Iranian Heart Journal; 2021; 22 (2)

Original Article

Outcomes of Oversized Coronary Stenting in Patients Undergoing Elective Percutaneous Coronary Intervention

Mohammad Javad Alemzadeh-Ansari[1], MD; Majid Kyavar[1], MD; Somayeh Khalesi[1*], MD; Saeid Dalouchi[1], MD; Feridoun Noohi[1], MD; Majid Maleki[1], MD; Mohamad Mehdi Peighambari[1], MD; Ata Firouzi[1], MD; Bahram Mohebbi[1], MD; Ali Zahedmehr[1], MD; Alireza Rashidinejad[1], MD; Farshad Shakerian[1], MD; Reza Kiani[1], MD; Yasaman Khalili[1], MD

ABSTRACT

Background: The size of the coronary stent has an important role in the efficacy of stenting and its complications. The present study focused on the clinical outcomes of undersized, normal-sized, and oversized stenting.

Methods: This historical cohort study, conducted from April 2016 to March 2017 at Rajaie Cardiovascular Medical and Research Center, analyzed the results of elective percutaneous coronary intervention (PCI) and angiography on patients who met the inclusion criteria. Based on the ratio between the stent and the reference vessel, the patients were divided into 3 groups: undersized stenting (stent diameter/reference vessel diameter <0.9), normal-sized stenting (ratio=0.9–1), and oversized stenting (ratio>1). Data on demographic characteristics, procedural characteristics, underlying diseases, the hospital length of stay, major adverse cardiac events (MACE), post- PCI restenosis, stent thrombosis, and post-PCI cerebrovascular accident were extracted from the patients' files and entered into a checklist.

Results: Oversized stenting significantly reduced the incidence of MACE 1 year after PCI compared with undersized and normal-sized stenting. The incidence of rehospitalization for acute coronary syndrome was 7.5 times lower in oversized stenting than in undersized stenting (P=0.002). The incidence of re-PCI on the involved vessel decreased significantly with an increase in the stent size (P=0.017). Additionally, there was no incidence of stent restenosis in oversized stenting (P=0.001). The other outcomes had no significant correlation with the stent size.

Conclusions: Based on the results of our study, oversized stenting could improve clinical outcomes. ***(Iranian Heart Journal 2021; 22(2): 44-50)***

KEYWORDS: Stable angina, Percutaneous coronary intervention, Stent, Major adverse cardiac event

[1] Cardiovascular Intervention Research Center, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, IR Iran.

***Corresponding Author:** Somayeh Khalesi, MD; Cardiovascular Intervention Research Center, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, IR Iran.
Email: Somayeh.khalesi@yahoo.com **Tel:** +989132675200

Received: March 18, 2020 **Accepted:** October 21, 2020

According to the World Health Organization's report, ischemic heart disease is responsible for 7.3 million deaths around the globe, with approximately 58 million disability-adjusted life years. [1] Angina pectoris occurs when myocardial blood perfusion is inadequate, and it is divided into 2 types: stable and unstable. [2, 3] Stable angina is caused by severe exercise or emotional stress. It has no symptoms at rest and usually responds to drugs; nonetheless, in certain cases with excessive stenosis or failure to respond to medication, revascularization is the best treatment option. [3] The goal of revascularization is to improve symptoms, quality of life, and long-term survival. Percutaneous coronary intervention (PCI) is a type of revascularization that has been drawn upon for more than 20 years. [4] Research indicates that the use of stents in patients with acute coronary syndrome (ACS) reduces the morbidity and mortality of myocardial infarction almost 5% more than medication only. [5, 6] In general, stenting overcomes the limitations of balloon angioplasty, lessens complications, and enhances cardiovascular outcomes. Highly sensitive diagnostic methods and their availability in hospitals can augment the diagnosis and treatment of patients. Recent investigations have demonstrated an association between the thrombolysis in myocardial infarction (TIMI) frame count (TFC) and such important echocardiographic indicators as the diastolic function, hence the use of the TFC for determining the prognosis of cardiac disorders. [7] Research has also shown that fractional flow reserve-guided PCI is preferable to medication in emergency revascularization. [8]

