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Original Article

Percutaneous coronary intervention in unprotected left main coronary artery stenosis: Mid-term outcomes of a single-center observational study

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A B S T R A C T

Background: Percutaneous coronary intervention (PCI) is an appropriate alternative to coronary artery bypass grafting (CABG) for revascularization of unprotected left main coronary artery (ULMCA) disease in patients with low-to–intermediate anatomic complexity or when the patient refuses CABG even after adequate counselling by heart team. We assessed the safety, in-hospital and mid-term outcomes of ULMCA stenting with drug-eluting stents (DES) in Indian patients.
Methods: Our study was a retrospective analysis of patients who had undergone ULMCA PCI at a tertiary center, between March 2011 and February 2020. Clinical characteristics, procedural data, and follow-up data were analyzed. The primary outcome was a composite of major adverse cardiovascular and cerebrovascular events (MACCE) during the hospital stay and at follow-up. The median follow-up was 2.8 years (interquartile range: 1.5–4.1 years).
Results: 661 patients (mean age, 63.5 ± 10.9 years) had undergone ULMCA PCI. The mean SYNTAX score was 27.9 ± 10.4 and the mean LVEF was 58.0 ± 11.1%. 3-vessel disease and distal lesions were noted in 54% and 70.6% patients, respectively. The incidence of in-hospital MACCE was 1.8% and the MACCE during follow-up was 11.5% (including 48 [8.4%] cardiac deaths). The overall survival rates after one, three, five, and nine years were 94%, 88%, 84%, and 82%, respectively. The multivariate analysis revealed that age >65 years and high SYNTAX scores were independent predictors of mid to long-term mortality.
Conclusion: ULMCA PCI with DES is safe and has acceptable in-hospital and mid-term outcomes among patients with low-to–intermediate SYNTAX score.

1. Introduction

Hemodynamically significant unprotected left main coronary artery (ULMCA) disease is a high-risk clinical condition[1] because of the large area of myocardium at risk and it requires prompt revascularization. Coronary artery bypass grafting (CABG) is the preferred method for revascularization in significant ULMCA stenosis.[2] Both European and American guidelines recommend CABG for ULMCA disease, especially in patients with a high SYNTAX score.[3–5] However, percutaneous coronary intervention (PCI) remains an appropriate alternative to CABG in low-intermediate anatomic complexity (SYNTAX score <33). Hence it is important to utilize the heart team's decision while considering revascularization of significant ULMCA stenosis. PCI to LMCA is considered as a complex PCI because of its anatomical importance and the procedural complexities.[1] A recent meta-analysis of randomized controlled trials (N = 4594 patients), including SYNTAX, PRECOMBAT, NOBLE, and EXCEL trials, as well as the trial by Buodriot et al, has shown that the incidence of all-cause death, myocardial infarction (MI), or stroke among patients with low-risk ULMCA stenosis is similar between PCI (using DES) and CABG.[6] Nevertheless, adopting a patient-centric revascularization strategy, while considering factors such as anatomical disease complexity, clinical characteristics, and operator's experience, may provide maximal benefits.[7]

Although there are multiple data related to the utilization and outcomes of ULMCA PCI, there is a paucity of data on mid and long-term outcomes in Indian settings. This retrospective study assessed

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Table 1
Baseline clinical characteristics.

Variable	Patients (N = 661)[a]
Age (mean ± SD; years)	63.5 ± 10.9
Gender	
Male	539 (81.5)
Female	122 (18.5)
Risk factors for CAD	
Hypertension	447 (67.6)
Diabetes mellitus	403 (61)
Dyslipidemia	344 (52)
Family history	109 (16.5)
Smoking	167 (25.3)
High-risk subsets	
Previous PCI	110 (16.6)
Previous LMCA intervention	8 (1.2)
Renal diseases/dysfunction	67 (10.1)
Pulmonary edema	44 (6.7)
Cardiogenic shock	4 (0.6)
Cardiac arrest	2 (0.3)
LVEF% (mean ± SD)	58.0 ± 11
Clinical presentation	
SIHD	240 (36.3)
NSTEMI	170 (25.7)
Unstable angina	150 (22.7)
STEMI	101 (15.3)

[a] All data presented as n (%) unless otherwise indicated. BMI: Body mass index; CABG: Coronary artery bypass grafting; CAD: Coronary artery disease; LVEF: Left ventricular ejection fraction; NSTEMI: Non-ST-elevation myocardial infarction; PCI: Percutaneous coronary intervention; STEMI: ST-elevation myocardial infarction; SD: Standard deviation.

the in-hospital and mid-term outcomes of patients who underwent ULMCA PCI. The impact of clinical variables, such as diabetes and stenting strategy on the clinical outcomes, was also assessed.

2. Methods

2.1. Study design and population

This was a single-center, retrospective, observational study of patients with ULMCA disease who had undergone PCI using DES at our center between March 2011 and February 2020. The study population included all consecutive patients who underwent ULMCA stenting and patients with incomplete data were excluded from the analysis. The follow-up period varied between six months to nine years (depending upon the time of data collection) and the median follow-up was 2.8 years (interquartile range: 1.5–4.1 years). Baseline clinical, angiographic and procedural characteristics and follow-up data were sourced from the electronic medical records maintained at the hospital. Ethics Committee approval for the retrospective analysis was obtained from the Institutional Ethics committee.

2.2. Procedural overview

All patients who required LMCA revascularization were advised both CABG or PCI according to the standard guidelines. Patients who refused CABG even after adequate counseling, were also scheduled for PCI. All the PCI procedures were done by a highly experienced single operator. Preprocedural coronary angiography (CAG) was performed in all cases according to the standard indications of acute coronary syndrome or stable ischemic heart disease. Patients who underwent CAG at outside centers were also included. Both elective and immediate LMCA PCI were done according to the urgency. Clinical history and examination, baseline electrocardiogram (ECG) and echocardiogram were recorded in all the cases prior to the PCI. Appropriate medications including dual

Table 2
Angiographic and procedural characteristics.

