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Independent Predictors of In-Hospital Outcomes Following Coronary Stent Implantation

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Objective: To identify independent clinical and angiographic predictors determining early outcomes following coronary stent implantation.

Methods: Nine hundred and forty six patients with a mean age of 61.04 ± 10.98 years (31 to 91 years of age) underwent stent implantation; 580 were males (61.3%). Procedural success was defined when a patient had at least one vessel successfully dilated with a residual stenosis < 20%. Clinical success occurred when the procedure was successful and no major complications occurred (MI, need for CABG, or death) during the hospital stay. Clinical and angiographic characteristics were analyzed. All variables related to early outcomes as assessed by the univariate analysis were included in the logistic regression model.

Results: Procedural success was achieved in 98.9%, clinical success in 95.7%, uncomplicated unsuccessful outcomes occurred in 0.1%, and major complications in 4.2%. The multivariate analysis showed that restenotic lesion, calcification, and irregular contour were related to procedural success. Diabetes mellitus, cardiogenic shock, acute coronary syndromes, age, left ventricular dysfunction, calcification, and total occlusion were predictors of clinical success. Diabetes mellitus, cardiogenic shock, acute coronary syndromes, age, multivessel disease, left ventricular dysfunction, calcification, long lesions, and total occlusion were predictors of major complications, whereas cardiogenic shock, acute coronary syndromes, age, hypertension, and left ventricular dysfunction were predictors of in-hospital mortality.

Conclusion: Our results suggest that the early outcomes following stent implantation were significantly related to cardiogenic shock, left ventricular dysfunction, age, calcification, and total occlusion.

Key words: Stent, risk factors, multivariate analysis, coronary arteriosclerosis, angina pectoris.

The introduction of percutaneous transluminal coronary angioplasty by Grüntzig[1] in 1977 represented a milestone in the treatment of coronary artery disease (CAD), and its indications became remarkably more widespread thereafter. Several factors contributed to increase success rates and reduce the number of complications, in addition to broadening the indications for the procedure, such as greater operator's expertise and technological evolution represented by the use of stents and platelet glycoprotein IIb/IIIa inhibitors[2-4].

Concurrently, clinical and angiographic characteristics as well as characteristics related to the procedure have been identified as determinants of early outcomes. Based on these observations, the American College of Cardiology and the American Heart Association conceived a classification according to angiographic criteria to estimate the probability of early success and occurrence of complications[5-6].

Several studies have sought to identify predictors of in-hospital outcomes following stent implantation, and some authors have developed prediction models of in-hospital events[7-21]. Risk estimates are important to assess outcomes as well as to help patients and their relatives to consent to the performance of the procedure. They are also important to help doctors choose or avoid a determined strategy or medication during the procedure.

Our objective is to analyze in-hospital outcomes of patients undergoing stent implantation, and to identify independent clinical and angiographic predictors related to success and major complications.

Methods

Patients - Nine hundred and forty two patients consecutively underwent stent implantation in 1,045 lesions from October 1995 to December 2002. Five hundred and eighty patients were males (61.3%) and 366 were females (38.7%), with a mean age of 61.04 ± 10.98 (31 to 91) years. Two hundred and forty three patients (25.7%) had diabetes mellitus, 677 (71.6%) had hypertension, 694 (73.4%) had dyslipidemia, and 291 patients were smokers (25.5%). Two hundred and fifty nine patients had previous history of infarction (27.4%), 86 of coronary artery bypass grafting (9.1%), and 47 of previous percutaneous coronary intervention in the treated vessel,

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Mean age (years)	61.04 ± 10.98
Gender	
Male	580 (61.3%)
Female	366 (38.7%)
Risk factors	
Diabetes mellitus	243 (25.7%)
Hypertension	677 (71.6%)
Smoking	241 (25.5%)
Dyslipidemia	694 (73.4%)
Previous Infarction	259 (27.4%)
Previous PCI (restenotic lesions)	47 (5.0%)
Previous myocardial revascularization	86 (9.1%)
Vessel disease	
Univessel	480 (50.7%)
Multivessel	466 (49.3%)
Left ventricular function	
Normal / mild dysfunction	673 (71.1%)
Moderate / severe dysfunction	273 (28.9%)
Clinical manifestation	
Stable angina	420 (44.4%)
Unstable angina	344 (36.4%)
Myocardial infarction	182 (19.2%)
Cardiogenic shock	22 (2.3%)

PCI = *percutaneous coronary intervention*

Table 1 - Clinical characteristics

Angulation	
< 45º	1010 (96.6%)
≥ 45º, < 90º	27 (2.6%)
≥ 90º	8 (0.8%)
Bifurcation	145 (13.9%)
Calcification	130 (12.4%)
Irregular contour	402 (38.5%)
Eccentricity	886 (84.8%)
Lesion length	
< 10 mm	759 (72.6%)
≥ 10 mm. < 20 mm	249 (23.8%)
> 20 mm	37 (3.5%)
Total occlusion	
< 3 months	124 (11.9%)
> 3 months	3 (0.3%)
Ostial	33 (3.2%)
Type of lesion	
A	40 (3.8%)
B1	248 (23.7%)
B2	707 (67.7%)
C	50 (4.8%)
Tortuosity	
Normal / mild	1013 (96.9%)
Moderate	27 (2.6%)
Severe	5 (0.5%)
Thrombus	223 (21.3%)

Table 2 - Angiographic characteristics

and which were, therefore, restenotic lesions (5.0%). Four hundred and sixty six patients had multivessel lesions (49.3%) and 273 had moderate to severe left ventricular dysfunction (28.9%). Prior to the intervention, 420 patients had stable angina (44.4%), 344 had unstable angina (36.4%) and 182 had acute myocardial infarction (19.2%). Twenty two of the patients with MI were in cardiogenic shock (2.2%). The clinical characteristics are summarized in Table 1.

