Original Article

Relationship between Body Mass Index and Outcome of Elective Percutaneous Coronary Intervention

Mohammad Alidoosti, MD[*], Mojtaba Salarifar, MD, Ali Mohammad Hajizeinali, MD, Seyed Ebrahim Kassaian, MD, Ebrahim Nematipour, MD, Hasan Aghajani, MD, Masoumeh Lotfi-Tokaldany, MD, MPH, Elham Hakki Kazazi, MD

Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran.

Abstract

Background: Studies have shown controversial effects of obesity on major adverse cardiac events (MACE) after percutaneous coronary intervention (PCI). We sought to investigate the impact of the body mass index (BMI) on the mid-term outcome following successful PCI.

Methods: Between March 2006 and August 2008, 3948 patients underwent successful elective PCI in Tehran Heart Center, Tehran, Iran, and were retrospectively included in this study. Patients who underwent PCI on the same day as the occurrence of myocardial infarction were excluded. The demographic, procedural, in-hospital, and follow-up information of these patients was extracted from the PCI Data Registry of our institution. The patients were divided into three groups: normal weight (No. 1058, BMI < 25 kg/m^2 age = 58 ± 10 years); overweight (No. 1867, 25 ≤ BMI < 30 kg/m^2, age = 57 ± 10 years); and obese (No. 1023, BMI ≥ 30 kg/m^2, age = 56 ± 10 years). MACE included death, myocardial infarction, target vessel revascularization, and target lesion revascularization.

Results: Compared with the other patients, the obese individuals were significantly younger and more frequently female, had a higher ejection fraction, and more frequently presented with hypertension, diabetes, and hyperlipidemia. There was no association between the BMI and the angiographic and procedural findings in the univariate analysis. While no difference was found in the rate of in-hospital death between the groups, the number of the obese patients undergoing emergent cardiac surgery was marginally different in the univariate analysis (p value = 0.06). At 9 months' follow-up, MACE had occurred in 92 (2.3%) patients and cardiac mortality was 9 (0.2%). After adjustments for confounders, no significant difference was observed in terms of MACE between the BMI groups.

Conclusion: The BMI had no significant effect on the rate of MACE at 9 months' follow-up in our study population. Interventionists' recommendations for patients undergoing PCI should, therefore, not be significantly influenced by the BMI status.

J Teh Univ Heart Ctr 2015;10(1):18-23

This paper should be cited as: Alidoosti M, Salarifar M, Hajizeinali AM, Kassaian SE, Nematipour E, Aghajani H, Lotfi-Tokaldany M, Hakki Kazazi E. Relationship between Body Mass Index and Outcome of Elective Percutaneous Coronary Intervention. J Teh Univ Heart Ctr 2015;10(1):18-23.

[*]**Corresponding Author:** *Mohammad Alidoosti, Associate Professor in Cardiology, Interventional Cardiology Department, Tehran Heart Center, North Kargar Street, Tehran, Iran. 1411713138. Tel: + 98 21 88089256. Fax: + 98 21 88089256. E-mail: salidoosti@hotmail.com.*

Introduction

Obesity is a well-established risk factor for coronary artery disease and is increasing throughout the developing world.[1, 2] Large population studies have demonstrated an association between obesity and cardiovascular death,[3] and the number of obese patients undergoing percutaneous coronary intervention (PCI) is high.[4]

Despite evidence for risk induced by an elevated body mass index (BMI), recent studies have suggested a paradoxical protective effect of obesity on post-PCI and coronary artery bypass grafting (CABG) mortality, rendering the relation between the BMI and the coronary intervention outcome even more complex.[5, 6]

The prevalence of obesity and overweight in the Iranian population has been reported to stand at 11.6% and 38.2%, respectively.[7] Obesity is, consequently, regarded as a leading cause of death in Iran.[8] The aim of the present study was to determine the relationship between the BMI and the mid-term outcome after PCI in a sample of Iranian population.

