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The association of abdominal obesity with the incidence of in-stent restenosis and thrombosis

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Abstract

BACKGROUND: Given the association between obesity and increased risks of cardiovascular diseases, the acceleration of atherosclerosis, and the significance of patient outcomes after percutaneous coronary intervention (PCI), this study aimed to investigate the relationship between abdominal obesity and the incidence of in-stent restenosis (ISR) or stent thrombosis (ST) following PCI.

METHODS: This cross-sectional study included 5,980 patients who underwent angioplasty at Chamran Specialty Heart Hospital from March 2023 to February 2025. Of this population, 105 patients who developed ISR or ST and returned to the hospital were evaluated. Their demographic and clinical characteristics were recorded, and waist circumference was measured to assess abdominal obesity.

RESULTS: The findings revealed that ISR and ST occurred in 66 (86.8%) and 10 (13.2%) cases, respectively, among patients with abdominal obesity, whereas in patients without abdominal obesity, these complications were observed in 25 (86.2%) and 4 (13.8%) cases, respectively ($P > 0.050$). Additionally, the incidence of ISR or ST was reported to occur over a longer period in patients without abdominal obesity, whereas it was observed within a shorter timeframe after PCI in patients with abdominal obesity ($P < 0.05$).

CONCLUSION: According to the results of this study, the prevalence of abdominal obesity was higher in patients with complications of ISR or ST after PCI. Also the incidence of ISR or ST occurred in a longer period of time in patients without abdominal obesity after PCI and in a shorter period of time after PCI in patients with abdominal obesity.

Keywords: Stent; Stent Thrombosis; In-Stent Restenosis; Abdominal Obesity; Percutaneous Coronary Intervention (PCI)

Introduction

Coronary artery disease (CAD) is one of the most prevalent cardiovascular conditions, characterized by the narrowing or occlusion of the coronary arteries. Treatment options include coronary artery bypass graft (CABG) surgery or percutaneous coronary intervention (PCI), which involves the deployment of drug-eluting or bare-metal stents to restore blood flow. PCI is generally preferred over CABG due to its minimally invasive nature and lower cost, allowing for a faster return to daily activities[1]. However, despite the widespread adoption of PCI and advancements in drug-eluting stent technology, complications such as in-stent restenosis (ISR) and stent thrombosis (ST) remain significant concerns[2, 3]. These complications can lead to adverse outcomes, including repeat PCI, CABG, ischemic heart disease, or even mortality[4].

Abdominal obesity (visceral obesity) refers to the accumulation of fat in the abdominal region and around internal organs such as the liver, pancreas, and intestines. This type of fat differs from subcutaneous fat, as visceral fat is more metabolically active and can have significant negative effects on overall health. Abdominal obesity is directly associated with an increased risk of cardiovascular disease, particularly CAD (atherosclerosis), as visceral fat contributes to the release of inflammatory cytokines (e.g., TNF-α and IL-6), increased triglycerides, decreased HDL cholesterol, increased LDL cholesterol, endothelial dysfunction (reduced ability of blood vessels to dilate), secretion of angiotensinogen, insulin resistance, and impaired lipid metabolism thus accelerating the process of atherosclerosis[5-9].

Although ST is a rare complication, the incidence of ISR remains high. The prevalence of these complications ranges from 3% to 20% and is influenced by various factors, including coronary anatomical characteristics, patient-specific risk factors, and a history of prior PCI. Contributing factors include endothelial dysfunction, smooth muscle hyperplasia, and inflammation, as well as a history of unstable angina or myocardial infarction. Additionally, patient demographics such as age, sex, hypertension, hyperlipidemia, diabetes, and smoking play a role in determining risk. Procedural and anatomical factors, including lesion location and length, the number of affected coronary arteries, stent type, number of stents implanted, and stent length, also significantly influence the likelihood of ISR and ST[5, 6, 10].

Furthermore, existing literature suggests that cardiovascular diseases are more prevalent in individuals with metabolic syndrome (MetS), a cluster of conditions characterized by increased waist circumference, dyslipidemia, systemic inflammation, insulin resistance, and diabetes. MetS is associated with an elevated risk of cardiovascular events, including myocardial infarction, heart failure, and other forms of coronary artery disease. Obesity, particularly visceral fat accumulation, is a significant risk factor for both MetS and coronary heart disease[4].