Lesions - One thousand and forty five lesions (1.11 lesion/patient) were treated, 536 of them in the left anterior descending (51.2%), 313 in the right coronary artery (30.0%), 157 in the left circumflex (15.0%), 8 in the left main coronary (0.8%), 25 saphenous vein bypass graft (2.4%) and 6 in the anastomosis of the left internal mammary artery to the left anterior descending (0.6%). Thirty five lesions (3.4%) involved angulations ≥ 45%, 145 were bifurcation lesions (13.9%), 130 were calcified lesions (12.4%), 402 had irregular contours (38.5%), 286 lesions were ≥ 10 mm long (27.4%), 127 were total occlusions (12.2%), 33 were ostial lesions (3.2%), 32 lesions had moderate to severe tortuosity in the proximal segment (3.1%) and 223 lesions had thrombus (21.3%). Seven hundred and fifty seven lesions were type B2 and C, considered complex lesions (72.4%). The angiographic characteristics are summarized in Table 2.

Procedure - The stent implantation procedure has already been described. **The femoral approach was used in 95% of the cases**[22]. Intravenous heparin was given in bolus (5,000 to 10,000 IU) following femoral artery puncture. Different types of stents were implanted under fluoroscopic guidance. The extension and diameter of the stents used were chosen by the operators. The final outcome was based on angiographic control. All patients were given aspirin (100 to 200 mg orally, once a day) and ticlopidine (250 mg orally, twice a day) or clopidogrel (initial dose of 300 mg orally, followed by 75 mg orally, once a day) starting 48 hours prior to the procedure, when clinically possible.

Definitions - Diabetes Mellitus: patients were considered to have diabetes if they had been previously diagnosed as such, if they were on medications (oral hypoglycemic agents or insulin), or if they had been diagnosed in the current hospitalization. The criterion used for the diagnosis of diabetes mellitus was two fasting plasma glucose levels ≥ 140 mg/dl[23] in the initial phase of the study, and ≥ 126 mg/dl as from July 1997 according to the definition of the American Diabetes Association[24].

Stable angina was graded according to the Canadian Cardiovascular Society (CCS) classification[25]. Unstable angina was defined as angina of recent onset, progressive angina, angina at rest and post-infarction angina. Acute myocardial infarction was defined according to the World Health Organization[26, 27]. Patients with unstable angina or acute myocardial infarction were considered to have acute coronary syndromes.

Multivessel disease was defined as the presence of stenosis >50% for the left main coronary or >70% in at least two of the coronary branches (right coronary artery, left anterior descending, or left circumflex).

Left ventricular dysfunction was semi-quantitatively defined according to visual assessment as mild, moderate and severe.

Procedural success was defined in cases where the vessel treated presented a residual lesion < 20% at the end of the procedure. Clinical success occurred when procedural success was achieved in the absence of major in-hospital complications (AMI, CABG, or death). Major complications included: AMI, need for coronary artery bypass grafting or death, the most severe complication always being the one considered. Non-complicated unsuccessful outcome occurred when the lesion was not successfully dilated, and no in-hospital complications occurred.

Statistical analysis - The SPSS statistical package for Windows version 9.0 was used for the statistical analysis. Continuous variables were expressed as mean value ± standard deviation. Categorical variables were expressed as proportions. The chi-square test or the Fisher's exact test was used to test the differences between proportions. Odds ratios (OR) and their respective 95% confidence intervals (95% CI) were used as estimates of prevalence ratios of risks of association between variables. Logistic regression models were constructed including clinical variables (age, diabetes mellitus, sex, systemic hypertension, dyslipidemia, smoking, clinical manifestations, previous infarction, previous percutaneous coronary intervention, previous coronary artery bypass grafting, multivessel disease, left ventricular dysfunction, and cardiogenic shock) and angiographic variables (angulation, bifurcation, calcification, irregular contour, eccentricity, lenght, ostial lesion, tortuosity, presence of thrombus, total occlusion). P values ≤0.05 were considered statistically significant.

Results

Procedural success was observed in 98.9% of the cases. Clinical success was observed in 95.7%, non-complicated unsuccessful outcome in 0.1%, and major complications in 4.2%. The most frequent complication was death in 22 patients (2.3%), followed by myocardial infarction in 15 (1.6%), and myocardial revascularization in 3 patients (0.3%). Excluding patients with cardiogenic shock, 11 deaths (1.2%), 14 myocardial infarctions (1.5%), and 3 myocardial revascularizations (0.3%) occurred.

Clinical characteristics - In-hospital results of the univariate analysis according to clinical characteristics are summarized in Table 3. Lower procedural success was observed in patients with a previous history of coronary artery bypass grafting (96.5% versus 99.2%; p=0.054). The variables related to lower clinical success were: clinical manifestations (97.4% for stable angina; 96.2% for unstable angina, and 90.7% for acute myocardial infarction; p=0.001); cardiogenic shock (45.5% versus 96.9%; p=0.0001); diabetes mellitus (92.6% versus 96.7%; p=0.006), multivessel disease (94.2% versus 97.1%; p=0.04); systemic hypertension (94.8% versus 97.8%; p=0.051) and moderate to severe left ventricular dysfunction

(92.3% versus 97.0%; p=0.002). Major complications were related to clinical manifestations (2.6% for stable angina; 3.5% for unstable angina and 9.3% for acute myocardial infarction; p=0.001); cardiogenic shock (54.5% versus 3.1%; p=0.0001); diabetes mellitus (7.0% versus 3.3%; p=0.013); multivessel disease (5.8% versus 2.7%; p=0.02) and moderate to severe left ventricular dysfunction (7.7% versus 2.8%; p=0.0008). Among the major complications, no variable was predictive of myocardial infarction. Restenotic lesion was predictive of myocardial revascularization (4.3% versus 0.1%; p=0.007). In-hospital death was related to the female gender (3.6% versus 1.6%; p=0.05), age ≥65 years (3.8% versus 1.4%; p<0.02), cardiogenic shock (50% versus 1.2%; p<0.0001), systemic hypertension (3.1% versus 0.4%; p<0.01), previous myocardial revascularization (5.8% versus 2.0%; p<0.05), multivessel disease (3.4% versus 1.3%; p<0.03), moderate to severe left ventricular dysfunction (5.9% versus 0.7%; p<0.0001) and acute coronary syndromes (0.5% for stable angina, 1.7% for unstable angina and 7.7% for myocardial infarction; p<0.0001).