Methods

Between March 2006 and August 2008, 4550 PCI procedures were performed at Tehran Heart Center. Complete demographic, procedural, in-hospital, and follow-up information of these patients was registered in the PCI Data Bank of our institution. Patients who underwent PCI on the same day as suffering myocardial infarction (MI) (regarded as primary PCI) were excluded (159 patients). In total, 344 (7.8%) patients were excluded because they failed to return to the hospital for at least one follow-up visit. The mean BMI was 27.48 ± 4.15 kg/m^2 for the missed patients and 27.62 ± 4.27 kg/m^2 for the included patients. This study complies with the Declaration of Helsinki, and its research protocol was approved by our institutional Review Board.

The frequency of the patients who completed a follow-up period of 9 months after discharge was more than 95% in all the groups (95.4%, 95.7%, and 95.5% for the normal-weight, overweight, and obese groups, respectively). From the remaining patients, 61 individuals who had unsuccessful PCI and 38 who had missing data on the BMI were also excluded. Finally, a total of 3948 successful coronary interventional procedures were included in the study.

The procedural description and detailed definition of the variables can be found in our previous study.[9, 10] In summary, the patients received 325 mg of Aspirin before the procedure, and coronary stenting was performed by routine methods. Following stent placement, Ticlopidine (250 mg twice daily) or Clopidogrel (75 mg daily) was given for 4 weeks to those with bare-metal stents and for 12 months to the ones with drug-eluting stents. Glycoprotein IIb/IIIa blocker was administered to none of our patients.

After discharge from the hospital, all the patients were monitored by cardiologists at 1, 5, and 9 months post angioplasty, and follow-up was done at our outpatient clinics or by telephone interviews.

The BMI was calculated as weight (kilograms) divided by the square of the individual's height in meters (kg/m^2). Based on the BMI, the study population was divided into normal (BMI < 25 kg/m^2), overweight ($25 \leq$ BMI < 30 kg/m^2, and obese (BMI $\geq$ 30 kg/m^2) patients. The glomerular filtration rate was calculated via the CKD-EPI formula.[11]

The in-hospital outcome was evaluated in terms of in-hospital death, in-hospital nonfatal MI, and abrupt closure. Abrupt closure refers to the total occlusion of the dilated artery occurring at any time during the procedure or repeat catheterization before hospital discharge or subtotal occlusion with electrocardiographic evidence of ischemia.

During the 9-month follow-up period, clinical data were recorded. Major adverse cardiac events (MACE), including cardiac death, nonfatal MI, target vessel revascularization ([TVR]: repeated PCI or elective CABG), and target lesson revascularization ([TLR]: repeat PCI on the same lesion), were recorded during the follow-up period.

The numerical variables are presented as mean $\pm$ standard deviation (SD), while the categorical variables are summarized by raw frequencies and percentages. The Kolmogorov-Smirnov test was used to test normal distribution. The continuous variables were compared using the one-way analysis of variance (ANOVA) or the Kruskal-Wallis test when the presumption of normality was not met, and the categorical variables were compared using the chi-squared test or the Fisher exact test (as appropriate), across the three BMI groups.

Multivariable Cox proportional hazards regression models adjusted for age, gender, smoking history, diabetes mellitus, systemic hypertension, PCI on the left anterior descending coronary artery (LAD), hyperlipidemia, and prior ST-elevation MI were established to examine differences in 9 months' MACE, TVR, TLT, nonfatal MI, and CABG across the BMI groups.

For the statistical analysis, the statistical software SPSS version 13.0 for Windows (SPSS Inc., Chicago, IL) and the statistical package SAS version 9.1 for Windows (SAS Institute Inc., Cary, NC, USA) were used. All the p values were 2-tailed, with statistical significance defined by a p value ≤ 0.05.

Results

The demographic and clinical characteristics of the patients are listed in Table 1. There were 1058 patients in the normal BMI, 1867 in the overweight, and 1023 in the obese groups. The patients with a higher BMI were younger and were more likely to be female. Compared to the other groups, the

obese group showed a higher frequency of diabetes mellitus and positive family history for coronary artery disease. The obese patients also had a higher mean of the left ventricular ejection fraction. As is shown in Table 2, there was no association between the BMI and the angiographic and procedural findings in the univariate analysis.

