

Original Article

Predictors of Left Main and Three-Vessel Coronary Artery Disease in Patients Undergoing Diagnostic Coronary Angiography: A Cross-Sectional Study from a Single Centre in Libya

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Left Main Disease; Three-Vessel Disease; Coronary Angiography; ST-Elevation Myocardial Infarction; Diabetes Mellitus; Insulin; Revascularisation.

Abstract

Left main and/or three-vessel coronary disease (LM/3VD) defines high-risk anatomy that shapes revascularisation decisions, yet its predictors in North African populations remain poorly characterised. This study examined the prevalence, pattern, clinical predictors and revascularisation strategies of LM/3VD in patients undergoing diagnostic coronary angiography at a Libyan centre. In this cross-sectional analytical study, 101 consecutive patients undergoing diagnostic coronary angiography at Albyda Medical Centre over one year were enrolled. Demographics, cardiovascular risk factors, clinical presentation, angiographic findings and management were recorded. The primary outcome was LM/3VD. Associations were tested using chi-square, Fisher's exact, Monte Carlo exact, Mann-Whitney U, Kruskal-Wallis and Spearman tests, and binary logistic regression (parsimonious primary model; sensitivity models). Mean age was 56.4 years (73.3% male); 53.5% had diabetes. LM/3VD affected 22/101 patients (21.8%; exact 95% CI 14.2-31.1). STEMI presentation was the strongest independent predictor (adjusted OR 4.16, 95% CI 1.42-12.21, $p = 0.009$); diabetes showed a borderline independent association (OR 2.57, 95% CI 0.86-7.69, $p = 0.091$). LM/3VD rose stepwise from 0% in unstable angina to 35.6% in STEMI (chi-square = 11.52, $p = 0.009$). All 22 patients with three-vessel disease were referred for coronary artery bypass grafting (100%). Among 54 diabetic patients, insulin therapy was strongly associated with LM/3VD (45.5% vs 4.8%; OR 16.67, 95% CI 2.00-139.14, $p = 0.001$). STEMI presentation and insulin-treated diabetes identified patients at highest risk of left main and three-vessel disease. These findings support targeted angiographic risk stratification of acute coronary syndrome patients and suggest insulin-treated diabetes marks a high-risk vascular phenotype.

Introduction

Coronary artery disease remains the leading cause of mortality worldwide, and its anatomic burden at the time of diagnostic angiography strongly determines both prognosis and treatment selection. The Global Burden of Disease collaboration attributes roughly one in four deaths globally to cardiovascular disease, with ischaemic heart disease the single largest component and much of this burden now falling on low- and middle-income regions[1]. Contemporary guidelines for chronic coronary disease and acute coronary syndromes place particular emphasis on the identification of high-risk anatomy, because left main disease and three-vessel disease change the calculus of revascularisation toward surgical or complex percutaneous strategies[2, 3].

The SYNTAX score, which quantifies anatomic complexity across the coronary tree, was developed precisely because vessel number, location, and left main involvement drive outcomes after revascularisation [4], a principle refined by the SYNTAX score II, which integrates anatomic and clinical variables to guide the choice between surgery and percutaneous treatment[5]. Understanding which clinical characteristics predict such anatomy before catheterization could therefore sharpen triage, guide heart-team discussions and inform consent[6]. Despite this importance, the clinical predictors of left main and three-vessel disease have been studied far less systematically than the predictors of obstructive disease in general. Most risk-prediction work addresses whether a patient has any coronary disease, not whether that disease is extensive or left main in location, echoing the classic probability framework of Diamond and Forrester, which estimated disease presence rather than extent [7]. This distinction matters clinically: a patient with single-vessel disease may be managed percutaneously or conservatively, whereas left main and three-vessel disease typically require surgical consultation, multivessel intervention, or both.

Untreated left main stenosis carried prohibitive historical mortality[8, 9], and landmark trials of complex and left main revascularisation confirm that anatomic extent, not merely disease presence, governs prognosis and treatment[10-13]. The epidemiologic rationale for studying diabetes is equally strong. Diabetes has long been regarded as a coronary risk-equivalent [14], and a collaborative meta-analysis of nearly 700,000 people confirmed a roughly two-fold vascular risk[15]. Diabetic patients develop more diffuse and extensive coronary disease, and current guidance recommends joint

cardiometabolic management with an early heart-team approach for multivessel disease[16]. Randomised evidence consistently favours surgery for diabetic patients with multivessel disease, an advantage persisting long-term[17-20]. Whether insulin-treated diabetes, a marker of longer-standing and more severe metabolic disease, predicts specifically high-risk anatomy has received far less attention.

Clinical presentation plausibly predicts anatomic extent: acute infarction frequently arises from rupture of one of multiple complex plaques scattered through the coronary tree [21]. Multivessel disease compromises outcomes of primary percutaneous intervention [22], and chronic total occlusion, a hallmark of advanced disease, is common in extensive anatomy[23]. Because primary angioplasty outperforms thrombolysis for acute infarction[24], a growing STEMI population reaches the catheterisation laboratory, where the extent of underlying disease is revealed. Regional data are scarcer still. In Libya and neighbouring North African countries, cardiovascular disease burden is high and rising, yet published angiographic cohort data remain limited. INTERHEART showed that conventional risk factors explain most myocardial infarction risk in Middle Eastern participants, as elsewhere[25], and a recent study of 615 Libyan angiography patients documented a heavy risk-factor profile, with smoking prominent among men and diabetes and hypertension among women, but did not examine predictors of high-risk anatomy[26]. In Western series, more than a third of elective angiograms reveal no obstructive disease[27], a reminder that referral case-mix shapes apparent disease patterns and may differ from the populations underlying guideline documents [28]. Whether the classic risk factors behave similarly in this population, and whether presentation type identifies patients likely to harbour left main or three-vessel disease, is unknown. We therefore conducted this cross-sectional analytical study at a single Libyan cardiac centre to determine, first, the prevalence and angiographic pattern of left main and three-vessel disease among patients undergoing diagnostic coronary angiography; second, the demographic and clinical predictors of this high-risk anatomy; and third, the revascularisation strategies adopted for it. We hypothesised that clinical presentation, diabetes mellitus and older age would be associated with left main and three-vessel disease, and that management would follow anatomic extent.