Despite the clinical benefits of stenting, there are some undesirable outcomes such as plaque rupture and embolus formation. [6, 8] An inappropriate stent size may increase the incidence of side effects. [9, 10] Although operators can select the best stent size by using intravascular ultrasound, optical coherence tomography, or even quantitative coronary angiography for the evaluation of a normal reference vessel, the majority of them tend to select the stent by using visual coronary arteriography, which is called the "eyeball estimation". Previous investigations on this method have indicated that in visual arteriography, severe lesions with over 50% stenosis are overestimated, whereas those with less than 50% are underestimated. Because of geometric complexities, visual estimation cannot be a reliable method for the determination of the percentage of stenosis and the selection of the stent size. [11] Given the paucity of research in the existing literature on the effect of the stent size on the clinical outcomes of patients undergoing elective PCI, we aimed to compare the clinical outcomes of undersized, normal-sized, and oversized stenting in patients undergoing elective PCI.

METHODS

The present historical cohort study was performed on patients with stable angina who underwent elective PCI in Rajaie Cardiovascular Medical and Research Center (a tertiary center) between April 2016 and March 2018. The patients' data were collected from their hospital files. The inclusion criteria were the indication for elective PCI in accordance with the American Heart Association's guideline, compliance with medications, and the consumption of clopidogrel and aspirin. The exclusion criteria comprised coronary artery bypass graft before PCI, PCI on more than 1 vessel, PCI on the left main, and bifurcation stenting. The patients' records were reviewed, and their angiography films were analyzed. According to the patients' angiography film, vessel diameters were calculated via quantitative coronary angiography before and after PCI. Based on the ratio between the stent size and the normal vessel, the study population was

divided into 3 groups. Group I consisted of patients with undersized stents (stent diameter/reference vessel diameter <0.9), Group II comprised patients with normal-sized stents (ratio=0.9–1), and Group III was comprised of patients with oversized stents (ratio>1). Data including demographic characteristics, underlying diseases, risk factors, the hospital length of stay, angiographic data, the type of involved vessel, and the type of stent used were recorded. Information on major adverse cardiac events (MACE) within 1 year after elective PCI, comprising stent restenosis, stent thrombosis, cardiovascular mortality, cerebrovascular accident (CVA), rehospitalization for acute coronary syndrome (re-ACS), and the need for re-PCI, was obtained by telephone calls or direct interviews with the patients or their family.

Numerical variables were described as the mean ± the standard deviation (SD) and qualitative variables as the frequency index (%). Data comparison between the 2 groups was performed using the Pearson χ^2 (or the Fisher exact) test for nominal variables. All the data were analyzed using the statistical software IBM SPSS Statistics 25 for Mac (IBM Inc, Armonk, NY).

The study protocol was approved by the institutional human subjects review board, and the requirement for informed written consent was waived.

RESULTS

During the study period, 1700 files of the patients who underwent PCI in the setting of stable angina were reviewed, and 1102 patients who met the inclusion criteria were selected for the study.

Based on the ratio between the stent diameter size and the reference vessel, the study population was divided into 3 groups: patients with undersized stents (Group I: n=247 [22.4%]), patients with normal-sized stents (Group II: n=364 [33%]), and patients with oversized stents (Group III: n=491 [44.6%]). The mean age of the patients was 59.18±10.89 years. The baseline characteristics of the 3 groups including demographic characteristics, underlying diseases, and risk factors were not significantly different between the groups (Table 1). The procedural characteristics including the involved vessels, the stent type, and significant increases in post-PCI cardiac enzymes and post-PCI TIMI scores were not uniformly distributed based on the stent size (Table 2).

Seven different types of drug-eluting stents were utilized: the XIENCE (X), the Orsiro (O), the Promus (P), the Ultimaster (U), the Resolute Onyx (R), the BioMatrix (B), and the Supraflex (S). According to our statistical analyses, the type of stent was significantly different between the groups (*P*=0.022).