Table 1. Baseline characteristics of the study population based on the BMI categories*

	Normal Weight (n=1058)	Overweight (n=1867)	Obese (n=1023)	P value
BMI (kg/m²)	22.79±1.70	27.33±1.37	33.12 ± 3.09	< 0.001
Age (y)	58.21±10.45	57.00±10.34	56.24±9.78	< 0.001
Female	217 (20.4)	499 (26.7)	492 (48.1)	< 0.001
Smoking history				< 0.001
Current	326 (30.8)	424 (22.8)	166 (16.2)	
Quitted	193 (18.3)	382 (20.46)	149 (14.6)	
No history	538 (50.9)	1056 (56.7)	707 (69.02)	
Diabetes mellitus	213 (20.1)	459 (24.6)	325 (31.8)	< 0.001
Systemic hypertension	360 (34.0)	842 (45.2)	569 (55.6)	< 0.001
Hyperlipidemia	640 (60.5)	1335 (71.8)	778 (76.1)	< 0.001
Positive family history	242 (23.0)	484 (26.0)	265 (26.1)	0.140
Renal failure	108 (10.4)	237 (12.9)	113 (11.2)	0.111
Prior STEMI	336 (31.8)	531 (28.5)	249 (24.5)	0.001
Acute coronary syndrome in recent one month	278 (26.3)	481 (25.8)	250 (24.4)	0.606
Cholesterol (mg/dl)	174.41±48.29	172.94±48.37	179.90±49.60	0.001
Triglyceride (mg/dl)	161.80±92.53	182.80±98.39	194.05±105.34	< 0.001
LDL (mg/dl)	100.24±38.65	96.10±38.95	100.06±41.56	0.002
HDL (mg/dl)	42.36±11.74	41.23±12.77	41.54±10.28	0.051
FBS (mg/dl)	109.40±45.54	111.27±41.59	120.00±47.55	< 0.001
Creatinine (mg/dl)	1.15±0.35	1.19±0.62	1.18±1.36	0.369
Ejection fraction	51.23±9.78	52.86±9.50	52.94±8.93	< 0.001
Use of beta blockers	865 (81.8)	1574 (84.5)	860 (84.3)	0.141
Use of ACE inhibitors	477 (45.1)	834 (44.8)	430 (42.2)	0.308

*Data are presented as mean±SD or n (%)
BMI, Body mass index; STEMI, ST-elevation myocardial infarction; LDL, Low-density lipoprotein; HDL, High-density lipoprotein; FBS, Fasting blood sugar; ACE, Angiotensin-converting enzyme

Table 2. Angiographic and procedural characteristics of the study population based on the BMI categories*

	Normal Weight (n=1058)	Overweight (n=1867)	Obese (n=1023)	P value
Target coronary artery				
LAD or its branches	693 (65.5)	1215 (65.1)	679 (66.4)	0.782
LCX or its branches	152 (14.4)	308 (16.5)	147 (14.7)	0.180
RCA or its branches	312 (29.5)	504 (27.0)	283 (27.7)	0.348
LM	4 (0.4)	3 (0.2)	3 (0.3)	0.513
Severity of CAD				0.167
One-vessel disease	467 (44.1)	767 (42.3)	419 (42.5)	
Two -vessel disease	424 (40.1)	706 (37.8)	401 (39.2)	
Three-vessel disease	167 (15.8)	364 (19.5)	184 (18.0)	
Stent type				0.271
Bare-metal	368 (34.8)	638 (34.2)	359 (35.1)	
Drug-eluting stents	679 (64.2)	1210 (64.9)	645 (63.1)	
Balloon	10 (0.9)	17 (0.9)	18 (1.80)	
Reference vessel diameter (mm)	3.16±0.42	3.21±0.57	3.21±0.47	0.051
Multi-vessel PCI	224 (21.2)	450 (24.1)	244 (23.9)	0.171
Multi-session PCI	58 (5.5)	125 (6.7)	71 (6.9)	0.326
Mean lesion length (mm)	22.06±10.64	21.51±9.24	21.75±10.32	0.344
Mean stent length (mm)	23.48±6.83	23.56±6.68	23.51±6.79	0.946