Variable	Patients (N = 661)[a]
Vessels Involved (N = 661)	
LMCA+3-VD	356 (53.9)
LMCA+2-VD	179 (27.1)
LMCA+1-VD	102 (15.4)
LMCA (Isolated)	19 (2.9)
Location of LM lesion (n = 581)	
Distal	410 (70.6)
Ostial	50 (8.6)
Shaft	22 (3.8)
No lesion**	99 (17.0)
Medina Classification (n = 581)	
1,1,1	246 (42.3)
1,1,0	141 (24.3)
0,1,0	69 (11.9)
1,0,0	72 (12.4)
0,1,1	26 (4.5)
1,0,1	23 (4.0)
0,0,1	4 (0.7)
Trifurcation	103 (15.6)
SYNTAX (n = 581) (mean ± SD)	27.9 ± 10.4
Low–to-intermediate SYNTAX score (<33)	402 (69.2)
High SYNTAX score (≥33)	179 (31)
Procedural characteristics	
Stent Characteristics	
Number of stents [total no. of stents, 1191)	
1	292 (44)
2	252 (38)
3	81 (12.3)
4	28 (4.2)
5	8 (1.2)
Type of stents [total no. of stents, 1191)	
SES	401 (33.6)
EES	543 (45.6)
ZES	246 (20.7)
PES	1 (0.08)
Total stent length (mean ± SD) mm	47.0 (27.0)
LM stent diameter (mean ± SD) mm	3.7 (0.4)
Mean number of stents/patient (±SD)	1.8 ± 0.9
Provisional stenting strategy	515 (77.9)
Two stents strategy	**146 (22.1)**
KBI (in two-stent)	139 (95.2)
POT (in two-stent)	144 (98.6)
Culotte	4 (2.7)
DK CRUSH	8 (5.5)
MINI CRUSH	109 (74.7)
SKS	1 (0.7)
TAP	22 (15.1)
V STENT	2 (1.4)
Imaging	**156 (23.6)**
IVUS	119 (76.3)
OCT	19 (12.1)
IVUS and OCT	18 (11.5)
Imaging at the center (year wise)^	
2013	2 (9.5)
2014	1 (3.3)
2016	1 (1.1)
2017	2 (1.5)
2018	58 (44.6)
2019	84 (53.5)
2020	8 (47.1)
Rotational atherectomy	41 (6.2)
Cutting Balloon	40 (6.1)

[a] All data are presented as n (%) unless otherwise specified; n varied in a few cases and has been specified accordingly. **It is an ostial branch vessel disease, but stenting was done from LMCA. ^percentage was derived out of procedures performed in that particular year. DVD: Dual vessel disease; EES: Everolimus eluting stents; IVUS: Intravascular ultrasound; KBI: Kissing balloon inflation; LM: Left Main; LMCA: Left main coronary artery; OCT: Optical coherence tomography; PCI: Percutaneous coronary intervention; PES: paclitaxel eluting stent; POT: Proximal optimization technique; SD: Standard deviation; SES: Sirolimus eluting stents; SVD: Single-vessel disease; SYNTAX: Synergy between percutaneous coronary intervention with Taxus and cardiac surgery; TVD: Triple-vessel disease; ZES: Zotarolimus eluting stents.

Table 3
Incidence of MACCE in total population and patients with STEMI.

Characteristics	Events[a]
In-hospital events (N = 661)	
Cardiac death	10 (1.5)
Stent thrombosis	2 (0.3)
Peri-procedural MI	4 (0.6)
Stroke	1 (0.15)
Follow-up (N = 572)	
MI	5 (0.9)
Stroke	12 (2)
Late stent thrombosis	1 (0.17)
PCI	24 (4.2)
CABG	6 (1)
Cardiac death	48 (8.4)
STEMI (N = 101)	
All cause death	13 (12.8)

[a] All data are presented as n (%) unless otherwise specified; n varied in a few cases and has been specified accordingly. MACCE: Major adverse cardiac and cerebrovascular events; MI: Myocardial infarction; PCI: Percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction.

antiplatelets (aspirin and clopidogrel or ticagrelor or prasugrel), statins, ACE inhibitors/ARBs and beta blockers were given to all patients according to the standard guidelines. Hydration with normal saline was administered both prior to and after the PCI, according to the hemodynamic status of the patient, to reduce the risk of contrast induced acute kidney injury (CI-AKI). Intra-aortic balloon pump (IABP) support was planned in patients with cardiogenic shock not responding to inotropic support; no other hemodynamic support devices were used. All the procedures were done with onsite surgical back up. Both radial and femoral approaches were used according to the operator's discretion. 6F/7 F guiding catheters and 7F/8 F guiding catheters were used for radial approach and femoral approach, respectively. Guidewire selection, lesion preparation, stent selection, stenting strategy and post dilatation were decided by the operator according to the standard practice. During earlier days without intracoronary imaging, rotational atherectomy was used for balloon uncrossable or undilatable calcified lesions. Similarly cutting/scoring balloons were used for undilatable lesions. Later, with availability of intracoronary imaging guidance, calcium arc > 180°, calcium length > 5 mm, calcium thickness >0.5 mm and calcific nodules were also considered for rotational atherectomy. After the initiation of intracoronary imaging usage, lesion preparation techniques, stent selection and stenting strategy were performed using imaging guidance. Provisional stenting was planned when the lesion extended into only one branch, i.e., medina (1,0,1) and (1,1,0). After main vessel stenting, side branch (SB) stenting was planned if any of the following were present: 1) significant SB dissection; 2) future access to the SB was considered necessary; 3) SB FFR <0.8; 4) SB TIMI flow <3. In complex bifurcation lesions involving side branches, upfront two stent strategies were planned. Commonly used two stent strategies were T/TAP technique, Crush techniques (Mini crush, DK crush and DK nano crush) and culotte technique. After procedure, patients were monitored in coronary care unit for 24 h. All patients were offered complete revascularization before discharge. As per the hospital protocol, patients were followed up after 7, 30 days, 3, 6 months clinically.