Angiographic characteristics, type of lesion and vessel treated - In-hospital results of the univariate analysis, according to the angiographic characteristics and type of lesion are summarized in Table 4; and according to the vessel treated are in Table 5. Lower procedural success was observed in calcified lesions (95.4% versus 99.5%; p=0.001); in lesions with irregular contours (97.8% versus 99.7%; p=0.004) and in long lesions (97.3% in lesions ≥ 20 mm; 97.6% in lesions ≥ 10 mm and 99.5% in lesions < 10 mm; p=0.03). Lower clinical success (91.5% versus 96.3%; p=0.014) and a higher percentage of complications (8.5% versus 3.6%; p=0.01) were observed in calcified lesions. Lesions ≥ 10 mm long showed lower procedural success (97.6% versus 99.5%; p=0.012), lower clinical success (93.7% versus 96.4%; p=0.052) and a higher percentage of complications (6.3% versus 3.4%; p=0.04). Total occlusions showed lower clinical success (92.1% versus 96.2%; p=0.04) and a higher percentage of complications (7.9% versus 3.7%; p=0.03). Lower clinical success (94.7% versus 98.3%; p=0.01) and a higher percentage of complications (5.3% versus 1.4%; p=0.003) were observed in complex lesions (lesions type B2 and C). Likewise, lesions in the left main coronary presented lower clinical success and a higher percentage of complications when compared to lesions treated in the left anterior descending (p<0.006), right coronary artery (p<0.003), left circumflex (p<0.004) and saphenous vein bypasses (p<0.04).

Multivariate analysis – clinical characteristics - The results of the multivariate analysis according to the clinical characteristics are summarized in Table 6. Previous coronary intervention (restenotic lesion) was the only independent clinical predictor of lower procedural success (OR = 0.18; 95% CI = 0.04 – 0.88; p=0.04). The clinical variables identified as independent predictors of lower clinical success were: diabetes mellitus (OR = 0.47; 95% CI = 0.24 – 0.90; p=0.02); cardiogenic shock (OR = 0.03; 95% CI = 0.01 – 0.65; p=0.00001); acute coronary syndromes (OR = 0.48; 95% CI = 0.23 – 0.98; p=0.04); age (OR = 1.03; 95% CI = 1.00 – 1.06; p=0.03) and moderate to severe left ventricular dysfunction (OR = 0.44; 95% CI = 0.23 – 0.84; p=0.01). The clinical variables

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	n	Procedural success	Clinical success	Non-complicated unsuccessful procedure	Major complications
		n (%)	n (%)	n (%)	n (%)
Gender					
Male	580	576 (99.3%)	560 (96.6%)	-	20 (3.4%)
Female	366	360 (98.4%)	345 (94.3%)	1 (0.3%)	20 (5.5%)
Age range					
< 65 years	582	575 (98.8%)	562 (96.6%)	1 (0.2%)	19 (3.5%)
> 65 years	364	361 (99.2%)	343 (94.2%)	-	21 (5.8%)
Clinical manifestation					
Stable angina	420	417 (99.3%)	409 (97.4%)♣	-	11 (2.6%)♣
Unstable angina	344	339 (98.5%)	331 (96.2%)	1 (0.3%)	12 (3.5%)
MI	182	180 (98.9%)	165 (90.7%)	-	17 (9.3%)
Diabetes mellitus					
No	703	697 (99.1%)	680 (96.7%)**	-	23 (3.3%)*
Yes	243	239 (98.4%)	225 (92.6%)	1 (0.4%)	17 (7.0%)
Hypertension					
No	269	267 (99.3%)	263 (97.8%)*	-	6 (2.2%)
Yes	677	669 (98.8%)	642 (94.8%)	1 (0.2%)	34 (5.0%)
Smoking					
No	407	403 (99.0%)	389 (95.6%)	1 (0.2%)	17 (4.2%)
Yes	241	237 (98.3%)	230 (95.4%)	-	11 (4.6%)
Former	298	296 (99.3%)	286 (96.0%)	-	12 (4.0%)
Dyslipidemia					
No	252	250 (99.2%)	239 (94.8%)	-	13 (5.2%)
Yes	694	686 (98.8%)	666 (96.0%)	1 (0.1%)	27 (3.9%)
Previous MI					
No	687	682 (99.3%)	657 (95.6%)	1 (0.2%)	29 (4.2%)
Yes	259	254 (98.1%)	248 (95.8%)	-	11 (4.2%)
Previous MR					
No	860	853 (99.2%)*	825 (95.9%)	1 (0.1%)	34 (4.0%)
Yes	86	83 (96.5%)	80 (93.0%)	-	6 (7.0%)
Previous PCI					
No	899	891 (99.1%)	861 (95.8%)	1 (0.1%)	37 (4.1%)
Yes	47	45 (95.7%)	44 (93.6%)	-	3 (6.4%)
Univessel	480	477 (99.4%)	466 (97.1%)*	1 (0.2%)	13 (2.7%)*
Multivessel	466	459 (98.5%)	439 (94.2%)	-	27 (5.8%)
Ventricular function					
Normal / mild dysf.	673	668 (99.3%)	653 (97.0%)*	1 (0.2%)	19 (2.8%)♣
Moderate / severe dysf.	273	269 (98.5%)	252 (92.3%)	-	21 (7.7%)
Disf. moderada / severa	273	269 (98,5%)	252 (92,3%)	-	21 (7,7%)
*p ≤ 0.05; ** p ≤ 0.01; ♣ p ≤ 0.001.					