*Data are presented as mean±SD or n (%)
BMI, Body mass index (kg/m²); LAD, Left anterior descending coronary artery; LCX, Left Circumflex coronary artery; RCA, Right coronary artery; LM, Left main coronary artery; CAD, Coronary artery disease; PCI, Percutaneous coronary intervention

There were no significant differences in terms of in-hospital death and nonfatal MI between the BMI groups. The overall frequency of in-hospital death was 2 (0.1%). The rates of in-hospital deaths in the normal-weight, overweight, and obese groups were 0%, 0.1%, and 0.1%, respectively. While 1 (0.1%) nonfatal MI was observed in the normal-weight patients, 8 (0.4%) patients in the overweight and 3 (0.3%) patients in the obese groups had in-hospital nonfatal MI (Table 3). The incidence of in-hospital emergent cardiac surgery in the obese patients was significantly different from that of the other groups (0.3% in the obese group vs. 0% in the normal-weight group and 0% in the overweight group; p value = 0.01). Abrupt closure occurred more frequently in the overweight patients (0.2%), with no remarkable difference from that in the normal (0%) and obese (0.1%) groups.

Because the incidence of this complication was very low, a logistic regression analysis for the in-hospital emergent cardiac surgery was not performed, as this could have yielded non-meaningful results. Whereas none of the patients in the normal-weight and overweight groups had in-hospital cardiac arrest, 2 obese patients suffered cardiac arrest (p value = 0.06).

Follow-up analysis

The prevalence of the patients with MACE after discharge was 2.3% (92 patients). The number of deaths at follow-up was 9 (0.2%): 3 (0.3%) in the normal-weight; 4 (0.2%) in the overweight; and 2 (0.2%) in the obese groups. The Kaplan-Meier survival curve with respect to the three BMI study groups is presented in Figure 1. The figure shows that the survival rate for each group decreased slightly, although this reduction did not reach a statistically significant difference between the BMI groups.

The occurrence rates of MACE during the follow-up period either in absolute term or in each of the subcategories (nonfatal MI, TLR, and TVR) are shown in Table 4. Although the rate of MACE rose as the BMI increased, it did not reach a statistically significant level. Additionally, the number of the individuals undergoing CABG during the follow-up period was 2 (0.2%), 10 (0.5%), and 5 (0.5%) in the normal-weight, overweight, and obese groups, respectively (p value = 0.358).
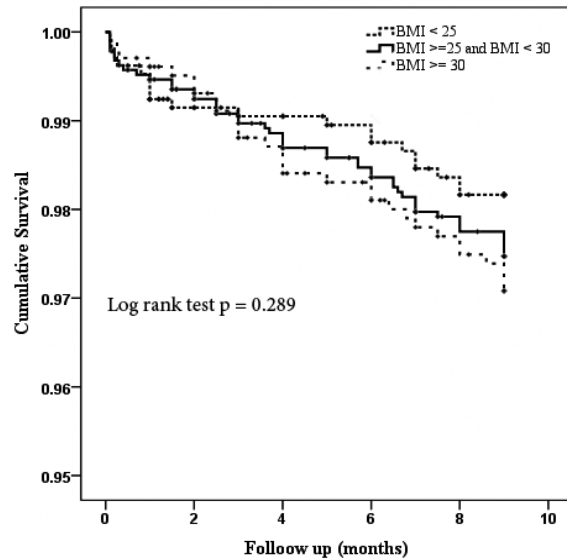

Figure 1. Kaplan-Meier survival curves based on the body mass index categorization, divided as normal (< 25 kg/m^2), overweight (≥ 25 to < 30 kg/m^2), and obese (≥ 30 kg/m^2), during a 9-month follow-up period