Visceral adipose tissue is now recognized as an active endocrine organ that secretes inflammatory mediators and cytokines, alters the prothrombotic profile, and contributes to endothelial dysfunction key mechanisms involved in atherosclerosis and thrombosis[10]. Consequently, it has been hypothesized that individuals with visceral obesity may be at a higher risk of ISR and ST. However, research on this association remains limited, as most studies have primarily investigated the relationship between obesity typically assessed by body mass index (BMI) and the incidence of ISR or ST[11-14]. The findings from these studies have been inconsistent, highlighting the need for further investigation.

On the other hand, studies evaluating the effect of abdominal obesity on these complications are crucial for accurate prediction and the implementation of preventive measures to improve the prognosis of patients with atherosclerotic diseases undergoing stent treatment. Hence, this study aimed to assess the frequency of ISR and ST and their association with abdominal obesity.

Materials and Methods

This cross-sectional study was conducted at Chamran Specialty Heart Hospital. The study population included all 5,980 patients who underwent percutaneous coronary intervention (PCI) between March 2023 and February 2025. Among them, 105 patients who presented with ST or ISR following PCI were included in the analysis.

After obtaining the ethical approval from the Ethics Committee of Isfahan University of Medical Sciences (approval code: IR.MUI.MED. REC.1403.167) and written consent from eligible patients, their demographic characteristics including gender, age, height, weight, BMI, underlying heart disease, history of any underlying diseases (such as diabetes, hypertension, hypercholesterolemia, hypertriglyceridemia, CKD), and smoking were recorded.

To assess abdominal obesity, waist circumference was measured as follows: the circular distance midway between the anterior superior iliac spine and the lowest subcostal margin was determined hypothetically and measured at the end of natural expiration. The average of two consecutive measurements was calculated as the final waist circumference value.

Abdominal obesity was considered with a waist circumference of more than 102 cm in men and more than 88 cm in women[15]. Additional recorded data included the number of implanted stents, the number of stented vessels, the occurrence of ISR or ST, the affected vessel and its precise location (proximal, mid, or distal segment), the time interval between stent implantation and the diagnosis of ISR or ST, initial clinical presentation at the time of stent implantation (e.g., acute coronary syndrome [ACS]), the use of non-compliant (NC) balloon post-dilation, and the size and diameter of the re-stenotic or thrombosed stent. Also, angiography films of all patients with ISR and ST were reviewed and approved by a team of authors who were all interventional cardiology.

Statistical analysis

The collected data were entered into SPSS software (Version 27) for statistical analysis. Quantitative and qualitative variables were reported as mean ± standard deviation (SD) and frequency and percentage (n, %), respectively. An independent samples t-test was used to compare the means of quantitative variables. Additionally, a chi-squared test (or Fisher's exact test, where appropriate) was performed to compare the frequency distributions of qualitative variables among patients with and without abdominal obesity and between those with ISR or ST. In all analyses, a significance level of less than 0.05 was considered statistically significant.

Results

In the present study, out of 5,980 patients who underwent PCI, 105 experienced ISR or ST and subsequently returned to the hospital. Of these, 76 (72.4%) had abdominal obesity, while 29 (27.6%) did not. The prevalence of abdominal obesity was significantly higher in women (82.9%) compared to men (17.1%) ($P = 0.005$).

The mean age of these patients was 60.56 ± 11.10 years, with no significant difference between those with and without abdominal obesity ($P > 0.05$). Additionally, although three-vessel disease (3VD) with ISR was more commonly observed in patients with abdominal obesity than in those without, the difference was not statistically significant ($P = 0.923$). Moreover, the number of stents used in patients with abdominal obesity was higher than that in patients without abdominal obesity, although this difference was also not statistically significant ($P > 0.050$).

ISR and ST occurred in 66 (86.8%) and 10 (13.2%) cases, respectively, among patients with abdominal obesity. Among patients without abdominal obesity, ISR and ST were reported in 25 (86.2%) and 4 (13.8%) cases, respectively, with no statistically significant difference between the two groups ($P > 0.050$) (Table 1).

