Impact of Body Mass Index on In-Hospital Outcomes after Percutaneous Coronary Interventions

Mohammad Khalilur Rahman Siddiqui, STM Abu Azam, Pradip Kumar Karmakar, Shaila Nabi, Pranob Karmaker, Ratan Kumar Datta, Mohammad Morshedul Ahsan, Anup Kumar Howlader, Sharadindu Shekhar Roy, Mohammad Sadaqul Islam Sikder

Department of Cardiology, National Institute of Cardiovascular Diseases, Dhaka

Key words:
Obesity, Body mass index, Coronary artery disease, Percutaneous coronary interventions, Risk factor for CAD.

Abstract:

Background: *Obesity, measured on the basis of body mass index (BMI), is an independent cardiovascular risk factor. However, some studies have reported the "obesity paradox" after percutaneous coronary intervention (PCI). The relationship between BMI and clinical outcomes after PCI has not been thoroughly investigated, especially in Bangladesh.*

Method: *This cross sectional observational study was conducted at National Institute of Cardiovascular Diseases, on total 100 patients who underwent PCI with two equally divided groups on the basis of BMI of Asian ethnicity: Group I (BMI < 23 kg/m2) and Group II (BMI e" 23.0 kg/m2). In-hospital outcomes were observed and recorded after PCI.*

Results: *The mean BMI of study population was 23.9 ± 1.9 kg/m^2. The sum of occurrence of adverse in-hospital outcomes was 14.0%. Complications were significantly (p < 0.01) higher in Group I than Group II. Among all adverse in-hospital outcomes, only acute left ventricular failure was found to be statistically significant between groups (p < 0.01). The difference of mean duration of hospital stay after PCI was higher in Group-I which was statistically significant (p < 0.01). Diabetes mellitus and dyslipidemia were found to be the independent predictors for developing adverse in-hospital outcome (OR= 1.68 and 1.46; 95% CI = 1.25 – 2.24 and 1.16 – 1.83; p = 0.018 and 0.040, respectively). BMI was inversely associated with adverse in-hospital outcome after PCI (OR = 0.95; 95% CI = 0.91 – 0.98; p = 0.007).*

Conclusion: *BMI is inversely associated with adverse in-hospital outcomes after PCI. The underweight and normal weight people are at greater risk to experience in-hospital adverse outcomes than overweight and obese people following PCI.*

(Cardiovasc. j. 2017; 10(1): 31-39)

Introduction:

Coronary heart disease (CHD) is a worldwide health epidemic. Globally, 30% of all deaths can be attributed to cardiovascular disease, of which more than half are caused by CHD. Those who die from cardiovascular diseases globally, 80% are in the developing countries.[1]

Ischemic heart disease (IHD) is a major and increasing health care issue in Bangladesh.[2] Only a limited number of small-scale epidemiological studies are available. IHD prevalence was between 2.7% and 3.4% in two studies with a rural sample and 19.6% with an urban sample of working professionals.[3] Despite marked disparity in values, there seems to be a rising prevalence of coronary artery disease (CAD) in Bangladesh.[4]

With the combination of sophisticated equipment, experienced operators, and modern drug therapy, coronary angioplasty has evolved into an effective nonsurgical modality for treating patients with CAD.[2,5]The number of PCIs is expected to grow modestly (1% to 5%) over the next decade as a result of the aging population and an increased frequency of diabetes and obesity.[6]

Institute for Health Metrics and Evaluation at University of Washington reported 17% of adults of Bangladesh as overweight or obese.[7]Overweight and obesity are established risk factors for major debilitating chronic diseases including hypertension, type II diabetes mellitus, dyslipidemia, stroke, and CAD.[8–11] There are limited data, however, on the

Address of Correspondence: Dr.Mohammad Khalilur Rahman Siddiqui, Department of Cardiology, National Institute of Cardiovascular Diseases, Dhaka, Bangladesh. Email: drmkrs@gmail.com

relationship of body mass index (BMI) as a prognostic risk factor for outcomes following revascularization procedures such as PCI.[12] A number of studies have shown that lean patients (<20 kg/m^2) and those with normal BMI (20–24.9 kg/m^2) are at a higher risk for adverse in-hospital outcomes and post-PCI complications than overweight (25–29.9 kg/m^2) and obese (e"30 kg/m^2) patients.[12–14] This unexpected phenomenon was explained by "obesity paradox".[12]