We performed multivariate analysis to adjust for clinical and procedural characteristics, including age, gender, smoking history, diabetes mellitus, systemic hypertension, PCI on the LAD, hyperlipidemia, and prior ST-segment

Table 3. Comparison between the three BMI categories according to in-hospital events[*]

	Normal Weight (n=1058)	Overweight (n=1867)	Obese (n=1023)	P value
In-hospital death	0	1 (0.1)	1 (0.1)	0.746
In-hospital MI	1 (0.1)	8 (0.4)	3 (0.3)	0.316
Abrupt closure	0	3 (0.2)	1 (0.1)	0.700

[*]Data are presented as n (%)
BMI, Body mass index; MI, Myocardial infarction

Table 4. Comparison between the three BMI categories according to total 9 months' MACE[*]

	Normal Weight (n=1058)	Overweight (n=1867)	Obese (n=1023)	P value
Number of patients with MACE	19 (1.8)	46 (2.5)	29 (2.8)	0.248
Nonfatal MI	9 (0.9)	19 (1.0)	12 (1.2)	0.744
TVR	8 (0.8)	32 (1.7)	18 (1.8)	0.072
TLR	5 (0.5)	13 (0.7)	10 (1.0)	0.374
CABG	2 (0.2)	10 (0.5)	5 (0.5)	0.358
Cardiac death	3 (0.3)	4 (0.2)	2 (0.2)	0.880

[*]Data are presented as n (%)
BMI, Body mass index; MACE, Major adverse cardiac events; MI, Myocardial infarction; TVR, Target vessel revascularization; TLR, Target lesion revascularization

elevation myocardial infarction (STEMI). After adjustment, there was no significant difference in terms of MACE between the three groups (p value = 0.603). Moreover, no significant difference was observed in TVR and TLR between the BMI groups (p value = 0.226 and p value = 0.724, respectively). The rate of nonfatal MI was not different between the three groups after adjustment for the above variables (p value = 0.836). The number of the individuals undergoing CABG was significantly different between the BMI groups before adjustment, while no remarkable difference was observed after adjustment (p value = 0.682).

Discussion

Our study showed that the occurrence of MACE was not significantly different between the BMI groups undergoing PCI after a follow-up period of 9 months. Moreover, there was an increasing trend of in-hospital outcomes such as cardiac death and emergent cardiac surgery in the obese individuals in the Iranian population.

To our knowledge, the present study is the first of its kind to aim at evaluating the effect of the BMI on mortality in patients undergoing successful elective PCI in the Iranian population. Several studies have reported a relationship between severe obesity and worse in-hospital outcomes after PCI. Ellis et al.[12] found that patients with BMI > 35 kg/m² had higher in-hospital mortality as well as those with BMI < 18.5 kg/m². A similar relation was found by Powell et al.[13] between mortality and extreme BMI after PCI. In our study, increased in-hospital outcomes in the obese patients were similar to those in the above studies. Be that as it may, a lack of underweight and severely obese participants meant that comparisons in our study were made between only three BMI groups: normal weight, overweight, and obese. It has been documented that in patients undergoing coronary revascularization (either bypass surgery or PCI) after acute MI, those with morbid obesity (BMI ≥ 40 kg/m²) have lower odds of in-hospital mortality compared to non-morbidly obese patients.[14] Patients with acute MI were excluded from this study. Based on the Cadillac study by Nikolski et al.,[15, 16] there is a correlation between lower mortality and higher BMI.[13, 15] A study conducted by Curtis et al.[17] revealed the protective effects of obesity on short-term and long-term mortality after PCI, which supports the existence of the obesity paradox. In contrast, among the studies with longer follow-up periods, the BARI trial, Bypass Angioplasty Revascularization Investigation by Gurm et al.,[6] and ARTS trial by Gruberg et al.[4, 5] showed no difference in long-term mortality in obese individuals compared to other groups. In addition, Tarastchuk et al.[18] found no effect of the BMI on short-term mortality in PCI patients, while waist circumference was an independent predictor of MACE. The most recent study is one conducted by Sarno et al.,[19]

who reported that after 1-year follow-up, the cumulative rate of cardiac death, MI, and clinically justified TVR was significantly higher in the obese group and that a higher BMI was an independent predictor of stent thrombosis.