Table 3 - Early outcomes according to clinical characteristics

identified as independent predictors of major complications were: diabetes mellitus (OR = 2.00; 95% CI = 1.03 – 3.88; p=0.04); cardiogenic shock (OR = 40.20; 95% CI = 15.72 – 102.79; p=0.00001); acute coronary syndromes (OR = 0.47; 95% CI = 0.30 – 0.71; p=0.0004); age (OR = 0.97; 95% CI = 0.94 – 0.99; p=0.03); multivessel disease (OR = 2.15; 95% CI = 1.08 – 4.30; p=0.03) and moderate to severe left ventricular dysfunction (OR = 2.55; 95% CI = 1.33 – 4.89; p=0.005). Age (OR = 0.0015; 95% CI = 0.87 – 0.97; p<0.002), cardiogenic shock (OR = 104.80; 95%

CI = 32.68 – 336.07; p=0.00001), systemic hypertension (OR = 7.68; 95% CI = 1.09 – 58.67; p=0.05), moderate to severe left ventricular dysfunction (OR = 6.82; 95% CI = 2.42 – 19.20; p=0.0003) and acute coronary syndromes (OR = 6.98; 95% CI = 1.58 – 30.74; p=0.01) were independent predictors of in-hospital mortality.

Multivariate analysis – angiographic characteristics - The results of the multivariate analysis according to angiographic characteristics are summarized in Table 6. Among the angiographic variables, calcification (OR = 0.13; 95% CI =

	n	Procedural success	Clinical success	Non-complicated unsuccessful procedure	Major complications
		n (%)	n (%)	n (%)	n (%)
Angulation					
< 45º	1010	999 (98.9%)	967 (95.7%)	1 (0.1%)	42 (4.2%)
> 45º, < 90º	27	27 (100.0%)	26 (96.3%)	-	1 (3.7%)
> 90º	8	8 (100.0%)	7 (87.5%)	-	1 (12.5%)
Bifurcation					
No	900	892 (99.1%)	864 (96.0%)	1 (0.1%)	35 (3.9%)
Yes	145	142 (97.9%)	136 (93.8%)	-	9 (6.2%)
Calcification					
No	915	910 (99.5%)♣	881 (96.3%)**	1 (0.1%)	33 (3.6%)**
Yes	130	124 (95.4%)	119 (91.5%)	-	11 (8.5%)
Irregular contour					
No	643	641 (99.7%)**	620 (96.4%)	1 (0.2%)	22 (3.4%)
Yes	402	393 (97.8%)	380 (94.5%)	-	22 (5.5%)
Eccentricity					
No	159	159 (100.0%)	150 (94.3%)	-	9 (3.4%)
Yes	886	875 (98.8%)	850 (95.9%)	1 (0.1%)	35 (4.0%)
Lesion length (millimeters)					
< 10	759	755 (99.5%)*	732 (96.4%)	1 (0.1%)	26 (3.4%)
> 10, < 20	249	243 (97.6%)	234 (94.0%)	-	15 (6.0%)
> 20	37	36 (97.3%)	34 (91.9%)	-	3 (8.1%)
Total occlusion					
No	918	907 (98.8%)	882 (96.1%)*	1 (0.1%)	35 (3.8%)*
< 3 months	124	124 (100.0%)	115 (92.7%)	-	9 (7.3%)
≥ 3 months	3	3 (100.0%)	3 (100.0%)	-	-
Ostial					
No	1012	1002 (99.0%)	970 (95.8%)	1 (0.1%)	41 (4.1%)
Yes	33	32 (97.0%)	30 (90.9%)	-	3 (9.1%)
Tortuosity					
No	1013	1002 (98.9%)	969 (95.7%)	1 (0.1%)	43 (4.2%)
Mod	27	27 (100.0%)	26 (96.3%)	-	1 (3.7%)
Sev	5	5 (100.0%)	5 (100.0%)	-	-
Thrombus					
No	822	812 (98.8%)	791 (96.2%)	1 (0.1%)	30 (3.6%)
Yes	223	222 (99.6%)	209 (93.7%)	-	14 (6.3%)
Type of lesion					
A	40	40 (100.0%)	40 (100.0%)	-	-
B1	248	247 (99.6%)	243 (98.0%)	1 (0.4%)	4 (1.6%)
B2	707	699 (98.9%)	670 (94.8%)	-	37 (5.2%)
C	50	48 (96.0%)	47 (94.0%)	-	3 (6.5%)
*p ≤ 0.05; **p ≤ 0.01; ♣ p ≤ 0.001.					

Table 4 - Early outcomes according to angiographic characteristics and type of lesion (AHA/ACC's classification).

0.04 – 0.43; p=0.0009) and irregular contour (OR = 0.15; 95% CI = 0.03 – 0.72; p=0.02) were predictive of lower procedural success. Calcification (OR = 0.40; 95% CI = 0.20 – 0.81; p=0.01) and total occlusion (OR = 0.44; 95% CI = 0.21 – 0.91; p=0.03) were predictive of lower clinical success. Calcification (OR = 2.98; 95% CI = 1.48 – 6.00; p=0.002); lesion lenght ≥ 10 mm (OR = 1.91; 95% CI = 1.02 – 3.55; p=0.04) and total occlusion (OR = 2.43; 95% CI

= 1.16 – 5.10; p=0.02) were predictive of higher occurrence of complications.