Methods:

This cross sectional observational study was conducted at the Department of Cardiology, National Institute of Cardiovascular Diseases and Hospital, Dhaka, during the period from November 2015 to October 2016. By purposive sampling technique total 100 patients who underwent PCI in NICVD during this period were selected. Study subjects were divided on the basis of their BMI in accordance with Asian ethnicity into two equal groups each containing 50 patients: Group I (BMI < 23 kg/m^2) and Group II (BMI ≥ 23.0 kg/m-^{2}). Patients with chronic kidney diseases, chronic liver disease, chronic obstructive pulmonary disease, valvular heart disease, congenital heart disease, cardiomyopathy, previous history of revascularization (PCI or CABG) were excluded from the study. Patients undergoing primary PCI, transradial interventions were not included, also. No ethical violation was made in conducting the study.

Patients were selected after having matched the inclusion and exclusion criteria. Weight and height were measured and recorded in all participants by a standard medical scale and stadiometer, respectively. Self-reported weight or height was not accepted. BMI was calculated, categorized and recorded accordingly.PCI was done by transfemoral approach. Following PCI patients were monitored at Coronary Care Unit for at least 24 hours. The following in-hospital outcomes were observed and recorded after PCI: bleeding, stroke, vascular access site complications, post-PCI ischemic chest pain, myocardial infarction with PCI, significant arrhythmia, acute stent thrombosis, repeat revascularization, acute heart failure, contrast induced nephropathy, cardiogenic shock, cardiovascular death.

Logistic regression analysis was performed to adjust for the potential confounders in predicting the association between BMI and in-hospital outcomes. Univariate logistic regression analysis was performed to specify the odds ratio (OR) for overall adverse in-hospital outcomes. Multivariate logistic regression analysis was then performed by using SPSS 23.0 to investigate independent predictors for adverse in-hospital outcomes. Variables yielding p values d" 0.05in univariate analysis were selected for multivariate model. Statistical significance was assumed if p d" 0.05 throughout the study.

Results

Out of 100 studied patients 84% were male and 16% were female. Male to female ratio was 4.5:1. No significant association (p>0.05) was found between the groups in terms of sex distribution. The mean age of the patients was51.1 ± 9.57 years and the mean age difference between two groups was not statistically significant (p>0.05). In both of the groups the highest percentages of patients were in the age range of 41-50 years (Table-I).

Table II shows that among the different risk factors dyslipidaemia, hypertension and diabetes mellitus were significantly more in group II (<0.05). The other risk factors i.e., smoking and family history of CAD were not significantly different between the groups (p >0.05).

The difference of means of height was insignificant (p>0.05) across the groups. But that of weight was found to be significant (p=0.001). BMI was significantly (p=0.001) higher in group II than group I. The breakdown of total patient would be 81 in Group I and 19 in Group II with statistically significant difference (p = 0.001) of mean BMI across the group had their conventional non-Asian BMI cut-off value been used (Table III).

The difference of means of height between the two sex groups was significant (p=0.001). The difference of means of weight across these groups was also significant (p<0.01). BMI was higher in female patients than in male but the difference between them was not statistically significant in any group (p>0.05) (Table IV).

Table V compares the distribution of clinical presentations between the groups. The percentage of STEMI was the highest in both groups. No statistically significant difference was noted between the two groups (p> 0.05).

Table -I

Comparison of the study groups by their demographic characteristics (N = 100).

Age in years	BMI				Total		*p*-value
	Group I (n = 50)		Group II (n = 50)		(N =100)		
	Number	%	Number	%	Number	%	
d” 40	4	8.0	5	10.0	9	9.0	$^{a}0.11^{NS}$
41-50	23	46.0	25	50.0	48	48.0	
51-60	17	34.0	14	28.0	31	31.0	
> 60	6	12.0	6	12.0	12	12.0	
Mean ± SD	51.2 ± 11.4	50.9 ± 9.1	51.1 ± 9.57	$^{b}0.91^{NS}$			
Sex							
Male	43	86.0	41	82.0	84	84.0	$^{a}0.92^{NS}$
Female	7	14.0	9	18.0	16	16.0	