The incidence of MACE, comprising stent restenosis, stent thrombosis, CVA, re-ACS, re-PCI, and death, was compared between the groups. Stent restenosis during a 1-year follow-up was significantly lower in the oversized stent group than in the other 2 groups (Group I: n=9 [3.6%] vs Group II: n=2 [0.5%] and Group III: n=0 [0%]; *P*=0.001). Stent thrombosis was a rare complication in our study (Group I: n=1 [0.4%], Group II: n=2 [0.5%], and Group III: n=0 [0%]; *P*=0.237). This complication did not occur among the patients with oversized stents within the 1-year follow-up, but there was no significant correlation between the stent size and the risk of stent thrombosis after 1 year (*P*=0.237). The incidence of CVA in each group was almost equal, so there was no correlation between the stent size and the incidence of CVA following PCI (*P*=1). The rate of re-ACS in each group was as follows: 11 (4.5%) in Group I, 8 (2.2%) in Group II, and 3 (0.6%) in Group III. Consequently, the rate of re-ACS

significantly decreased in oversized stenting (*P*=0.002). During the 1-year follow-up, 88 patients needed re-PCI (Group I: n=29 [11.7%], Group II: n=30 [8.2%], and Group III: 29 [5.9%]). The rate of re-PCI in the oversized stenting group showed a reduction by comparison with the undersized stenting group (*P*=0.022). Moreover, oversized stenting reduced the risk of re-PCI in the same vessel (*P*=0.017) (Table 3). During the 1-year follow-up, 13 (0.1%) patients died, with 76% of the deaths (n=10) being due to cardiovascular events. Although most of the deaths were in consequence of cardiac events, there was no significant relationship between the stent size and the mortality rate (*P*=0.751) (Table 3).

The incidence rates of some secondary outcomes such as the hospital length of stay after PCI were also assessed. The post-PCI hospital length of stay was 3 days in most of the patients in the 3 groups, and every patient needed at least 1 day of hospitalization after PCI.

Table 1: Baseline characteristics of the study population

	Group I (n=247)	Group II (n=364)	Group III (n=491)	*P* value	Total/mean±SD (N=1102)
Male (%)	169 (68.4%)	276(67.8%)	346(70.5%)	0.094	791 (71.8%)
Age (y)	58.46±11.41	59.17±10.48	59.56±10.92	0.438	59.18±10.89
Diabetes mellitus (%)	126(51.0%)	172 (47.3%)	237(48.3%)	0.650	535(48.5%)
Hypertension (%)	178 (72.1%)	239 (65.7%)	358 (72.9%)	0.057	775(70.3%)
Dyslipidemia (%)	186 (75.3%)	257 (70.6%)	365 (74.3%)	0.345	808(73.3%)
History of cerebrovascular accident (%)	0 (0%)	2 (0.5%)	1 (0.2%)	0.605	3(0.3%)
History of myocardial infarction (%)	2 (0.8%)	8 (2.2%)	5 (1%)	0.236	15(1.4%)
History of percutaneous coronary intervention (%)	3 (1.2%)	5 (1.4%)	8 (1.6%)	0.895	16(1.5%)
Family history of cardiovascular disease (%)	26 (10.5%)	31 (8.5%)	44(9%)	0.684	101(9.2%)
Smoking (P/Y)	32 (13%)	41 (11.3%)	62 (12.6%)	0.775	135(12.3%)
Serum creatinine (mg/dL)	0.99±0.36	0.98±0.29	0.98±0.29	0.151	0.97±0.30
Left ventricular ejection fraction (%)	48.7±5.7	48±6.6	48±6.3	0.824	48.21±6.30