Discussion

Since the introduction of percutaneous transluminal coronary angioplasty in 1977[1], the utilization of percutaneous coronary interventions has spread rapidly. Because of the large

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	n	Procedural success	Clinical success*	Non-complicated unsuccessful procedure	Major complications*
		n (%)	n (%)	n (%)	n (%)
Left anterior descending	536	528 (98.5%)	510 (95.1%)	-	26 (4.9%)
Right coronary artery	313	312 (99.7%)	303 (96.8%)	-	10 (3.2%)
Left circumflex	157	156 (99.4%)	152 (96.8%)	-	5 (3.2%)
Left main coronary	8	8 (100.0%)	5 (62.5%)	-	3 (37.5%)
Saphenous vein bypass graft	25	24 (96.0%)	24 (96.0%)	1 (4.0%)	-
Internal mammary artery graft	6	6 (100.0%)	6 (100.0%)	-	-

*p< 0.01, comparing left main coronary with anterior descending, right coronary and circumflex, and p<0.05 comparing left main coronary with saphenous vein bypass.

Table 5 - Early outcomes according to the vessel treated

number of procedures performed, in addition to morbidity and mortality risks, several studies have identified factors determining early and long-term outcomes[7-21].

We have verified that our results corroborate those of several studies published previously. Among the several series published, procedural success occurred from 95 to 99%, clinical success from 86 to 96%, and major complications from 3.5 to 13.2% (death from 0.4 to 3.5%; myocardial revascularization from 2.1 to 6.0%, and myocardial infarction from 0,9 to 6.8%)[7,9-11,28-30]. The variation observed between clinical success and major complications resulted mainly from a higher prevalence of patients with advanced age, left ventricular dysfunction and mainly cardiogenic shock, in addition to the study length and to the use of other percutaneous coronary intervention procedures associated to the stents. Cardiogenic shock is the major cause of mortality in patients hospitalized for acute myocardial infarction, ranging from 26 to 72%[31,32]. Sutton et al[33] analyzed retrospectively 113 patients with cardiogenic shock treated with percutaneous coronary interventions. Similar to our results, mortality was 51%. The authors have identified that age > 70 years, previous myocardial infarction and failure of the thrombolytic treatment were independent variables related to in-hospital mortality.

Effect of the clinical variables - In the present study, patients with advanced age, diabetes mellitus, acute coronary syndromes, cardiogenic shock, and moderate to severe left ventricular dysfunction presented lower clinical success and higher percentage of in-hospital complications. Multivessel patients presented a higher percentage of complications. Restenotic lesions were a variable predictive of lower procedural success and of occurrence of in-hospital myocardial revascularization. Age, cardiogenic shock, systemic hypertension, moderate to severe left ventricular dysfunction and acute coronary syndromes were independent predictors of in-hospital mortality. O'Connor et al[34] identified age, cardiogenic shock, urgency/emergency procedures, left ventricular dysfunction, use of intra-aortic balloon and type C lesions as independent predictors of mortality. Renal dysfunction and heart failure were also predictors of death. These two latter variables and the use of intra-aortic balloon were not included in our analysis because data were not available for all patients. Resnic et al[13] identified similar factors predictive of mortality including cardiogenic shock, heart failure, tachycardia, renal failure, age ≥ 75 years, acute myocardial infarction and unstable angina. Block et al[30]

analyzed the data of 8 different studies and identified a number of variables predictive of adverse events following percutaneous coronary interventions. The variables identified as predictive of myocardial infarction were: age, multivessel disease, acute ischemic syndromes, and restenotic lesion in 2 databases, and cardiogenic shock in 1. The variables identified as predictive of myocardial revascularization were: cardiogenic shock in 3 databases, left ventricular dysfunction in 2, acute ischemic syndrome in 1, and restenotic lesion in 1.

Effect of the angiographic variables, treated vessel and type of lesion - Of all angiographic characteristics included in the American College of Cardiology/ American Heart Association's classification, calcification, lesion lenght, total occlusion and irregular contour were identified as predictive of early outcomes. Other studies have sought to identify which angiographic characteristics, type of lesion, and vessel treated are related to the outcomes[7,18].

In our study, calcification was predictive of lower procedural success, lower clinical success, and higher occurrence of complications. Calcified lesions lead to a reduction in vessel distension, thus an inadequate stent expansion occurs, resulting in lower success and higher possibility of complications[35,36]. Ellis et al[7] studied 10,907 lesions and identified calcification as an independent predictor of ischemic complications.

Lesions with irregular contours were predictive of lower procedural success whereas in Ellis et al[7]'s study an irregular contour was an independent predictor of ischemic complications.

In our analysis, total occlusion was an independent variable predictive of lower clinical success and of higher occurrence of complications. Total occlusions include a broad spectrum that goes from recent occlusions secondary to atherosclerotic plaque rupture and vessel occlusion (97.6% of our case series) to chronic occlusions when the thrombus is organized (2.4% of all occlusions)[37,38]. In Ellis et al[7]'s analysis total occlusion lasting < 3 months was the angiographic variable the most strongly correlated with the occurrence of in-hospital ischemic complications. In our study, unlike Ellis et al[7]'s results, calcification was the variable the most strongly correlated with both success and complications.