Group I = Patients with BMI <23 kg/m^2
Group II = Patients with BMI ≥ 23 kg/m^2
NS= Not Significant (*p*>0.05)
^{a}*p*-value reached from chi-squared (Ç^2) test and Fisher exact test
^{b}*p*-value reached from unpaired t-test

Table -II

Comparison of the study groups according to their risk factors (N = 100)

Risk factors	BMI				Total		*p*-value
	Group I (n = 50)		Group II (n = 50)		(N =100)		
	Number	%	Number	%	Number	%	
Smoking	20	40.0	24	48.0	44	44.0	0.587^{NS}
DM	9	18.0	21	42.0	30	30.0	0.038^{S}
Hypertension	11	22.0	23	46.0	34	34.0	0.048^{S}
Dyslipidaemia	7	14.0	20	40.0	27	27.0	0.022^{S}
Family history of CAD	14	28.0	14	28.0	28	28.0	0.931^{NS}

Group I = Patients with BMI < 23 kg/m^2
Group II = Patients with BMI e” 23 kg/m^2
DM = Diabetes Mellitus
CAD = Coronary Artery Disease
S = Significant (*p* < 0.05)
NS = Not Significant (*p* > 0.05)
p-value reached from chi-squared (Ç^2) test

Table-III

Comparison of the study groups by their height, weight and BMI (N=100).

Parameters	BMI		Total	*p*- value
	Group I (n = 50)	Group II (n = 50)	(N =100)	
	Mean ± SD	Mean ± SD	Mean ± SD	
Height(in meter)	1.61 ± 0.07	1.63 ± 0.06	1.62 ± 0.06	0.26^{NS}
Weight(in kilogram)	55.5 ± 5.5	65.7 ± 5.9	63.4 ± 7.2	0.001^{S}
BMI cutoff value 23 kg/m^2	21.3 ± 1.4	24.7 ± 1.4	23.9 ± 1.9	0.001^{S}
	*Group I (n=81)	*Group II (n= 19)		
BMI cutoff value 25 kg/m^2	23.3 ± 1.5	26.7 ± 1.3	23.9 ± 1.9	0.001^{S}

Group I = Patients with BMI <23 kg/m^2
Group II = Patients with BMI e” 23 kg/m^2
* = Had non-Asian BMI category been used in this study
S= Significant (*p*<0.05)
NS= Not Significant (*p*>0.05)
p-value reached from unpaired t-test

Table-IV

Comparison of height, weight and BMI within each study groups by sex of the patients (N = 100).

Study group	Male (n= 84)		Female (n= 16)		Mean ± SD	*p*-value
	Number	Mean ± SD	Number	Mean ± SD	(N =100)	
Height in meter	84	1.64 ± 0.04	16	1.51 ± 0.06	1.62 ± 0.06	0.001^{S}
Weight in kilogram	84	64.5 ± 6.3	16	56.4 ± 8.6	63.4 ± 7.2	0.006^{S}
Group I(n = 50)	43	21.2 ± 1.4	7	21.9 ± 0.8		0.436^{NS}
Group II(n = 50)	41	24.6 ± 1.3	9	25.3 ± 1.9		0.169^{NS}
	84	23.9 ± 1.9	16	24.5 ± 2.3	23.9 ± 1.9	0.294^{NS}

Group I = Patients with BMI <23 kg/m^2, Group II = Patients with BMI e" 23 kg/m^2.
S= Significant (p<0.05)
NS= Not Significant (p>0.05)
p-value reached from unpaired t-test

Table-V

Comparison of the study population by clinical presentations (N = 100)

Diagnosis	BMI				Total		*p*-value
	Group I (n = 50)		Group II (n = 50)		(N =100)		
	Number	%	Number	%	Number	%	
CSA	6	12.0	5	10.0	11	11.0	0.27^{NS}
UA	6	12.0	7	14.0	13	13.0	
NSTEMI	9	18.0	11	22.0	20	20.0	
STEMI	29	58.0	27	54.0	56	56.0	

Group I = Patients with BMI < 23 kg/m^2
Group II = Patients with BMI e" 23 kg/m^2
CSA = Chronic Stable Angina
UA = Unstable Angina
NSTEMI = Non-ST-segment Elevation Myocardial Infarction
STEMI = ST-segment Elevation Myocardial Infarction
NS = Not Significant (p > 0.05)
p-value reached from chi-squared (Ç^2) test

Table VI shows that the baseline LV function measured by echocardiography between the two study groups was not statistically significant (p > 0.05). The difference of mean LVEF was also insignificant statistically (p > 0.05) between the groups. Post-PCI echocardiography to assess LV function was not done routinely.