2.3. Definitions and endpoints

Unprotected left main stenosis was defined as LMCA stenosis without previous history of CABG or absence of patent grafts in angiogram, if previous CABG had been done. Significant LMCA stenosis was defined as angiographic diameter stenosis >50%.[8] Successful PCI was defined as residual angiographic stenosis <10% after stenting without loss of significant SB or flow limiting

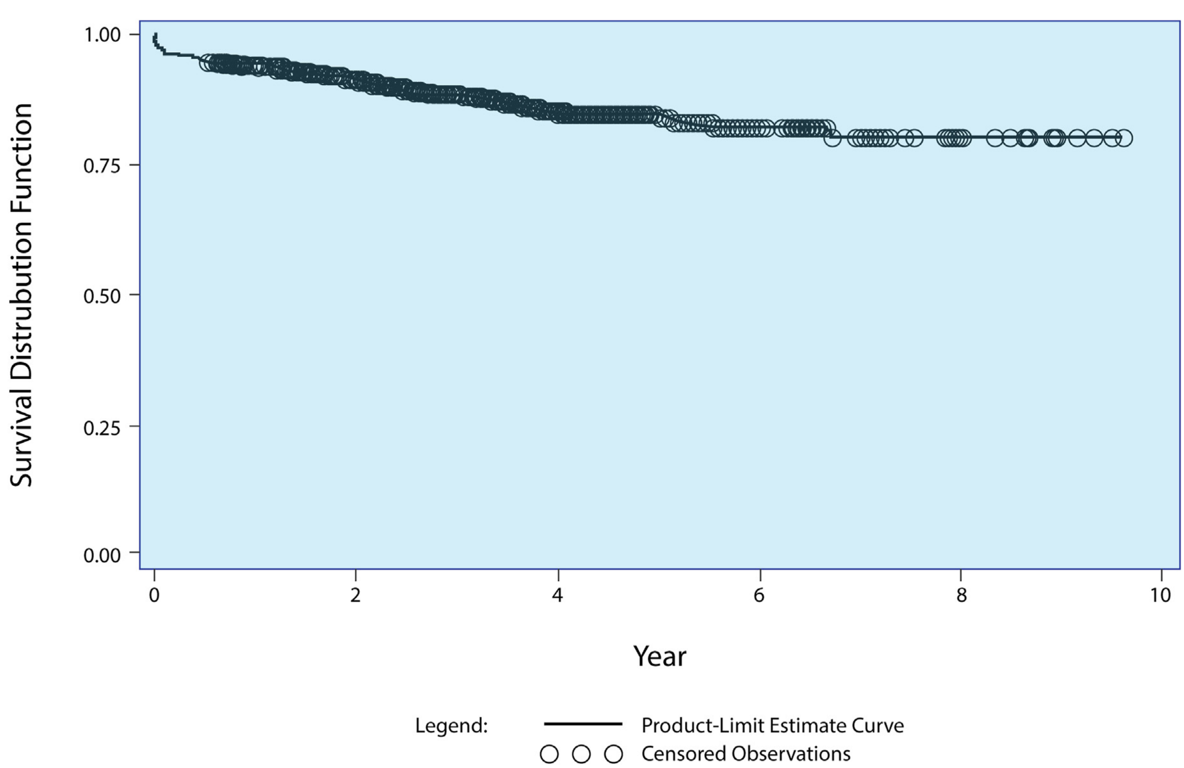


Fig. 1. Kaplan–Meier's survival curves in the total population.