Previous studies have demonstrated that the lesion lenght is directly related to the percentage of complications[7,39,40], which corroborates our findings. Kornowski et al[39] demonstrated that major complications were more frequent in long lesions

	Univariateanalysis		Multivariate analysis		
	p	p	Odds Ratio	95% CI	IC 95%
Procedural success					
Restenotic lesion	0.08	0.04	0.18	0.04 – 0.88	0,04 – 0,88
Calcification	0.001	0.0009	0.13	0.04 – 0.43	0,04 – 0,43
Irregular contour	0.004	0.02	0.15	0.03 – 0.72	0,03 – 0,72
Clinical success					
Diabetes mellitus	0.006	0.02	0.47	0.24 – 0.90	0,24 – 0,90
Cardiogenic shock	0.0001	0.00001	0.03	0.01 – 0.65	0,01 – 0,65
Acute coronary syndromes	0.001	0.04	0.48	0.23 – 0.98	0,23 – 0,98
Age	0.02	0.03	1.03	1.00 – 1.06	1,00 – 1,06
Mod/severe LV dysfunction	0.002	0.01	0.44	0.23 – 0.84	0,23 – 0,84
Calcification	0.01	0.01	0.40	0.20 – 0.81	0,20 – 0,81
Total occlusion	0.04	0.04	0.44	0.21 – 0.91	0,21 – 0,91
Major complications					
Diabetes mellitus	0.01	0.04	2.00	1.03 – 3.88	1,03 – 3,88
Cardiogenic shock	0.0001	0.00001	40.20	15.72 – 102.79	15,72 – 102,79
Acute coronary syndromes	0.001	0.0004	0.47	0.30 – 0.71	0,30 – 0,71
Age	0.01	0.03	0.97	0.94 – 0.99	0,94 – 0,99
Multivessel disease	0.02	0.03	2.15	1.08 – 4.30	1,08 – 4,30
Mod/severe LV dysfunction	0.0008	0.005	2.55	1.33 – 4.89	1,33 – 4,89
Calcification	0.01	0.002	2.98	1.48 – 6.00	1,48 – 6,00
Lesions ≥10 mm	0.04	0.04	1.91	1.02 – 3.55	1,02 – 3,55
Total occlusion	0.03	0.02	2.43	1.16 – 5.10	1,16 – 5,10
In-hospital death					
Hypertension	0.008	0.05	7.68	1.09 – 58.67	1,09 – 58,67
Cardiogenic shock	0.00001	0.00001	104.80	32.68 – 336.07	32,68 – 336,07
Acute coronary syndromes	0.0001	0.01	6.98	1.58 – 30.74	1,58 – 30,74
Age	0.01	0.002	0.93	0.87 – 0.97	0,87 – 0,97
Mod/severe LV dysfunction	0.0001	0.0003	6.82	2.42 – 19.20	2,42 – 19,20

LV = left ventricle, CI = confidence interval, Mod = moderate.

Table 6 - Multivariate analysis results

(3.4% versus 1.0%; p=0.04). In Ellis et al[7]'s study, lesion lenght between 10 and 20 mm was an independent predictor of ischemic complications.

Lesions in the left main coronary and in the left anterior descending have been described as predictive of early complications[15,16]. Block et al[30] verified that lesions in the left main coronary were predictive of in-hospital mortality in 2 studies. In our study, lesions in the left main coronary were predictive of major complications, and no statistical significance was observed when we analyzed the other arteries.

Several studies have demonstrated the predictive value of the ACC/AHA's classification when early outcomes following percutaneous coronary interventions are analysed[15,30]. However, the predictive value of the type of lesion has been lower than that previously observed because of the technical refinement including a high percentage of stent implantation and the use of platelet glycoprotein IIb/IIIa inhibitors. Krone et al[18] verified that ACC/AHA's classification presented a lower power of discrimination of early outcomes following percutaneous coronary interventions than the Society for Angiography and

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Interventions' (SCAI) classification, which was not used in our study. In our study, although complex lesions had presented lower clinical success and higher percentage of complications, we decided not to include the type of lesion in the multivariate model. This choice was based on the fact that the angiographic characteristics of the ACC/AHA's classification had been included in our model and, therefore, the inclusion of the variable type of lesion would be inadequate.

Limitations - This is an observational non-randomized study of patients consecutively treated with coronary stent implantation. We cannot generalize the findings; because our clinic is a reference center, the patients may have peculiarities that modified the outcomes and which we could not control. Some variables such as renal function and body mass index were not analyzed. Additionally, we did not assess blood glucose control in diabetics, a factor related to a lower occurrence of target lesion revascularization, re-hospitalization, and recurrent angina[41]. However, our experience represents the real world and not that of randomized clinical trials. Certain characteristics were observed in a small number; thus, they may have not reached a statistical significance due to the small sample size (type II error). Another limitation refers to the analysis of the lesions, which was performed by a single observer. We did not assess the degree of stenosis using quantitative coronary angiography (QCA), a method that is more precise than the visual assessment[42,43], although we have already demonstrated a good correlation between QCA and visual estimate[44]. Likewise, the left ventricular function was estimated using visual assessment, and none of the imaging methods that estimate left ventricular function more accurately in addition to identifying the ventricular region affected[45] were used.

Conclusion

In the current phase of percutaneous coronary interventions with a significant use of stents, we have verified that clinical factors present a greater influence on early outcomes when compared to angiographic factors / type of lesion and vessel treated. Our analysis identified 3 clinical factors (cardiogenic shock, left ventricular dysfunction and age) and 2 angiographic factors (calcification and total occlusion) as independent predictors of early outcomes following stent implantation.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

References

1. Grüntzig AR. Transluminal Dilatation of Coronary-Artery Stenoses. Lancet 1978; 1:263.

2. Colombo A, Hall P, Nakamura S, Almagor Y, Maiello L, Martini G, et al. Intracoronary stenting without anticoagulation accomplished with intravascular ultrasound guidance. Circulation 1995; 91:1676-88.

3. Moussa I, Reimers B, Moses J, Di Mario C, Di Francesco L, Ferraro M, et al. Long-term angiographic and clinical outcome of patients undergoing multivessel coronary stenting. Circulation 1997; 96: 3873-9.

