coronary heart disease: what is the role of lifestyle factors and obesity? Eur J Public Health. 2012;22:831–5.
20. Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. INTERHEART Study Investigators Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case–control study. Lancet. 2004;364:52.
21. Rossi R, Iaccarino D, Nuzzo A, Chiurlia E, Bacco L, Venturelli A, et al. Influence of body mass index on extent of coronary atherosclerosis and cardiac events in a cohort of patients at risk of coronary artery disease. Nutr Metab Cardiovasc Dis. 2011;21:86–93.
22. Ellis SG, Elliott J, Horrigan M, Raymond RE, Howell G. Low normal or excessive body mass index: newly identified and powerful risk factors for death and other complications with percutaneous coronary intervention. Am J Cardiol. 1996;78:642–6.
23. Cordero A, León M, Andrés E, Ordoñez B, Laclaustra M, Grima A, et al. MESYAS Registry investigators Gender differences in obesity related cardiovascular risk factors in Spain. Prev Med. 2009;48:134–9.
24. Alegría E, Cordero A, Laclaustra M, Grima A, León M, Casasnovas JA, et al. Investigadores del registro MESYAS Prevalence of metabolic syndrome in the Spanish working population: MESYAS registry. Rev Esp Cardiol. 2005;58:797–806.
25. López-Jiménez F, Cortés-Bergoderi M. Update: systemic diseases and the cardiovascular system (i): obesity and the heart. Rev Esp Cardiol. 2011;64:140–9.
26. Oliveira CS, Giuffrida FM, Crispim F, Saddi-Rosa P, Reis AF. ADIPOQ and adiponectin: the common ground of hyperglycemia and coronary artery disease? Arq Bras Endocrinol Metabol. 2011;55:446–54.
27. Litwin SE. Which measures of obesity best predict cardiovascular risk? J Am Coll Cardiol. 2008;52:616–9.
28. Coutinho T, Goel K, Corrêa de Sá D, Kragelund C, Kanaya AM, Zeller M, et al. Central obesity and survival in subjects with coronary artery disease: a systematic review of the literature and collaborative analysis with individual subject data. J Am Coll Cardiol. 2011;57:1877–86.