In a meta-analysis of studies on the effect of obesity on short- and long-term mortality after coronary revascularization,[20] compared to individuals with non-elevated BMI levels, obese patients undergoing PCI had lower short- and long-term mortality. This study suggested that further research was needed to confirm the validity of these findings. Subsequently, Hastie et al.[21] studied a cohort of 4880 patients undergoing PCI and reported that, compared with normal-weight patients, only a subgroup of patients categorized as overweight II patients (27.5 ≤ BMI < 30 kg/m²) had a reduced risk of dying after 5 years' follow-up either after the procedure or 30 days after the procedure. In their study, risk of death was similar when the normal-weight patients were compared with overweight I (25 ≤ BMI < 27.5 kg/m²) and obese (BMI ≥ 30 kg/m²) cases. Our overweight (25 ≤ BMI < 30 kg/m²) and obese patients had similar mid-term cardiac mortality compared to the normal-weight group. The results of our study, with an about 2.5-fold larger study sample, are consistent with the results of the Poston et al.[22] study, which reported no protection afforded by obesity against cardiac events 6 months after PCI. However, this result can still be considered the obesity paradox as one would expect that a higher BMI would indicate an increased risk of cardiac mortality after PCI.

This is a retrospective study and, thus, suffers from all the limitations inherent in studies of its kind. There were only 35 underweight and severely obese patients in our ample population, which precluded separate analysis. The non-inclusion of waist and hip circumferences in the analysis, which should be analyzed as an index of central obesity, is one of the limitations of our study.

Conclusion

We found that the BMI status was not a significant predictor of MACE at a 9-month follow-up period among patients having undergone PCI. It seems that the BMI should not have a significant effect on the clinicians' therapeutic recommendations for such patients.

Acknowledgements

This study was approved and supported by Tehran University of Medical Sciences.