4. Lincoff AM, Califf RM, Anderson KM, Weisman HF, Aguirre FV, Kleiman NS, et al. EPIC Investigators. Evidence for prevention of death and myocardial infarction with platelet membrane glycoprotein IIb/IIIa receptor blockade by abciximab (c7E3 Fab) among patients with unstable angina undergoing percutaneous coronary revascularization. J Am Coll Cardiol 1997; 30: 149-56.

5. Ryan TJ, Faxon DP, Gunnar RM, Kennedy JW, King SB, Loop FD, et al. Guidelines for percutaneous transluminal coronary angioplasty. A report of the American College of Cardiology/American Heart Association Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures (Subcommittee on Percutaneous Transluminal Coronary Angioplasty). Circulation 1988; 78:486-502.

6. Ellis SG, Vandormael MG, Cowley MJ, Disciascio G, Deligonul U, Topol EJ, et al. Multivessel Angioplasty Prognosis Study Group. Coronary morphologic and clinical determinants of procedural outcome with angioplasty for multivessel coronary disease: implications for patient selection. Circulation 1990;82:1193-202.

7. Ellis SG, Guetta V, Miller D, Whitlow PL, Topol EJ. Relation between lesion characteristics and risk with percutaneous intervention in the stent and glycoprotein IIb/IIIa era. An analysis of results from 10907 lesions and proposal for new classification scheme. Circulation 1999;100:1971-6.

8. Kastrati A, Schomig A, Elezi S, Dirschinger J, Mehili J, Schulen H, et al. Prognostic value of the modified American College of Cardiology/American Heart Association stenosis morphology classification for long-term angiographic and clinical outcome after coronary stent placement. Circulation 1999; 100: 1285-90.

9. van Domburg RT, Foley DP, de Jaegere PPT, de Feyter P, van den Brand M, van der Giessen W, et al. Long term outcome after coronary stent implantation: a 10 year single center experience of 1000 patients. Heart 1999; 82 Suppl II: II27-II34.

10. Briguori C, Nishida T, Adamian M, Di Mario C, Moses J, Colombo A. Multivessel coronary stenting: predictors of early and late outcome. Ital Heart J 2000;1:420-5.

11. Holmes Jr DR, Berger PB, Garratt KN, Mathew V, Bell MR, Barsness GW, et al. Application of the New York State PTCA mortality model in patients undergoing stent implantation. Circulation 2000; 102: 517-22.

12. Moscucci M, Kline-Rogers E, Share D, O'Donnel M, Maxwell-Eward A, Meengs WL, et al. Blue Cross Blue Shield of Michigan Cardiovascular Consortium. Simple Bedside Additive Tool for Prediction of In-Hospital Mortality After Percutaneous Coronary Interventions. Circulation 2001;104:263-8.

13. Resnic FS, Ohno-Machado MHA, Selwyn A, Simon DI, Popma JJ. Simplified risk score models accurately predict the risk of major in-hospital complications following percutaneous coronary intervention. Am J Cardiol 2001;88:5-9.

14. Mattos LA, Sousa AGMR, Pinto IMF, Neto CMC, Labrunie A, Alves CR, et al. Investigadores da CENIC (Central Nacional de Intervenções Cardiovasculares) / SBHCI (Sociedade Brasileira de Hemodinâmica e Cardiologia Intervencionista). Evolução temporal com a utilização da angioplastia coronariana primária no infarto agudo do miocárdio no Brasil. Análise dos preditores de sucesso e dos eventos adversos hospitalares em 9.434 pacientes. Arq Bras Cardiol 2002; 79:405-11.

15. Shaw RE, Anderson V, Brindis RG, Krone RJ, Klein LW, McKay CR, et al. ACC-NCDR. Development of a risk adjustment mortality model using the American College of Cardiology-National Cardiovascular Data Registry (ACC-NCDR) Experience: 1998-2000. J Am Coll Cardiol 2002;39:1104-12.

16. Singh M, Lennon RJ, Holmes Jr DR, Bell MR, Rihal CS. Correlates of Procedural Complications and a Simple Score for Percutaneous Coronary Intervention. J Am Coll Cardiol 2002;40:387-93.

17. Kizer JR, Berlin JA, Laskey WK, Schwartz JS, Sauer WH, Krone RJ, et al. Limitations of current risk-adjustment models in the era of coronary stenting. Am Heart J 2003; 145:683-92.

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18. Krone RJ, Shaw RE, Block PC, Anderson HV, Weintraub WS, Brindis RG, et al. ACC-National Cardiovascular Data Registry. Evaluation of the American College of Cardiology/American Heart Association and the Society for Coronary Angiography and Interventions Lesion Classification System in the Current "Stent Era" of Coronary Interventions (From the ACC-National Cardiovascular Data Registry). Am J Cardiol 2003; 92:389-94.

19. Holmes DR, Selzer F, Johnston JM, Kelsey SF, Holubkov R, Cohen HA, et al. Modeling and Risk Prediction in the Current Era of Interventional Cardiology. A Report from the National Heart, Lung, and Blood Institute Dynamic Registry. Circulation 2003;107: 1871-6.

20. Mehran R, Dangas GD, Kobayashi Y, Lansky AJ, Mintz GS, Aymong ED, et al. Short-and long-term results after multivessel stenting in diabetic patients. J Am Coll Cardiol 2004; 43: 1348-54.

21. Qureshi MA, Safian RD, Grines CL, Goldstein JA, Westveer DC, Glazier S, et al. Simplified scoring system for predicting mortality after percutaneous coronary intervention. J Am Coll Cardiol 2003; 42: 1890-5.

22. Mathew V, Hasdai D, Holmes Jr DR, Garratt KN, Bell MR, Lerman A, et al. Clinical Outcome of Patients Undergoing Endoluminal Coronary Artery Reconstruction With Three or More Stents. J Am Coll Cardiol 1997;30:676-81.