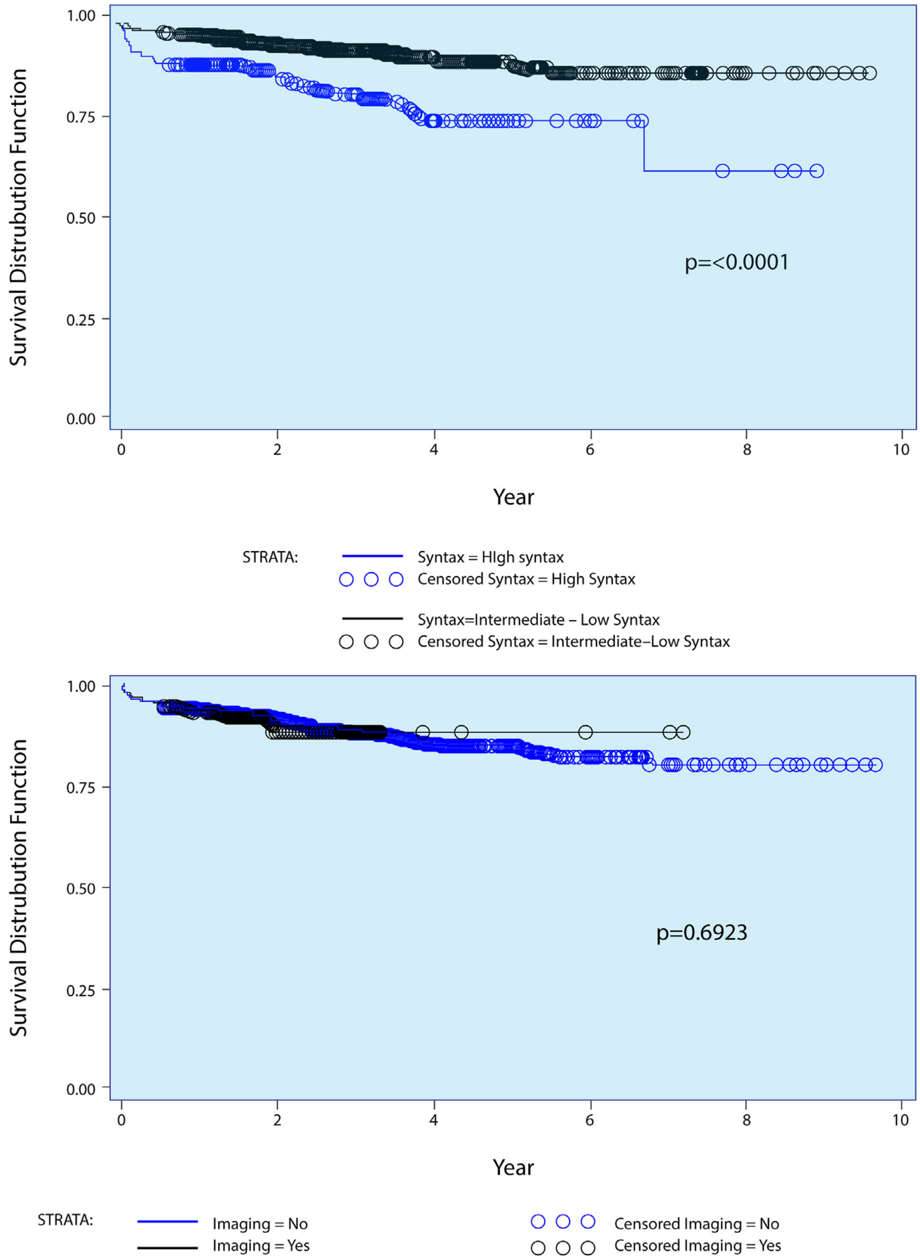


Fig. 2. Kaplan–Meier's survival curves for subgroups.2A: High SYNTAX (Score ≥33) and intermediate–low SYNTAX (Score <33) subgroups; 2B: Intracoronary imaging and non-imaging subgroups; 2C: Patients with diabetes and patients without diabetes subgroups; 2D: Provisional and two-stent strategy subgroups.

dissection. Cardiogenic shock was defined as systolic blood pressure (SBP) < 90 mmHg or requiring inotropic support to maintain SBP ≥90 mmHg and evidence of end-organ hypoperfusion. Contrast-induced AKI was defined as a rise in serum creatinine by ≥ 0.3 mg/dL within 48 h after contrast exposure or ≥50% rise within seven days (Kidney disease Improving Global Outcomes [KIDGO] working group definition). Provisional stenting was defined as stenting across main vessel followed by SB stenting if required. Two stent strategy was defined as upfront stenting of both main vessel and SB with any of the standard techniques according to the bifurcation anatomy and operator experience. Major adverse cardiovascular and cerebrovascular events (MACCE) was defined as the composite of cardiac death, MI, and stroke during the hospital stay and follow-up. Cardiac death, MI, stroke, and TVR were defined according to the Academic Research Consortium-2 Consensus Document.[9]

2.4. Statistical analysis

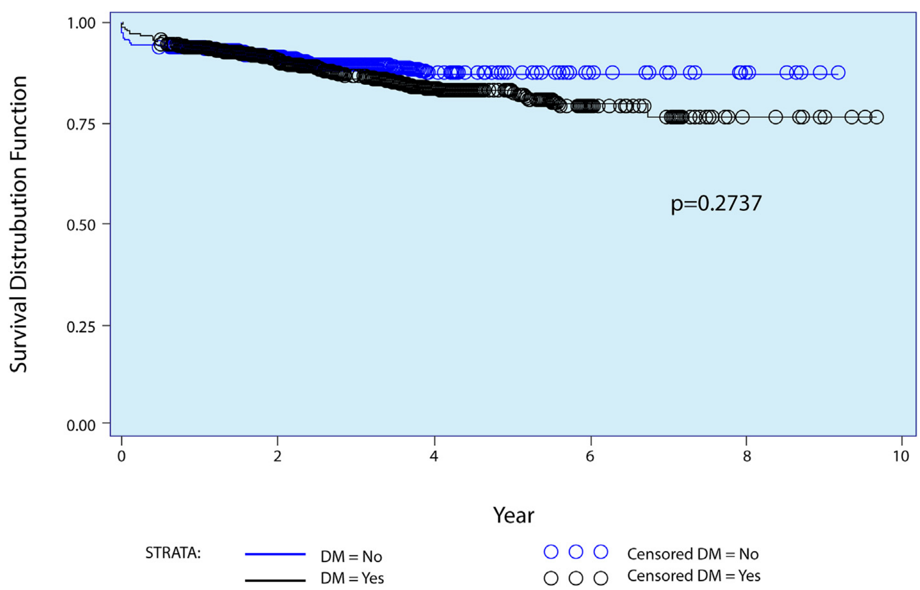
Categorical variables have been presented as numbers and percentages and continuous data as mean and standard deviation. Kaplan–Meier survival curves were obtained for the overall population and various subgroups. Univariate and multivariate Cox regression analysis were conducted to analyze the predictors of mortality. The overall survival curves for the different subgroups were compared using the log-rank test method. The probability of death for the overall population as well as for the subgroups was also estimated by using cumulative incidence rates. P-value < 0.05 was considered as significant.

3. Results

Between March 2011 and February 2020, a total of 661 patients with ULMCA lesions underwent PCI with DES. The mean age of the study population was 63.5 ± 10.9 years and 18.5% of the patients were females. The mean ejection fraction was 58.0 ± 11.1%. The key risk factors for coronary artery disease included arterial hypertension 447 (67.6%), diabetes 403 (61%), and dyslipidemia 344 (52%). The most frequent clinical presentations were SIHD 240 (36.3%), followed by NSTEMI 170 (25.7%), unstable angina 150 (22.7%), and STEMI 101 (15.3%). Other baseline clinical characteristics are summarized in Table 1.