Table VII compares the involvement of vessels between the groups. There was no statistical significance of difference between the two groups (p > 0.05).

Table VIII compares the types of stent used between the groups. DES outnumbers BMS in each group. No significant difference was found between the groups (p > 0.05).

The adverse in-hospital outcomes were significantly (p<0.01) higher in Group I than Group II. Among all adverse in-hospital outcomes, only acute LVF was found to be statistically significant between the two study groups (p< 0.01) (Table IX).

Smoking and family history of CAD were not included in multivariate model as univariate analysis yielded them as statistically insignificant in the current study (OR = 1.29 and 1.10; 95% CI = 0.82– 1.78 and 0.46 – 1.75; p=0.273 and 0.087, respectively). Hypertension and left ventricular ejection fraction (LVEF) that were significant (OR = 1.51 and 1.53; 95% CI = 1.05 – 2.10 and 1.32 – 1.78; p=0.026 and 0.049, respectively) in univariate analysis were found to be insignificant (OR = 1.36 and 1.15; 95% CI = 0.92 – 1.95 and 0.98 – 1.35; p=0.114 and 0.087, respectively) in multivariate regression analysis. Diabetes mellitus and dyslipidaemia were found to be the independent predictors for developing adverse in-hospital outcome after PCIs (OR= 1.68 and 1.46; 95% CI = 1.25 – 2.24 and 1.16 – 1.83; p=0.018 and 0.040, respectively). BMI was inversely associated with adverse in-hospital outcome after adjustment by multivariate logistic regression analysis (OR = 0.95; 95%CI = 0.91–0.98; p=0.007) (Table X).

Table-VI

Comparison of the study groups according to their LVEF (N = 100)

LVEF	BMI				Total		*p*-value
	Group I (n = 50)		Group II (n = 50)		(N =100)		
	Number	%	Number	%	Number	%	
<50	23	46.0	29	58.0	52	52.0	$^{a}0.79^{NS}$
>50	27	54.0	31	62.0	58	58.0	
Mean ± SD	53.4 ± 8.2		52.1 ± 8.1		53.3 ± 8.1		$^{b}0.69^{NS}$

Group I = Patients with BMI < 23 kg/m^2
Group II = Patients with BMI e” 23 kg/m^2
LVEF = Left Ventricular Ejection Fraction
NS = Not Significant ($p > 0.05$)
[a]*p*-value reached from chi-squared (Ç^2) test
[b]*p*-value reached from unpaired t-test

Table-VII

Comparison of the study groups by involvement of vessels (N = 100)

Vessels involved	BMI				Total		*p*-value
	Group I (n = 50)		Group II (n = 50)		(N =100)		
	Number	%	Number	%	Number	%	
LAD	16	32.0	12	24.0	28	28.0	0.07^{NS}
RCA	19	38.0	21	42.0	40	40.0	
LCX	7	14.0	10	20.0	17	17.0	
LAD & RCA	5	10.0	6	12.0	11	11.0	
RCA & LCX	1	2.0	0	0.0	1	1.0	
LAD & LCX	2	4.0	1	2.0	3	3.0	

Group I = Patients with BMI < 23 kg/m^2
Group II = Patients with BMI e” 23 kg/m^2
LAD = Left Anterior Descending Artery
RCA = Right Coronary Artery
LCX = Left Circumflex Artery
NS = Not Significant ($p > 0.05$)
p-value reached from chi-squared (Ç^2) test and Fisher exact test

Table-VIII

Comparison of the study groups according to the types of stent used (N = 100)

Types of stent used	BMI				Total		*p*-value
	Group I (n = 50)		Group II (n = 50)		(N =100)		
	Number	%	Number	%	Number	%	
DES	27	54.0	29	58.0	56	56.0	0.07^{NS}
BMS	16	32.0	15	30.0	31	31.0	
DES & BMS	7	14.0	6	12.0	13	13.0	