Table 2: Angiographic and procedural data

	Group I (n=247)	Group II (n=364)	Group III (n=491)	*P* value	Total Number (1102)
Involved Vessel					
Left anterior descending artery	122 (49.4%)	209 (57.4%)	252 (51.3%)		583 (52.9%)
Left circumflex artery	38 (15.4%)	41 (11.3%)	47 (9.6%)		126 (11.4%)
Right coronary artery	61 (24.7%)	89 (24.5%)	153 (31.2%)	0.081	303 (27.5%)
Obtuse marginal	20 (8.1%)	23 (6.3%)	31 (6.3%)		74 (6.7%)
Posterior descending artery	1 (0.4%)	1 (0.3%)	2 (0.4%)		4 (0.4%)
Diagonal	5 (2%)	1 (0.3%)	6 (1.2%)		12 (1.1%)
Stent Type					
XIENCE	93 (37.7%)	166 (45.6%)	209 (42.6%)		468 (42.5%)
Orsiro	38 (15.4%)	54 (14.8%)	57 (11.6%)		149 (13.5%)
Promus	83 (33.6%)	83 (22.8%)	116 (23.6%)	0.022	282 (25.6%)
Ultimaster	24 (9.7%)	35 (9.6%)	81 (16.5%)		140 (12.7%)
Resolute Onyx	4 (1.6%)	21 (5.8%)	23 (4.7%)		48 (4.4%)
BioMatrix	3 (1.2%)	4 (1.1%)	3 (0.6%)		100 (0.9%)
Supraflex	2 (0.8%)	1 (0.3%)	2 (0.4%)		5 (0.5%)
Increase in troponin after PCI (%) (Significant:>5×baseline)	3 (1.2%)	13 (3.6%)	22 (4.5%)	0.071	38 (3.4%)
TIMI Score after PCI					
2	8 (3.2%)	9 (2.5%)	8 (1.6%)	0.364	25 (2.3%)
3	239 (96.8%)	355 (97.5%)	483 (98.4%)		1077 (97.7%)

TIMI, Thrombolysis in myocardial infarction; PCI, Percutaneous coronary intervention

Table 3: Incidence of major adverse cardiac events during the 1-year follow-up

	Group I (n=247)	Group II (n=364)	Group III (n=491)	*P* value	Total (N=1102)
Stent restenosis	9 (3.6%)	2 (0.5%)	0 (0%)	0.001	11 (1%)
Stent thrombosis	1 (0.4%)	2 (0.5%)	0 (0%)	0.237	3 (0.3%)
Cerebrovascular accident	1 (0.4%)	1 (0.3%)	1 (0.2%)	1.000	3 (0.3%)
Rehospitalization for acute coronary syndrome	11 (4.5%)	8 (2.2%)	3 (0.6%)	0.002	22 (2%)
Needed re-PCI	29 (11.7%)	30 (8.2%)	29 (5.9%)	0.022	88 (8%)
Repeat PCI on the same vessel	7 (2.8%)	2 (0.5%)	2 (0.4%)	0.017	11 (1%)
Total Death	4 (1.6%)	3 (0.8%)	6 (1.2%)	0.666	13 (1.2%)
Cardiac death	3 (1.2%)	3 (0.8%)	4 (0.8%)	0.751	10 (0.9%)

PCI, Percutaneous coronary intervention

DISCUSSION

Stable angina is usually a compressive chest pain caused by intense activity and often a symptom of coronary heart disease. [12] In clinical practice, there are different types of treatment strategies for stable angina that range from medication to revascularization. [13] In 2007, Russo et al [14] examined the outcomes of oversized stenting by primary stent replacement in 60 vessels of 33 white pigs and reported that after 28 days, oversized stenting significantly induced hyperplasia in the vessel intima, leading to the extension of the intima to the edge of the stent.

In the current study, we focused on the clinical outcomes of stenting based on the size of the stent. There are also other factors concerning the outcome of elective PCI. For instance, a previous study demonstrated that severe anemia with a hemoglobin level of below 10 g/dL was associated with an increased risk of MACE (hazard ratio: 4.623, 95% confidence interval: 1.642 to 13.021; *P*=0.004). [15] Our main finding was that in patients with elective PCI, the incidence of MACE decreased with an increase in the size of the stent. Additionally, oversized stenting decreased the recurrence of stenosis significantly and the need for re-PCI in the involved vessel. A rise in the incidence of re-ACS causes more admissions due to cardiac events and subsequently increases morbidity and mortality. The risk of re-ACS decreased in oversized stenting in our study population. A drop in the incidence of restenosis, re-ACS, and re-PCI can lower the morbidity and mortality of revascularization and its financial burden on the community. Several investigations have also evaluated the effect of the stent size on the outcomes of PCI and have revealed results similar to our study.