3.1. Lesion characteristics and procedural details

Table 2 summarizes the baseline vessel/lesion and procedural characteristics. Nineteen patients (2.9%) had isolated left main coronary disease; LMCA plus three-vessel and two-vessel disease were noted in 356 (53.9%) and 179 (27.1%) patients, respectively. Distal LMCA lesion was noted in 402 (70.6%) patients. Medina 1,1,1 bifurcation lesion was noted in 246 (42.3%) patients. The mean SYNTAX score of the study population was 27.9 ± 10.4. Debulking techniques used included rotational atherectomy in 41 (6.2%) patients and cutting balloon in 40 (6.1%) patients. Provisional stenting strategy was employed in 515 (77.9%) patients. The two-stent technique was employed in 146 (22.1%) patients. Among these, the crush techniques (mini-crush or double kissing [DK] crush) were employed in 117 and the non-crush (T and small protrusion [TAP], SKS, V-stent or culotte) techniques were employed in 29 patients. The mean number of stents used was 1.8 ± 0.9 while the



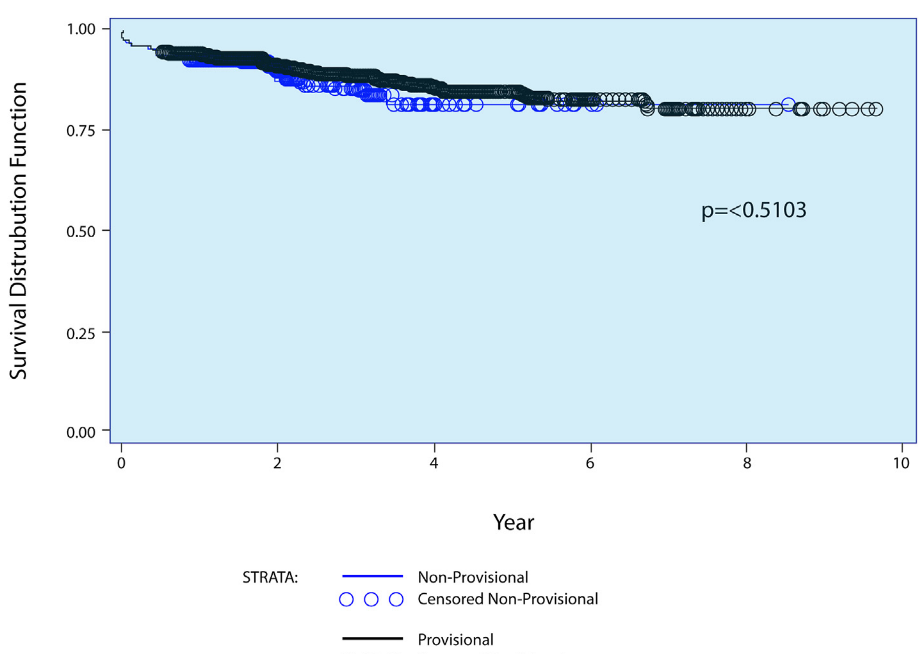


Fig. 2. (*continued*).