On the other hand, waist circumference (WC) in patients with ST had a mean value of 113.22 ± 8.41 cm, which was higher than the mean WC in patients with ISR (112.015 ± 9.63 cm),

Table 1. Patients' baseline and clinical characteristics based on abdominal obesity

Variables	Total (n=105)	Abdominal Obesity (n=76)	Non Abdominal Obesity (n=29)	P value
Sex				
Male	26(24.8%)	13(17.1%)	13(44.8%)	0.005
Female	79(75.2%)	63(82.9%)	16(55.2%)	
Age; year	60.56±11.10	60.86±11.22	59.79±10.95	0.663
Height; cm	169.56±7.59	170.39±6.83	167.38±9.06	0.069
Weight; kg	75.19±11.72	78.33±11.18	66.97±8.84	<0.001
BMI; kg/m²	26.10±3.34	26.96±3.32	23.85±2.16	<0.001
Comorbidity				
DM	34(32.4%)	25(32.9%)	9(31.0%)	0.855
HTN	64(61.0%)	47(61.8%)	17(58.6%)	0.825
HCL	7(6.7%)	7(9.2%)	0(0.0%)	0.186
HTG	1(1.0%)	1(1.3%)	0(0.0%)	1.00
Smoking	11(10.5%)	9(11.8%)	2(6.9%)	0.723
Anticoagulants				
Aspirin and Plavix	74(70.5%)	53(69.7%)	21(72.4%)	0.214
Aspirin and Ticagrelor	7(6.7%)	7(9.2%)	0(0.0%)	
Aspirin alone	24(22.9%)	16(21.1%)	8(27.6%)	
ACS	95(90.5%)	69(90.8)	26(89.7%)	0.826
NC Post-dilatation	24(24.2%)	17(23.6%)	7(25.9%)	0.811
CAD				
SVD	27(25.7%)	19(25.0%)	8(27.6%)	0.923
2VD	35(33.3%)	25(32.9%)	10(34.5%)	
3VD	43(41.0%)	32(42.1%)	11(37.9%)	
Number of stents				
1	69(66.3%)	48(64.0%)	21(72.4%)	0.492
>1	35(33.7%)	27(36.0%)	8(27.6%)	
ISR*	91(86.7%)	66(86.8%)	25(86.2%)	0.932
LAD	59(56.2%)	43(56.6%)	16(55.2%)	0.897
Diagonal	5(4.8%)	5(6.6%)	0(0.0%)	0.319
LCX	17(16.2%)	9(11.8%)	8(27.6%)	0.074
OM	3(2.8%)	3(3.9%)	0(0.0%)	0.559
RCA	25(23.8%)	20(26.3%)	5(17.2%)	0.444
PDA	1(1.0%)	1(1.3%)	0(0.0%)	1.00
ST*	14(13.3%)	10(13.2%)	4(13.8%)	0.932
LAD	7(6.7%)	4(5.3%)	3(10.3%)	0.392
LCX	3(2.9%)	2(2.6%)	1(3.4%)	1.00
OM	2(1.9%)	2(2.6%)	0(0.0%)	1.00
RCA	2(1.9%)	2(2.6%)	0(0.0%)	0.559
Location of involved artery				
Proximal	55(52.4%)	42(55.3%)	13(44.8%)	0.338
Mid part	60(57.1%)	40(52.6%)	20(69.0%)	0.186
Distal	7(6.7%)	6(7.9%)	1(3.4%)	0.670
Time of restenosis				
<1 month	19(18.1%)	17(22.4%)	2(6.9%)	0.211
1-6 month	22(21.0%)	17(22.4%)	5(17.2%)	
6 month- 1 year	18(17.1%)	12(15.8%)	6(20.7%)	
>1 year	46(43.8%)	30(39.5%)	16(55.2%)	
Size of stent				
<= 20 mm	41(41.4%)	30(42.3%)	11(39.3%)	0.825
> 20 mm	58(58.6%)	41(57.7%)	17(60.7%)	
Diameter of stent				
<= 2.5 mm	8(8.1%)	5(7.0%)	3(10.7%)	0.546
> 2.5 mm	91(91.9%)	66(93.0%)	25(89.3%)	

*In-stent restenosis or thrombosis may occur in more than one vessel.