De Benedetti et al, [16] in a review study on the stent size in PCI, concluded that oversized stenting could result in extra trauma and subsequently more intimal hyperplasia, increasing the risk of the dissection and rupture of the coronary vessels. They also showed that undersized stenting was associated with stent restenosis and thrombosis. According to the studies reviewed in their article, a stent-to-vessel ratio of 1: 1 was associated with favorable clinical outcomes.

In 2017, Kitahara et al [17] examined 2931 vessels and evaluated the effect of the size of drug-eluting stents on the short- and long-term outcomes of stenting. Their results showed that oversized stenting could confer better clinical outcomes and decrease the risk of post-dilation and re-PCI.

The goal of PCI in patients with stable angina is to reduce adverse outcomes and improve the quality of life. The findings of the present study clearly showed the clinical

advantage of oversized stenting in patients with stable angina.

We found that some other outcomes including mortality due to cardiac events and CVA were not correlated with the stent size. Nevertheless, since these outcomes may occur after 1 year in some cases, longer follow-up periods can yield accurate results. A short follow-up period is, indeed, the salient limitation of our study. In addition, given the fact that such procedural factors as the involved vessel and the stent type affect the outcomes of PCI, our failure to match the procedural characteristics between our 3 study groups is another weakness of note. The results of our retrospective study should be confirmed in future prospective investigations with longer follow-up periods.

CONCLUSIONS

The main finding of the current historical cohort study was that in patients undergoing elective PCI, the incidence of MACE decreased with an increase in the size of the stent. Oversized stenting reduced the incidence of restenosis, re-ACS, and re-PCI in the same vessel significantly and improved the clinical outcome in our study population.

REFERENCES

1. Gaziano TA, Bitton A, Anand S, Abrahams-Gessel S, Murphy A. Growing epidemic of coronary heart disease in low-and middle-income countries. Current problems in cardiology. 2010 Feb 1;35(2):72-115. https://doi.org/10.1016/j.cpcardiol.2009.10.002 . PMID:201099792.

2. Pepine CJ, Wolff AA, Ranolazine Study Group. A controlled trial with a novel anti-ischemic agent, ranolazine, in chronic stable angina pectoris that is responsive to conventional antianginal agents. The American journal of cardiology. 1999 Jul 1; 84(1):46-50. https://doi.org/10.1016/s0002-9149 (99)00190-3.PMID: 10404850

3. Braunwald E, Morrow DA. Unstable angina: is it time for a requiem?. Circulation. 2013 Jun 18; 127(24):2452-7. https://doi.org/10.1161/CIRCULATIONAHA.113.001258 . PMID: 237751

4. Martín JJ, Ruigómez AC, Varela CC, Vicente MN, Antolín JM, Calle PT, Abad CG. Indicaciones de revascularización: aspectos clínicos. Revista española de cardiología. 2005 Feb 1; 58(2):198-216. https://doi.org/10.1157/13071894.PMID: 15743566

5. Fischman DL, Leon MB, Baim DS, Schatz RA, Savage MP, Penn I, Detre K, Veltri L, Ricci D, Nobuyoshi M, Cleman M. A randomized comparison of coronary-stent placement and balloon angioplasty in the treatment of coronary artery disease. New England Journal of Medicine. 1994 Aug 25; 331(8):496-501. DOI: 10.1056/NEJM199408253310802.PMID:8041414

6. Serruys PW, De Jaegere P, Kiemeneij F, Macaya C, Rutsch W, Heyndrickx G, Emanuelsson H, Marco J, Legrand V, Materne P, Belardi J. A comparison of balloon-expandable-stent implantation with balloon angioplasty in patients with coronary artery disease. New England Journal of Medicine. 1994 Aug 25; 331(8):489-95. https://doi.org/10.1056/NEJM199408253310801. PMID: 8041413

7. Omidi N, Kashani BS, Piranfar MA, Khorgami MR, Yekta BG, Omidi H. The correlation of diastolic dysfunction with TIMI frame count in patients with chronic stable angina pectoris. Tehran University Medical Journal. 2012 Dec 1; 70(9).