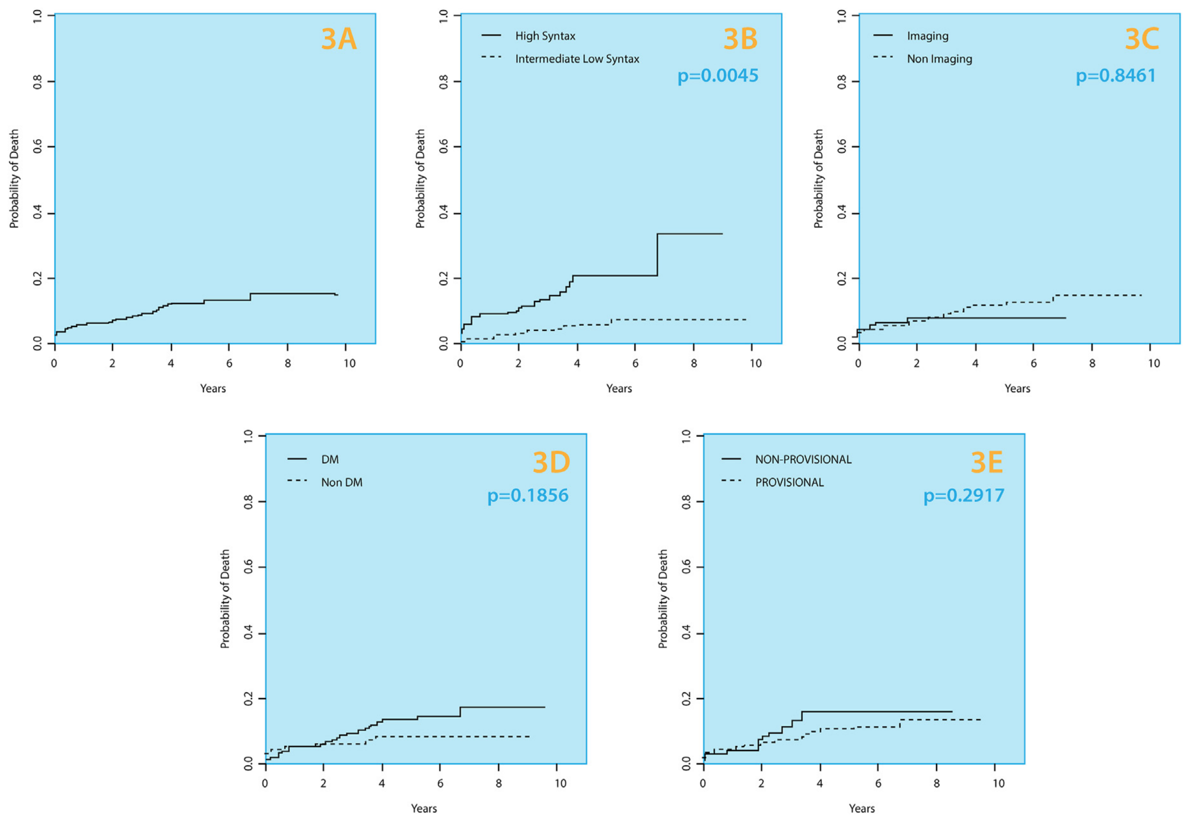


Fig. 3. Cumulative incidence curves in the total population and sub-groups. 3 A: Overall population; 3 B: High SYNTAX (score ≥33) and low–intermediate (Score <33) SYNTAX subgroups; 3C: Intracoronary imaging and non-imaging subgroups; 3D: Patients with diabetes and patients without diabetes subgroups; 3 E: Provisional and two-stent strategy subgroups.

mean total stent length and diameter were 47.0 ± 27.0 mm and 3.7 ± 0.4 mm, respectively. Stent types used included sirolimus eluting stents (401, 33.6%), everolimus eluting stents (543, 45.6%), and zotarolimus eluting stents (246, 20.7%). All patients received DAPT; clopidogrel 347 (52.5%) patients, ticagrelor 273 (41.3%) and Prasugrel 41 (6.2%) of patients.

4. Outcomes

In-hospital MACCE were noted in 12 (1.8%) patients: cardiac deaths in ten (1.5%) cases, stent thrombosis in two (0.3%) cases, periprocedural MI in four (0.6%) cases, and stroke in one (0.15%) case (Table 3). Among these, both stent thrombosis and MI were noted in one patient, while another had MI followed by death; one patient had three events: ST and MI followed by death. A single case of coronary perforation (distal wire perforation) was observed during the procedure. There were no major vascular complications requiring vascular surgery or intervention. However, minor vascular complications, such as hematoma, pseudoaneurysm subsided with manual compression alone, and access site bleeding requiring transfusions were seen in a total of 35 (5.3%) patients. CI-AKI was observed in 25 (3.7%) patients. However, dialysis was not required in any of these patients.

The median follow-up was 2.8 years (interquartile range: 1.5–4.1) with 13.5% patients lost to follow-up. During follow-up (N = 572), MACCE occurred in 66 (11.5%) patients, including 48 (8.4%) cardiac deaths. One (0.17%) patient had developed late stent thrombosis, five (0.9%) patients had MI, and stroke was noted in 12 (2%) patients. A total of 24 (4.2%) and six (1%) patients had undergone PCI and CABG, respectively, during the follow-up (Table 3). As per the latest follow-up, 493 (84.6%) patients were alive; incidence of MACCE was 13.6% and non-cardiac death occurred in 21 (3.7%) patients.Thirteen (12.8%) deaths were noted among patients with STEMI.

The survival probability in the total study population is presented in Fig. 1. The Kaplan–Meier estimates of overall survival after one year, and three, five, and nine years were 94%, 88%, 84%, and 82%, respectively. Fig. 2 (A–D) shows Kaplan–Meier estimates in different subgroups. In patients with high SYNTAX scores (SYNTAX score ≥33), LMCA PCI was associated with significantly lower survival compared to patients with low–to–intermediate scores (SYNTAX score <33) ($p < 0.0001$; Fig. 2A). There was no significant difference in the overall survival pattern between imaging (OCT and/or IVUS) and non-imaging patients, patients with and without diabetes, and provisional and two-stent strategy groups (Fig. 2B–D).

The cumulative incidence of cardiac death after one year, and three, five, and eight years were 5%, 7%, 11%, and 12%, respectively (Fig. 3A). Fig. 3 (B–E) shows the cumulative incidence curves of cardiac death in different subgroups. The probability of cardiac death was significantly higher with a high SYNTAX score (≥33) compared to low–to–intermediate SYNTAX score (<33) ($p < 0.0045$). The probability of cardiac death was numerically higher in patients with diabetes vs. patients without diabetes; however, there was no statistical difference between the groups. Similarly, there was no statistical difference in cardiac deaths between imaging and non-imaging, and provisional and two-stent strategy groups.

4.1. Predictors of mid to long-term mortality

The univariate Cox regression model was run for all the covariates shown in the Table 4. Age more than 65 years (hazard ratio [HR] 2.54, 95% confidence interval [CI]: 1.58, 4.08; p = 0.0001), high SYNTAX score (HR 2.19, 95% CI: 1.40, 3.43; p = 0.0006) and distal left main lesions (HR 1.66, 95% CI: 1.01, 2.74; p = 0.0456) were significantly related to high mid to long-term mortality post ULMCA PCI. Other factors with considerable influence included previous cerebrovascular accident (HR 1.6, 95% CI: 0.65, 4.02; p = 0.2947), and history of hypertension (HR 1.48, 95% CI: 0.88, 2.48; p = 0.1328) or diabetes (HR 1.30, 95% CI: 0.81, 2.09; p = 0.2758). In the multivariate analysis, age more than 65 years (HR 2.3, 95% CI: 1.42, 3.71; p = 0.0006) and high SYNTAX score (HR 1.90, 95% CI: 1.19, 3.05; p = 0.0071) were independent predictors of mid to long-term mortality (Table 5). Other independent predictors included diabetes (HR 1.27, 95% CI: 0.79, 2.06; p = 0.3128) and distal main lesion (HR 1.6, 95% CI: 0.74, 2.14; p = 0.3841).