BMI: Body mass index; ACS: Acute coronary syndrome; NC post-dilatation: non-compliant post-dilatation; DM: Diabetes mellitus; HTN: Hypertension; HCL: Hypercholesterolemia; HTG: Hypertriglyceridemia; CAD: Coronary artery disease; LCX: Left circumflex; OM: Obtuse marginal; RCA: Right coronary artery; PDA: Posterior descending artery; LAD: Left anterior descending; ISR: In-stent restenosis; ST: Stent thrombosis

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though this difference was not statistically significant (P = 0.659) (Fig. 1).

Notably, the incidence of ISR or ST after PCI occurred over a longer period in patients without abdominal obesity, whereas these complications developed in a shorter timeframe among patients with abdominal obesity (P < 0.05) (Fig. 2).

Discussion

The findings of the present study revealed that approximately 1.75% of PCI patients were readmitted to the hospital due to ISR or ST. Among these cases, over 85% were ISR, while fewer than 15% were ST. As previously reported, ST is a rare but severe complication, leading to sudden occlusion of the stented artery and posing a high risk of myocardial infarction and sudden death. Although ISR is not as immediately life-threatening as ST, it imposes a substantial burden on healthcare systems due to increased treatment costs and an elevated risk of adverse outcomes, including mortality and re-hospitalization. Given these serious

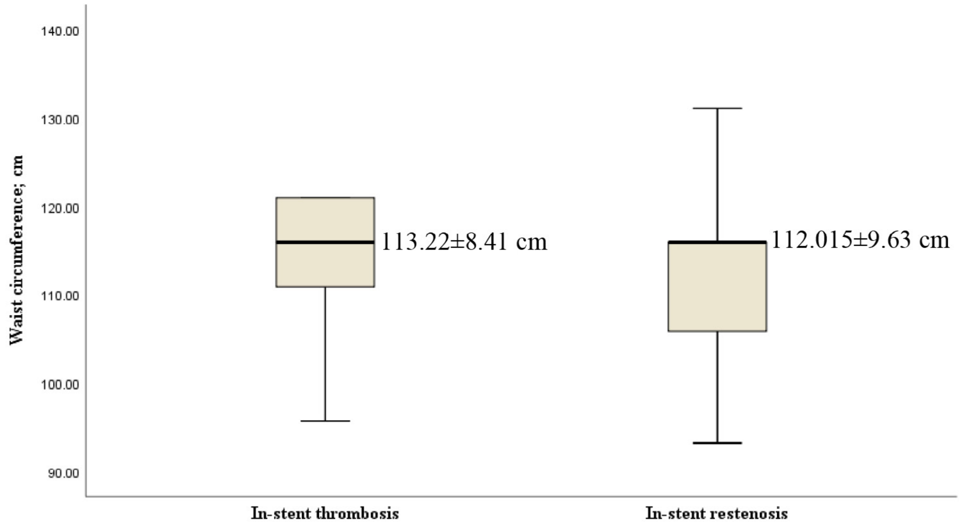

Figure 1. Box-plot of waist circumference by in-stent restenosis and thrombosis

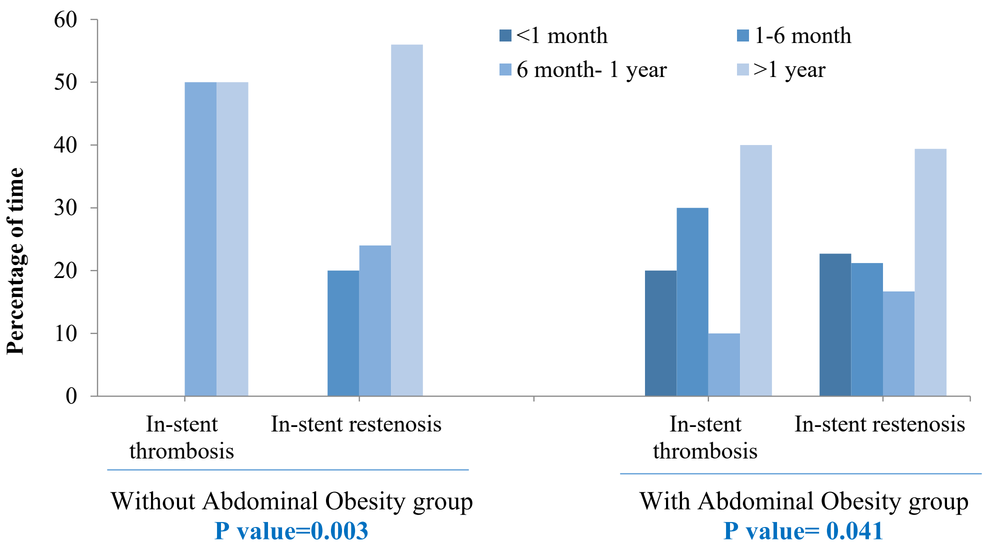

Figure 2. The incidence percentage of ISR or ST at different time intervals after PCI in each of the two groups with and without abdominal obesity