8. Grines CL, Cox DA, Stone GW, Garcia E, Mattos LA, Giambartolomei A, Brodie BR, Madonna O, Eijgelshoven M, Lansky AJ, O'Neill WW. Coronary angioplasty with or without stent implantation for acute myocardial infarction. New England Journal of Medicine. 1999 Dec 23; 341(26):1949-56. DOI: 10.1056/NEJM199912233412601

9. Endo M, Hibi K, Shimizu T, Komura N, Kusama I, Otsuka F, Mitsuhashi T, Iwahashi N, Okuda J, Tsukahara K, Kosuge M.

Impact of ultrasound attenuation and plaque rupture as detected by intravascular ultrasound on the incidence of no-reflow phenomenon after percutaneous coronary intervention in ST-segment elevation myocardial infarction. JACC: Cardiovascular Interventions. 2010 May 1; 3(5):540-9. DOI: 10.1016/j.jcin.2010.01.015

10. Ohshima K, Ikeda S, Kadota H, Yamane K, Izumi N, Ohshima K, Hamada M. Impact of culprit plaque volume and composition on myocardial microcirculation following primary angioplasty in patients with ST-segment elevation myocardial infarction: virtual histology intravascular ultrasound analysis. International journal of cardiology. 2013 Aug 10; 167(3):1000-5. https://doi.org/10.1016/j.ijcard.2012.03.079

11. Hermiller JB, Fry ET, Peters T, Orr CM, Van Tassel J, Pinkerton CA. Quantitative and Qualitative Coronary Angiography. InVascular Diagnostics 1994 (pp. 267-275). Springer, Berlin, Heidelberg.https://doi.org/10.1002/ccd.1810250207. PMID: 1544153

12. Tobin KJ. Stable angina pectoris: what does the current clinical evidence tell us?. Journal of the American Osteopathic Association. 2010 Jul 1; 110(7):364. PMID: 20693568

13. Pursnani S, Korley F, Gopaul R, Kanade P, Chandra N, Shaw RE, Bangalore S. Percutaneous coronary intervention versus optimal medical therapy in stable coronary artery disease: a systematic review and meta-analysis of randomized clinical trials. Circulation: Cardiovascular Interventions. 2012 Aug; 5(4):476-90.https://doi.org/10.1161/CIRCINTERVENTIONS.112.970954

14. Russo RJ, Silva PD, Yeager M. Coronary artery overexpansion increases neointimal hyperplasia after stent placement in a porcine model. Heart. 2007 Dec 1; 93(12):1609-15. https://doi.org/10.1136/hrt.2006.105981. PMID: 17639098

15. Hosseini SK, Ansari MJ, Tokaldany ML, Sharafi A, Kazazi EH, Poorhosseini H. Association between preprocedural hemoglobin level and 1-year outcome of elective percutaneous coronary intervention. Journal of cardiovascular medicine. 2014 Apr 1; 15(4):331-5. https://doi.org/10.2459/JCM.0b013e32835ec938. PMID: 23422885

16. De Benedetti E, Urban P. Coronary stenting: why size matters. Heart. 2007 Dec;93(12):1500.https://dx.doi.org/10.1136%2Fhrt.2006.113860. PMID: 18003677

17. Kitahara H, Okada K, Kimura T, Yock PG, Lansky AJ, Popma JJ, Yeung AC, Fitzgerald PJ, Honda Y. Impact of stent size selection on acute and long-term outcomes after drug-eluting stent implantation in de novo coronary lesions. Circulation: Cardiovascular Interventions. 2017 Oct; 10(10):e004795. https://doi.org/10.1161/CIRCINTERVENTIONS.116.004795 .