5. Discussion

Advancements in the stent design and bifurcation techniques over the years have enabled us to perform optimal PCI for ULMCA stenosis. Our single-center experience has demonstrated that ULMCA stenting with DES is safe with acceptable in-hospital and mid-term outcomes in patients with significant ULMCA stenosis. Furthermore, we also found age >65 years and high SYNTAX scores (Score ≥33) as significant predictors of mid to long-term mortality, based on multivariate Cox regression analysis. The study population included all consecutive patients who underwent ULMCA stenting to avoid selection bias.

The outcomes of patients who undergo PCI for distal left main lesions are reportedly poor in comparison to those undergo PCI for ostial or mid-shaft lesions. It is noteworthy to mention that the outcomes in patients with LMCA bifurcation lesions treated with stenting of both the main and side branches are not satisfactory.[10] However, the mid and long-term outcomes for ostial/shaft unprotected LMCA PCI are usually favorable. In our study, more than half of the patients had distal LMCA lesions and true bifurcation lesions (Medina 1,1,1, 0,1,1, or 1,0,1) were present in about 50% of our cohort. Our study also confirmed that PCI in patients with distal LMCA lesions were associated with higher mid to long-term mortality. In addition, about 15.6% of the patients had trifurcation lesions. PCI to LMCA trifurcation is technically challenging compared to bifurcated lesions.[11] The 12th consensus document from European Bifurcation Club recommends provisional stenting strategy for most of the left main bifurcation lesions.[12] Accordingly, in the current study, more than 75% of patients underwent provisional stenting.

Rotational atherectomy and cutting balloon were used in 6% patients (each) in the current study. Balloon dilatation or debulking is often essential for successful implantation of stents in calcified lesions. Rotational atherectomy before placement of the DES is reported to be useful as a primary strategy in the management of severely calcified coronary lesions. Cutting balloons are also useful and can be used with smaller size catheters. Both strategies were associated with excellent clinical outcomes.[13]

Left main disease was historically treated with CABG. However, the subset analysis of SYNTAX,[14] PRECOMBAT,[15] and COMPARE[16] trials has demonstrated that PCI can be an appropriate alternative for patients with low-intermediate anatomic complexity. Furthermore, increased operator experience, along with better understanding of physiological assessment and imaging techniques, have improved the outcomes in patients with left main disease. Notably,

Table 4
Relationship of selected indices with mortality— univariate Cox regression analysis.

Parameter	Hazard Ratio	95% CI for the Hazard Ratio	P value
Imaging vs. Non-Imaging	1.128	(0.62, 2.04)	0.6921
Diabetes Mellitus Yes vs. No	1.302	(0.81, 2.09)	0.2758
Provisional vs. Non-Provisional	0.834	(0.48, 1.43)	0.5110
Sex	0.765	(0.45, 1.29)	0.3170
Previous CVA	1.624	(0.65, 4.02)	0.2947
Smoking-Yes	1.151	(0.69, 1.91)	0.5884
Previous PCI	1.035	(0.57, 1.87)	0.9094
Previous LMCA intervention	1.160	(0.16, 8.34)	0.8831
Syntax (High vs. low)	2.195	(1.40, 3.43)	0.0006
Hypertension	1.486	(0.88, 2.48)	0.1328
Age (≥65 vs.<65)	2.547	(1.58, 4.08)	0.0001
Indication (ACS vs. Non-ACS)	1.203	(0.75, 1.92)	0.4408
LM Lesion (Distal vs. Non distal)	1.667	(1.01, 2.74)	0.0456

ACS: Acute coronary syndrome; CABG: Coronary artery bypass grafting; CI: Confidence interval; CVA: Cerebrovascular accident; LM: Left Main; LMCA = left-main coronary artery; NSTEMI: Non-ST-elevation myocardial infarction; PCI: Percutaneous coronary intervention.

Table 5
Relationship of selected indices with mortality— multivariate Cox regression analysis.

Parameter	Hazard Ratio	95% CI for the Hazard Ratio	P value
Imaging vs. Non-Imaging	1.207	(0.65, 2.22)	0.5487
Diabetes Mellitus Yes vs. No	1.279	(0.79, 2.06)	0.3128
Provisional vs. Non-Provisional	1.048	(0.59, 1.83)	0.8705
Indication (ACS vs. Non-ACS)	1.098	(0.68, 1.76)	0.6981
LM Lesion (Distal vs. Non distal)	1.264	(0.74, 2.14)	0.3841
Syntax (High vs. low)	1.908	(1.19, 3.05)	0.0071
Age (≥65 vs.<65)	2.301	(1.42, 3.71)	0.0006

ACS: Acute coronary syndrome; CI: Confidence interval; LM: Left Main.

Table 6
Comparison of the clinical outcomes in different trials.

	Current study	PRECOMBAT[21]	SYNTAX[14]	EXCEL[17]			NOBLE[18]			MAIN COMPARE[22]
				30 D MACE	3-yr MACE	5-yr MACE	30 D MACE	3-yr MACE	5-yr MACE	
MACE	13.6%	18.2% vs. 17.5%	9.0% vs 20.8%	4.9% vs. 7.9%	15.4% vs. 14.7%	22% vs. 19.2%	2.5% vs. 3.7%	NR	28.9% vs. 19.1%	20.6% vs. 18.18%
Repeat revascularization	4.2%	13.0% vs 7.3%	26.7% vs 15.5%	12.6% vs 7.5%			16.0% vs 10.0%			Higher risk with stents (HR: 5.11; 95% CI: 3.52 to 7.42, $p < 0.001$)
All-cause mortality	12.6%	14.5% vs. 13.8%	12.8% vs 14.6%	8.2% vs 5.9%			11.6% vs. 9.5%			Risk of death similar (HR: 1.13; 95% CI: 0.88 to 1.44, $p = 0.35$)