References

1. Larijani B, Fakhrzadeh H, Hamidi A, Heshmat R, Pourebrahim R. Household cardiovascular health education. A school-based approach. Saudi Med J 2007;28:643-655.
2. Gurney M, Gorstein J. The global prevalence of obesity: an initial overview of available data. World Health Stat Q 1988;41:251-254.
3. Byrne J, Spence MS, Fretz E, Mildenberger R, Chase A, Berry B, Pi D, Janssen C, Klinke P, Hilton D. Body mass index, periprocedural bleeding, and outcome following percutaneous coronary intervention (from the British Columbia Cardiac Registry). Am J Cardiol 2009;103:507-511.
4. Gruberg L, Weissman NJ, Waksman R, Fuchs S, Deible R, Pinnow EE, Ahmed LM, Kent KM, Pichard AD, Suddath WO, Satler LF, Lindsay J, Jr. The impact of obesity on the short-term and long-term outcomes after percutaneous coronary intervention: the obesity paradox? J Am Coll Cardiol 2002;20:578-584.
5. Minutello RM, Chou ET, Hong MK, Bergman G, Parikh M, Iacovone F, Wong SC. Impact of body mass index on in-hospital outcomes following percutaneous coronary intervention (report from the New York State Angioplasty Registry). Am J Cardiol 2004;93:1229-1232.
6. Gurm HS, Whitlow PL, Kip KE; BARI Investigators. The impact of body mass index on short- and long-term outcomes in patients undergoing coronary revascularization. Insights from the bypass angioplasty revascularization investigation (BARI). J Am Coll Cardiol 2002;39:834-840.
7. Rezaeian M, Salem Z. Prevalence of obesity and abdominal obesity in a sample of urban adult population within South East of Iran. Pak J Med Sci 2007;23:193-197.
8. Malekzadeh R, Mohamadnejad M, Merat SH, Pourshams A, Etemadi A. Obesity pandemic: an Iranian perspective. Arch Iranian Med 2005;8:1-5.
9. Alidoosti M1, Salarifar M, Haji-Zeinali AM, Kassaian SE, Dehkordi MR, Fathollahi MS. Clinical outcomes of drug-eluting stents compared with bare metal stents in our routine clinical practice. Hellenic J Cardiol 2008;49:132-138.
10. Kassaian SE, Sahebjam M, Salarifar M, Alidoosti M, Haji Zeinali AM, Kazemi Saleh D, Poorhoseini H, Paydari N, Davoodi GH, Mahmoodian M, Abbasi SH. Predictors of long-term outcome in patients with acute coronary syndrome undergoing percutaneous coronary intervention: a single center registry. J Teh Univ Heart Ctr 2006;3:155-161.
11. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF, 3rd, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T, Coresh J; CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration). A new equation to estimate glomerular filtration rate. Ann Intern Med 2009;150:604-612.
12. 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;15:642-646.
13. Powell BD, Lennon RJ, Lerman A, Bell MR, Berger PB, Higano ST, Holmes DR, Jr, Rihal CS. Association of body mass index with outcome after percutaneous coronary intervention. Am J Cardiol 2003;91:472-476.
14. Dhoot J, Tariq S, Erande A, Amin A, Patel P, Malik S. Effect of morbid obesity on in-hospital mortality and coronary revascularization outcomes after acute myocardial infarction in the United States. Am J Cardiol 2013;111:1104-1110.
15. Nikolsky E, Kosinski E, Mishkel GJ, Kimmelstiel C, McGarry TF, Jr, Mehran R, Leon MB, Russell ME, Ellis SG, Stone GW. Impact of obesity on revascularization and restenosis rates after bare-metal and drug-eluting stent implantation (from the TAXUS-IV trial). Am J Cardiol 2005;15:709-715.
16. Nikolsky E, Stone GW, Grines CL, Cox DA, Garcia E, Tcheng JE, Griffin JJ, Guagliumi G, Stuckey T, Turco M, Negoita M, Lansky AJ, Mehran R. Impact of body mass index on outcomes after primary angioplasty in acute myocardial infarction. Am Heart J 2006;151:168-175.
17. Curtis JP, Selter JG, Wang Y, Rathore SS, Jovin IS, Jadbabaie F, Kosiborod M, Portnay EL, Sokol SI, Bader F, Krumholz HM. The obesity paradox: body mass index and outcomes in patients with heart failure. Arch Intern Med 2005;165:55-61.
18. Tarastchuk JC, Guérios EE, Bueno Rda R, Andrade PM, Nercolini DC, Ferraz JG, Doubrawa E. Obesity and coronary intervention: should we continue to use body mass index as a risk factor? Arq Bras Cardiol 2008;90:284-289.
19. Sarno G, Garg S, Onuma Y, Buszman P, Linke A, Ischinger T, Klauss V, Eberli F, Corti R, Wijns W, Morice MC, di Mario C, van Geuns RJ, Eerdmans P, Garcia-Garcia HM, van Es GA, Goedhart D, de Vries T, Jüni P, Meier B, Windecker S, Serruys P. The impact of body mass index on the one year outcomes of patients treated by percutaneous coronary intervention with Biolimus- and Sirolimus-eluting stents (from the LEADERS Trial). Am J Cardiol 2010;105:475-479.
20. Oreopoulos A, Padwal R, Norris CM, Mullen JC, Pretorius V, Kalantar-Zadeh K. Effect of obesity on short- and long-term mortality post coronary revascularization: a meta-analysis. Obesity (Silver Spring) 2008;16:442-450.
21. Hastie CE, Padmanabhan S, Slack R, Pell AC, Oldroyd KG, Flapan AD, Jennings KP, Irving J, Eteiba H, Dominiczak AF, Pell JP. Obesity paradox in a cohort of 4880 consecutive patients undergoing percutaneous coronary intervention. Eur Heart J 2010;31:222-226.
22. Poston WS, Haddock CK, Conard M, Spertus JA. Impact of obesity on disease-specific health status after percutaneous coronary intervention in coronary disease patients. Int J Obes Relat Metab Disord 2004;28:1011-1107.