Group I = Patients with BMI < 23 kg/m^2
Group II = Patients with BMI e” 23 kg/m^2
DES = Drug Eluting Stent
BMS = Bare Metal Stent
NS = Not Significant ($p > 0.05$)
p-value reached from chi-squared (Ç^2) test

Table-IX

-Comparison of the study groups by in-hospital outcomes after PCI (N=100)

Types of stent used	BMI				Total (N =100)		p-value
	Group I (n = 50)		Group II (n = 50)				
	Number	%	Number	%	Number	%	
Adverse outcomes	11	22.0	3	6.0	14	14.0	0.006S
Chest pain	2	4.0	1	2.0	3	3.0	0.630NS
Arrhythmia	2	4.0	0	0.0	2	2.0	0.058NS
Access site complications	1	2.0	1	2.0	2	2.0	0.630NS
Acute LVF	4	8.0	0	0.0	4	4.0	0.007S
Shock	2	4.0	0	0.0	2	2.0	0.058NS
Death	0	0.0	1	2.0	1	1.0	0.594NS

Group I = Patients with BMI < 23 kg/m^2
Group II = Patients with BMI e" 23 kg/m^2
S = Significant (p <0.05)
NS = Not Significant (p > 0.05)
p-value reached from chi-squared (Ç^2) test and Fisher exact test

Table-X

Univariate and multivariate logistic regression analyses of variables associated with adverse in-hospital outcomes.

Variables of interest	Univariate analysis		p- value	Multivariate analysis		p- value
	OR	95% CI of OR		OR	95% CI of OR	
Smoking	1.29	0.82 - 1.78	0.273			
Hypertension	1.51	1.05–2.10	0.026	1.36	0.92 – 1.95	0.114
Diabetes	1.97	1.61 – 2.41	0.011	1.68	1.25 – 2.24	0.018
Dyslipidaemia	1.54	1.11 – 1.72	0.034	1.46	1.16 – 1.83	0.040
Family history	1.10	0.46 – 1.75	0.087			
LVEF	1.53	1.32 – 1.78	0.049	1.15	0.98 – 1.35	0.087
BMI	0.89	0.87 – 0.92	0.004	0.95	0.91 – 0.98	0.007

Discussions:

Obesity measured on the basis of BMI is an independent cardiovascular risk factor. A number of studies have shown that the lean patients and those with normal BMI are at a higher risk for adverse in-hospital outcomes and post-PCI complications than overweight and obese patients. This is contrary to the common clinical perception that overweight and obese patients would be at a higher risk of adverse outcomes following PCI. To date, there is not a complete understanding of this complex effect. It calls for more investigations for better understanding and explanations which are essential to formulate strategy to deal with coexistence of obesity with various morbidities.

The age distribution of the studied patients was very close to the other relevant studies.[15,16]The sex distribution of this study population is not comparable to the overall population of Bangladesh because there were fewer females in this study. This is probably due to the fact that males have greater access to health care or lack on the part of the female population about participating in screening programs. In Bangladesh, almost all of the studies reported an overwhelming majority of male patients.[17–19]

Females were found to be more obese than male in the current study as well as in the other studies.[20-21]In comparison with Europeans, the mean stature of Bangladeshi counterparts is 1.3 cm to 11.8 cm shorter.[22] BMI tends to be higher among shorter adults, especially women.[23]

In-hospital adverse outcomes after PCI was significantly higher in Group I. Compared with normal-weight individuals, overweight and obese patients had lower in-hospital adverse outcomes after PCI.[24]

Among all the adverse in-hospital outcomes, only acute LVF was found to be significantly more in Group-I. A study on 1,203 individuals with class IV heart failure found that higher BMI was associated with better survival, and multivariate analysis showed an inverse association between BMI and mortality.[25]

BMI was inversely associated with post-PCI adverse in-hospital outcome after adjustment by multivariate logistic regression analysis in this study. Gruberg et al.[12]noticed that very lean patients (BMI <18.5) and those with normal BMI are at the highest risk for in-hospital complications and cardiac death. Patients at the extremes of BMI (<18.5 and >40kg/m^2) were also at increased risk of adverse outcomes after PCI.[26] Park et al. found that low BMI was associated with increased risks of adverse in-hospital outcomes and death.[27] They also found no excess risks of these events to be associated with a high BMI. A Japanese real-world multicenter registry analysis[27] reported that lean patients, rather than obese patients were at greater risk for in-hospital complications during and after PCI.