Data are presented as percentage treated with PCI/percentage treated with CABG. CABG indicates coronary artery bypass grafting; MI, myocardial infarction; MAIN-COMPARE, Revascularization for Unprotected Left Main Coronary Artery Stenosis: Comparison of Percutaneous Coronary Angioplasty Versus Surgical Revascularization; NOBLE, Coronary Artery Bypass Grafting Vs Drug Eluting Stent Percutaneous Coronary Angioplasty in the Treatment of Unprotected Left Main Stenosis; PCI, percutaneous coronary intervention; PRECOMBAT, Premier of Randomized Comparison of Bypass Surgery versus Angioplasty Using Sirolimus-Eluting Stent in Patients with Left Main Coronary Artery Disease; and SYNTAX, Synergy Between Percutaneous Coronary Intervention With TAXUS and Cardiac Surgery.

the use of imaging in our center has increased considerably in the recent years (2017–2 cases; 2018–58 cases; 2019–84 cases).

Second-generation DES were used in both EXCEL[17] and NOBLE[18] trials in more than 80% of patients with LMCA stenosis and low or intermediate SYNTAX scores. In the EXCEL trial, there were fewer 30-day major adverse events with PCI compared to CABG (4.9% vs. 7.9%; $p = 0.008$). At three years, the primary outcomes of MACCE were similar between the two groups (15.4% vs. 14.7%; $p = 0.018$ for noninferiority); while ischemia-driven revascularization was 12.6% and 7.5% in PCI and CABG groups, respectively ($p < 0.0001$). At five years, the primary outcomes were not significantly different between PCI and CABG groups (22% vs. 19.2%).[19] In the NOBEL[18] trial, the 30-day MACCE were not significantly different between PCI and CABG groups (2.5% vs. 3.7%); however, at five years, PCI was inferior to CABG, with a higher rate of MACCE (28.9% vs. 19.1%; $p = 0.0066$). Although death rates were similar (11.6% with PCI vs. 9.5% with CABG), nonprocedural MI was more frequent with PCI (6.9% vs. 1.9%; $p = 0.004$). In an observational study conducted in India, the incidence of four-year MACCE was 16.5% including 10.7% target lesion revascularization.[20] The incidence of 30-day MACCE events (2.7%) including cardiac mortality (2.6%) in the current study is comparable to the previous studies. The five-year MACCE (13.6%) were fewer, while all-cause mortality (12.6%) was similar to that reported in previous trials.[18,19] Table 6 provides a comparison between the clinical outcomes noted in these trials and the current study.

According to the ten-year PRECOMBAT trial results, the incidences of MACE and all-cause mortality were not statistically different between PCI and CABG arms (18.2% vs. 17.5% and 14.5% vs. 13.8%, respectively).[21] Similarly, the ten-year MACE events in the subset of patients with low or intermediate SYNTAX scores in the MAIN-COMPARE trial were not significantly different between the PCI and CABG groups (20.6% vs. 18.18%, respectively).[22] Overall MACCE and cardiovascular mortality in the current study at the latest follow-up were 13.6% and 10%, respectively.

In the current study, 4.2% of patients had undergone repeat revascularization with PCI or CABG during the follow-up. However, ischemia-driven target-vessel revascularization rates were more frequent after PCI in the NOBEL,[18] EXCEL[19] (both ~12%), extended–PRECOMBAT (16%),[21] and MAIN-COMPARE (5.7%) trials compared to our study.[22]

A real-world study in India by Ray et al[23] reported no in-hospital deaths or MI events among 86 patients who underwent ULMCA PCI with DES. At 6.5 years follow-up, MACE events were reported in 8.2% of patients including death in 3.5% patients. In the current study, there were four cases of periprocedural MI events including two cases of early stent thrombosis and all-cause mortality of 12.7%. Among the 58 cardiac deaths in our study, patients were aged more than 65 years in 44 cases (76%), SYNTAX score was ≥33 in 32 cases (55%) and 13 (12.8%) deaths occurred among patients with STEMI ($N = 101$). The major differences between the real-world study and the current study are that: 1) the sample size of our study was much larger (661 vs. 86 patients); 2) STEMI patients were included in our study, whereas they were excluded in the other study; 3) the mean age of our study was higher than the other study; 4) the proportion of patients with a SYNTAX score ≥33 was also higher (31%) in our study compared to the other study (12%); and 5) In our study, renal dysfunction, pulmonary edema and previous LMCA interventions were present in 10%, 6.7% and 1.2% patients respectively.

The above-mentioned real-world study reported significantly higher MACE in patients with a high SYNTAX score compared to low and intermediate (≤32) SYNTAX scores ($p = 0.005$) and higher MACE events among patients with diabetes compared to those without diabetes.[23] While the overall survival rates were significantly lower in patients with a high SYNTAX compared to those with low-to–intermediate SYNTAX scores ($p < 0.0001$) in our study, there was no statistically significant difference in survival rates and MACCE between patients with or without diabetes. The five-year EXCEL study also reported no statistical difference in MACE events between patients with or without diabetes.[19]

5.1. Limitations

This study had a few limitations. This was a nonrandomized, observational study that was intended for descriptive analysis only. The sample size of patients who underwent imaging was small. The RISK scores were not recorded in the study population.

6. Conclusion

In patients with significant ULMCA lesions and low-to–intermediate SYNTAX scores, PCI with DES (when performed by expert hands) was found to be safe with low MACCE at mid-term follow-up. The SYNTAX scores significantly affected the overall survival rates while imaging, diabetes, and stenting strategy did not have any significant impact. Further long-term studies are warranted to ascertain these findings in Indian settings.

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Declaration of competing interest

The authors report no relationships that could be construed as a conflict of interest.

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