23. Olefsky JM. Diabetes Mellitus. In: Wyngaarden JB & Smith Jr. LH, editors. Cecil Textbook of Medicine. 18th ed. Philadelphia: WB Saunders International Edition; 1988. p.1360-81.

24. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 1997;20:1183-97.

25. Campeau L. Grading of angina pectoris (letter). Circulation 1976;54:522-3.

26. Gillum RF, Fortmann SP, Prineas RJ, Kottke TE. International diagnostic criteria for acute myocardial infarction and acute stroke. Am Heart J 1984;108:150-8.

27. Tunstall-Pedoe H, Kuulasmaa K, Amouyel P, Arveiler D, Rajakangas AM, Pajak A. Myocardial infarction and coronary deaths in the World Health Organization MONICA Project. Registration procedures, event rates, and case-fatality rates in 38 populations from 21 countries in four continents. Circulation 1994;90:583-612.

28. Zaacks SM, Allen JE, Calvin JE, Schaer GL, Palvas BW, Parrillo JE, et al. Value of the American College of Cardiology/American Heart Association Stenosis Morphology Classification for Coronary Interventions in the Late 1990s. Am J Cardiol 1998; 82:43-9.

29. Maynard C, Goss JR, Malenka DJ, Reisman M. Clinical Outcomes Assessment Program. Adjusting for patient differences in predicting hospital mortality for percutaneous coronary interventions in the Clinical Outcomes Assessment Program. Am Heart J 2003; 145:658-64.

30. Block PC, Peterson EC, Krone R, Kesler K, Hannan E, O'Connor GT, et al. Identification of variables needed to risk adjust outcomes of coronary interventions: Evidence-based guidelines for efficient data collection. J Am Coll Cardiol 1998; 32: 275-82.

31. Antoniucci D, Valenti R, Santoro GM, Bolognese L, Trapani M, Moschi G, et al. Systematic direct angioplasty and stent-supported direct angioplasty therapy for cardiogenic shock complicating acute myocardial infarction: In-hospital and long-term survival. J Am Coll Cardiol 1998; 31: 294-300.

32. Himbert D, Juliard JM, Steg PG, Karrillon GJ, Aumont MC, Gourgon R. Limits of reperfusion therapy for immediate cardiogenic shock complicating acute myocardial infarction. Am J Cardiol 1994; 74: 492-4.

33. Sutton AGC, Finn P, Harcombe AA, Wright RA, de Belder MA. Predictors of outcome after percutaneous treatment for cardiogenic shock. Heart 2005; 91: 339-44.

34. O'Connor GT, Malenka DJ, Quinton H, Robb JF, Kellett Jr MA, Shubrooks S, et al. Northern New England Cardiovascular Disease Study Group. Multivariate prediction of in-hospital mortality after percutaneous coronary interventions in 1994-1996. J Am Coll Cardiol 1999;34:681-91.

35. Goldberg SL, Hall P, Almagor Y, Maiello L. Intravascular ultrasound guided rotational atherectomy of fibro-calcific plaque prior to intra-coronary deployment of Palmaz-Schatz stents. J Am Coll Cardiol 1994; 24: 290A.

36. Henneke KH, Regar E, Konig A, Werner F, Klauss V, Metz J, et al. Impact of target lesion calcification on coronary stent expansion after rotational atherectomy. Am Heart J 1999; 137: 93-9.

37. Ambrose JA, Winters SL, Stern A, Eng A, Teichholz LE, Gorlin R, et al. Angiographic Morphology and the Pathogenesis of Unstable Angina Pectoris. J Am Coll Cardiol 1985; 5: 609-16.

38. Myler RK, Shaw RE, Stertzer SH, Hecht HS, Ryan C, Rosenblum J, et al. Lesion morphology and coronary angioplasty: Current experience and analysis. J Am Coll Cardiol 1992;19: 1641-52.

39. Kornowski R, Bhargava B, Fuchs S, Lansky AJ, Satler LF, Pichard AD, et al. Procedural results and late clinical outcomes afer percutaneous interventions using long (≥25 mm) versus short (<20 mm) stents. J Am Coll Cardiol 2000; 35: 612-8.

40. Kastrati A, Elezi S, Dirschinger J, Hadamitzky M, Neumann FJ, Schomig A. Influence of lesion length on restenosis after coronary stent placement. Am J Cardiol 1999; 83: 1617-22.

41. Corpus RA, George PB, House JA, Dixon SR, Ajluni SC, Devlin WH, et al. Optimal glycemic control is associated with a lower rate of target vessel revascularization in treated type II diabetic patients undergoing elective percutaneous coronary intervention. J Am Coll Cardiol 2004; 43: 8-14.

42. Scoblionko DP, Brown BG, Mitten S, Caldwell JH, Kennedy JW, Bolson EL, et al. A New Digital Electronic Caliper for Measurement of Coronary Arterial Stenosis: Comparison with Visual Estimates and Computer-Assisted Measurements. Am J Cardiol 1984; 53: 689-93.

43. Kearney P & Erbel R. Imaging in the catheterization laboratory. Current Opinion in Cardiology 1993; 8:988-99.

44. Neri-Souza AJ, Lapa-Godinho AG, Ramos NB, Santos-Jesus R, Araújo B, Gamalho M, et al. Comparison of quantitative coronary angiography and visual coronary stenosis estimates. J Am Coll Cardiol 2002; 39(suppl B): 307B.

45. Little WC, Braunwald E. Assessment of Cardiac Function. In: Braunwald E (ed.). Heart Disease. A Textbook of Cardiovascular Medicine. 5th ed. Philadelphia: Saunders; 1997. p. 421-44.