The underlying mechanisms for 'obesity paradox' remain elusive and several mechanisms have been suggested to explain it.[12]

- Role of age and less risky obesity: Obese patients with risky abdominal obesity die earlier, and thus, among obese in the higher age categories, those with less risky lower-body obesity survive.[28]
- Medical treatment: More optimal medical treatment was there in patients with a high BMI than in those with a normal BMI. This fact may explain a lower mortality in obese patients.[29]
- Body composition: Lean body mass but not body fat was associated with favorable changes in prognostic factors.[30] A decreased BMI could be a surrogate of the "malnutrition-inûammation complex syndrome" that may cause a worse prognosis.[31]
- Enlarged muscle mass and better nutritional status: Higher mortality in the low BMI categories may be due to the sarcopenic obesity that is characterized by low muscle mass.[32] Elderly patients with heart failure, who exhibited high BMI and had improved survival.[33]
- Cardio respiratory ûtness: Obese subjects with an increased cardio respiratory ûttness have lower all-cause mortality and lower risk of cardiovascular disease.[34]
- Increased muscle strength: Muscle mass need not reûect muscle function, which largely differs and is dependent on the size, number, and contractility of ûbers; fat inûltration; collagen content etc.[32] It is muscle strength not muscle mass that is a marker of muscle quality.[35] Muscle strength is negatively associated with metabolic risks.[36]
- Endothelial progenitor cells: Less coronary atherosclerosis demonstrated in autopsies of obese[37] and paradoxical preservation of vascular function in severely obese individuals[38] may provide partial protection from atherogenesis through a greater mobilization of endothelial progenitor cells.[39]
- Thromboxane production: Levels of thromboxane B2, a stable metabolite of thromboxane A2, were lower in morbidly obese subjects than in lean and obese subjects. Thromboxane B2 negatively correlated with BMI and leptin.[40]
- Ghrelin sensitivity: Ghrelin sensitivity in the hypothalamus and myocardium associated with increased caloric intake and weight gain may be a protective factor against both heart failure and cardiac cachexia.[28]
- Soluble tumor necrosis factor receptor: Among patients with heart failure, obese subjects exhibit lower concentrations of TNF which may cause a better outcome in obese patients with heart failure.[41]

Conclusion:

BMI was inversely associated with adverse in-hospital outcomes after PCI in this study. The underweight and normal weight people were at greater risk to experience in-hospital adverse outcomes than overweight and obese people following PCI. Though obesity is a recognized risk factor for cardiovascular diseases, once cardiovascular disease is developed, this obesity seems to play protective roles and provide some benefits. This 'Obesity Paradox' leads us to reshuffle and reorganize our plans whether we should take aggressive attempts or schemes to lose weight of an obese patient once he or she develops coronary artery disease. Verily it calls for more research and observations.

Limitations of the study

There are some facts to be considered which might have affected the result of the current study.

- The study population was heterogeneous, including patients with different severities of CAD, ranging from chronic stable angina to myocardial infarction.
- The complexity of the lesions, procedural complications, use of anticoagulants and antiplatelets were not recorded which might have affected the incidence of complications in each of the BMI groups.

Conflict of Interest - None.

References:

1. Kim MC, Kini AS, Fuster V. Definitions of acute coronary syndrome. In: Fuster V, Walsh RA, Harrington RA. Eds. *Hurst's The Heart*. 13th ed. New York: The McGraw-Hill Companies, Inc, 2011: 1287–1295.
2. Rahman MT, Majumder AAS, Rahman MA. APSC 2015-1030 Immediate and In-Hospital Complications of Percutaneous Coronary Intervention. *Global Heart* 2015;10:e18.
3. Saquib N, Saquib J, Ahmed T, Khanam M, Cullen MR. Cardiovascular diseases and Type 2 Diabetes in Bangladesh: A systematic review and meta-analysis of studies between 1995 and 2010. *BMC Public Health* 2012;12:434.
4. Islam AM, Majumder AAS. Coronary artery disease in Bangladesh: A review. *Indian Heart Journal* 2013; 65: 424–435.
5. Douglas, Jr JS, King III SB. Percutaneous coronary intervention. In: Fuster V, Walsh RA, Harrington RA. Eds. *Hurst's The Heart*. 13th ed. New York: The McGraw-Hill Companies, Inc, 2011: 1440–1456.
6. Mauri L, Bhatt DL. Percutaneous Coronary Intervention. In: Mann DL, Zipes DP, Libby P, Bonow RO. Eds. *Braunwald's Heart Disease - A Textbook of Cardiovascular Medicine*. 10th ed. Philadelphia: Elsevier Saunders, 2015: 1245–1268.
7. Institute for Health Metrics and Evaluation at University of Washington. Adult rates of overweight and obesity rise in Bangladesh [cited 10-Sep-16]. Available from: http://www.healthdata.org/adult-rates-overweight-and-obesity-rise-bangladesh.
8. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW, JR. Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med* 1999;341: 1097–1105.
9. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. *JAMA* 1999;282:1523–1529.
10. Sharma AM. Obesity and cardiovascular risk. *Growth Hormone & IGF Research* 2003;13:S10-S17.
11. Sowers JR. Obesity as a cardiovascular risk factor. *Am J Med* 2003;115:37–41.
12. Gruberg L, Weissman NJ, Waksman R, Fuchs S, Deible R, Pinnow EE, et al. The impact of obesity on the short-term andlong-term outcomes after percutaneous coronary intervention: the obesity paradox? *J Am Coll Cardiol* 2002;39:578–584.
13. Ellis SG, Omoigui N, Bittl JA, Lincoff M, Wolfe MW, Howell G, et al. Analysis and comparison of operator-specific outcomes in interventional cardiology. From a multicenter database of 4860 quality-controlled procedures. *Circulation* 1996;93:431–439.
14. Powell BD, Lennon RJ, Lerman A, Bell MR, Berger PB, Higano ST, et al. Association of body mass index with outcome after percutaneous coronary intervention. *Am J Cardiol* 2003;91:472–476.
15. Rafiquzzaman K. Association of body mass index with angiographic severity of coronary artery disease in patients with acute ST-segment elevation myocardial infarction (Thesis). NICVD, Dhaka: University of Dhaka. 2015.
16. Trisha NES, Rahman SMM, Uddin MJ, Moniruzzaman MSA, Manisha D. Risk Factors among the coronary heart disease (CHD) patients attending at tertiary level hospitals of Dhaka city, Bangladesh. *SMU Medical Journal* 2014; 1: 251–260.
17. Amanullah M. Intravenous thrombolytics in acute myocardial infarction. *Bangladesh Heart Journal* 1994; 5: 5–6.
18. Islam MS, Talukder R, Sakib AM, Mokhlesuzzaman AK. Study of relation between body mass index (BMI) and angiographically severity of coronary artery disease. *KYAMC Journal* 2013;1:39–42.
19. Sabah KMN, Chowdhury AW, Khan HILR, Hasan ATMH, Haque S, Ali S, et al. Body mass index and waist/height ratio for prediction of severity of coronary artery disease. *BMC Research Notes* 2014;7:246.
20. Islam A, Munwar S, Talukder S, Reza AQ. Incidence and prevalence of atherosclerotic renal artery stenosis (RAS) in patients with coronary artery disease (CAD). *Cardiovasc j* 2010;2.

21. Mohammadifard N, Nazem M, Sarrafzadegan N, Nouri F, Sajjadi F, Maghroun M, et al. Body Mass Index, Waist-circumference and Cardiovascular Disease Risk Factors in Iranian Adults: Isfahan Healthy Heart Program. *J Health Popul Nutr* 2013;31:388–397.

22. Khadem MM, Islam MA. Development of anthropometric data for Bangladeshi male population. *International Journal of Industrial Ergonomics* 2014;44:407–412.

23. Sperrin M, Marshall AD, Higgins V, Renehan AG, Buchan IE. Body mass index relates weight to height differently in women and older adults: Serial cross-sectional surveys in England (1992-2011). *J Public health (Oxf)* 2016;38:607–613.