implications, identifying risk factors associated with ISR and ST is crucial for improving patient outcomes and guiding preventive strategies[16, 17].

In the present study, 72.4% of the 105 patients who developed ISR or ST after PCI had abdominal obesity. The prevalence of abdominal obesity was significantly higher in women than in men. Furthermore, a higher percentage of patients with abdominal obesity exhibited more severe CAD, a greater number of affected vessels, and a higher number of stents implanted, though these differences were not statistically significant.

Stimulatingly, more than 70% of patients with ISR or ST had abdominal obesity in our study although the incidence of these two complications was not significantly different in patients with and without abdominal obesity. However, this finding is perplexing as abdominal obesity was a common characteristic in these patients. Therefore, it seems that a more detailed examination of this characteristic in larger populations of patients with and without ISR or ST could be associated with more reliable results.

Additionally, a study by Gai et al. found that waist circumference in the ISR group was greater than in the non-ISR group, although BMI and waist circumference were not significantly associated with ISR incidence[18]. Conversely, in a study by Liu et al., the mean waist circumference in the ISR group was significantly greater than in the non-ISR group[7].

In this study, abdominal obesity was not significantly associated with the incidence of ISR or ST. Moreover, the waist circumference of patients with ST was higher than that of patients with ISR, although this difference was not statistically significant. Using waist circumference as a criterion alongside other factors may provide a more comprehensive assessment of the impact of obesity—especially abdominal obesity—on the incidence of complications following PCI.

In our study, the incidence of ISR or ST in patients with abdominal obesity, as compared to patients without abdominal obesity, occurred at shorter intervals after PCI. Therefore, it may be supposed that patients with abdominal obesity can be considered a higher-risk group, which highlights the necessity of their follow up after PCI in order to prevent the incidence of adverse complications early.

Various cardiovascular risks and comorbidities are associated with obesity. The undesirable outcomes might be attributed to the mentioned comorbidities, and the body weight or abdominal obesity itself is not responsible in this respect. Previous studies indicated that patients with obesity are predisposed to some factors unfavorably affecting their clinical outcomes. Hence, a resistance to aspirin or clopidogrel administration may be observed in obese and overweight patients[19-21].

Furthermore, the findings of this study suggest that administering ticagrelor with aspirin provided the best therapeutic outcome for these patients. This underscores the importance of tailoring post-PCI treatment management to individual patient characteristics, including overall obesity and abdominal obesity, to optimize effectiveness.

It should be noted that although investigating the association between abdominal obesity and the incidence of ISR or ST was one of the strengths of this study and has been addressed in few studies, the non-consideration of the control group and the small sample size can be considered as the weaknesses of this study. It is recommended to conduct future studies investigating the association between abdominal obesity and complications after PCI involving a larger sample size and considering the control group (without ISR or ST), the type of stent, and a wider range of treatments prescribed after discharge.

Conclusion

According to the findings of this study, more than 75% of patients who developed ISR or ST complications after PCI had abdominal obesity. Although multivessel CAD was more prevalent in patients with abdominal obesity than in those without, this difference was not statistically significant. Additionally, the incidence of ISR or ST did not significantly differ between patients with and without abdominal obesity.

The mean waist circumference in patients with ST was slightly higher than its mean in patients with ISR. In contrast, the incidence of ISR or ST occurred in a longer period of time in patients without abdominal obesity after PCI and in a shorter period of time after PCI in patients with abdominal obesity.

Conflict of interests
The authors declare no conflict of interest.

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Author's Contributions
Study Conception or Design: HS, ES
Data Acquisition: BSB
Data Analysis or Interpretation: BSB
Manuscript Drafting: BSB
Critical Manuscript Revision: HS, ES

All authors have approved the final manuscript and are responsible for all aspects of the work.

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