24. Lancefield T, Clark DJ, Andrianopoulos N, Brennan AL, Reid CM, Johns J, et al. Is there an obesity paradox after percutaneous coronary intervention in the contemporary era? An analysis from a multicenter Australian registry. *JACC Cardiovasc Interv* 2010; 3:660–668.

25. Artham SM, Lavie CJ, Milani RV, Ventura HO. Obesity and Hypertension, Heart Failure, and Coronary Heart Disease—Risk Factor, Paradox, and Recommendations for Weight Loss. *Ochsner J* 2009;9:124–132.

26. Minutello RM, Chou ET, Hong MK, Bergman G, Parikh M, Iacovone F, et al. 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.

27. Numasawa Y, Kohsaka S, Miyata H, Kawamura A, Noma S, Suzuki M, et al. Impact of Body Mass Index on In-Hospital Complications in Patients Undergoing Percutaneous Coronary Intervention in a Japanese Real-World Multicenter Registry. *PLoS ONE* 2015;10.

28. Hainer V, Aldhoon-Hainerová I. Obesity paradox does exist. *Diabetes Care* 2013;36 Suppl 2:S276-281.

29. Schenkeveld L, Magro M, Oemrawsingh RM, Lenzen M, Jaegere Pd, van Geuns R-J, et al. The influence of optimal medical treatment on the 'obesity paradox', body mass index and long-term mortality in patients treated with percutaneous coronary intervention: a prospective cohort study. *BMJ Open* 2012;2:e000535.

30. Oreopoulos A, Ezekowitz JA, McAlister FA, Kalantar-Zadeh K, Fonarow GC, Norris CM, et al. Association Between Direct Measures of Body Composition and Prognostic Factors in Chronic Heart Failure. *Mayo Clin Proc* 2010;85:609–617.

31. Kalantar-Zadeh K, Block G, Horwich T, Fonarow GC. Reverse epidemiology of conventional cardiovascular risk factors in patients with chronic heart failure. *J Am Coll Cardiol* 2004;43:1439–1444.

32. Stenholm S, Harris TB, Rantanen T, Visser M, Kritchevsky SB, Ferrucci L. Sarcopenic obesity: definition, cause and consequences. *Curr Opin Clin Nutr Metab Care* 2008;11:693–700.

33. Casas-Vara A, Santolaria F, Fernández-Bereciartúa A, González-Reimers E, García-Ochoa A, Martínez-Riera A. The obesity paradox in elderly patients with heart failure: analysis of nutritional status. *Nutrition* 2012;28:616–622.

34. Hainer V, Toplak H, Stich V. Fat or Fit: What Is More Important? *Diabetes Care* 2009;32:S392-7.

35. McAuley PA, Artero EG, Sui X, Lee D-c, Church TS, Lavie CJ, et al. The obesity paradox, cardiorespiratory fitness, and coronary heart disease. *Mayo Clin Proc* 2012;87:443–451.

36. Newman AB, Kupelian V, Visser M, Simonsick EM, Goodpaster BH, Kritchevsky SB, et al. Strength, But Not Muscle Mass, Is Associated With Mortality in the Health, Aging and Body Composition Study Cohort. *J Gerontol A Biol Sci Med Sci* 2006;61:72–77.

37. Kortelainen M-L, Porvari K. Extreme obesity and associated cardiovascular disease verified at autopsy: time trends over 3 decades. *Am J Forensic Med Pathol* 2011;32:372–377.

38. Biasucci LM, Graziani F, Rizzello V, Liuzzo G, Guidone C, Caterina AR de, et al. Paradoxical preservation of vascular function in severe obesity. *Am J Med* 2010;123:727–734.

39. Fadini GP, Boscaro E, Kreutzenberg S de, Agostini C, Seeger F, Dimmeler S, et al. Time course and mechanisms of circulating progenitor cell reduction in the natural history of type 2 diabetes. *Diabetes Care* 2010;33:1097–1102.

40. Graziani F, Biasucci LM, Cialdella P, Liuzzo G, Giubilato S, Della Bona R, et al. Thromboxane production in morbidly obese subjects. *Am J Cardiol* 2011;107: 1656–1661.

41. Feldman AM, Combes A, Wagner D, Kadakomi T, Kubota T, You Li Y, et al. The role of tumor necrosis factor in the pathophysiology of heart failure. *J Am Coll Cardiol* 2000;35:537–544.