Methods

Study Design and Setting

This was an observational, cross-sectional analytical study conducted at Albyida Medical Centre (AMC), Albyida, Libya, over one year. All patients referred for diagnostic coronary angiography during the study period were considered for enrolment. The study was approved by the institutional review process and conducted in accordance with the Declaration of Helsinki; patient identity was protected through anonymised serial numbering, and no patient-identifiable information was retained in the analytical dataset.

Participants

Consecutive patients undergoing clinically indicated diagnostic coronary angiography were eligible. Exclusion criteria were prior coronary artery bypass grafting or percutaneous coronary intervention with restenosis rendering de novo anatomy assessment unreliable, known inborn coronary anomalies as the sole indication, and refusal or inability to provide angiographic follow-through. Of 101 enrolled patients, none were excluded after data cleaning: the final analytical dataset contained 101 complete records with no missing values, no protocol-violating entries and no biologically implausible values.

Data Collection

Demographic variables (age, sex), cardiovascular risk factors (diabetes mellitus, hypertension, dyslipidemia, current smoking, family history of coronary artery disease, prior antiplatelet and lipid-lowering therapy) and, among diabetic patients, the glucose-lowering regimen (oral agents, insulin, combined oral plus insulin, or neither) were recorded. Clinical presentation was classified as stable angina, unstable angina, ST-elevation myocardial infarction (STEMI) or non-ST-elevation myocardial infarction (NSTEMI), using standard definitions of myocardial infarction[29]; unstable angina and both infarction categories were additionally grouped as acute coronary syndrome. Angiographic variables comprised the presence of obstructive coronary artery disease (luminal stenosis greater than 50% in at least one epicardial vessel), the number of diseased vessels (zero to three), involvement of the left anterior descending, left circumflex and right coronary arteries, left main involvement, chronic total occlusion, and the distribution of stenosis severity. Management strategy was recorded as medical treatment alone, percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG) referral, or no obstructive disease requiring therapy, in accordance with contemporary guidance[30].

Outcome Definitions

The primary outcome was the composite of left main and/or three-vessel disease (LM/3VD), defined as left main involvement and/or three-vessel disease. In this cohort, every patient with left main involvement also had three-vessel disease, so the composite was identical to three-vessel disease. Secondary outcomes were the prevalence and pattern of angiographic disease, the association between clinical presentation and the revascularisation strategy adopted by disease extent.

Statistical Analysis

Analyses followed a pre-specified statistical analysis plan and were performed with SPSS-27 software. Two-sided alpha was set at 0.05. Categorical variables were summarised as frequencies and percentages; continuous variables as mean with standard deviation, median with interquartile range, and range. Because the Shapiro-Wilk test rejected normality of age in the total cohort ($W = 0.954$, $p = 0.002$) and in the non-LM/3VD group ($p = 0.007$), non-parametric tests were used for age throughout, with the independent-samples t test retained as a sensitivity check. Categorical comparisons used the Pearson chi-square test, with continuity (Yates) correction reported alongside for all 2-by-2 tables; Fisher's exact test was applied whenever any expected cell count fell below five; and Monte Carlo exact testing with 10,000 sampled tables confirmed inference for sparse larger tables [31]. Effect sizes were reported as odds ratios with 95% confidence intervals (Woolf method [32], with Haldane-Anscombe 0.5 correction where a cell contained zero and was clearly flagged as such [33]), the phi coefficient for 2-by-2 tables and Cramer's V for larger tables, and $r = z$ divided by the square root of N for the Mann-Whitney U test. All prevalence estimates carried exact (Clopper-Pearson) 95% confidence intervals [34]. Monotonic relationships were examined with Spearman rank correlations. Differences in age across the four disease-extent groups were tested with the Kruskal-Wallis test followed by Dunn post-hoc contrasts with Bonferroni adjustment [35] for the six pairwise comparisons.

Multivariable analysis used binary logistic regression with the enter method. Because only 22 outcome events occurred, the full seven-predictor protocol model (age, sex, diabetes, hypertension, dyslipidemia, smoking, STEMI) yielded an events-per-variable ratio of approximately three, below the recommended minimum [36-38]. A parsimonious three-predictor model (age, diabetes, STEMI) was therefore pre-specified as the primary inferential model, with the seven-predictor model and an obstructive-CAD-only model reported as sensitivity analyses. Model adequacy was assessed with the likelihood-ratio chi-square, Nagelkerke R -squared [39] and the Hosmer-Lemeshow goodness-of-fit test with ten groups [40]. Classification accuracy, sensitivity, and specificity were reported at a 0.5 cut-off. Variance inflation factors (all below two) excluded relevant collinearity, and the Box-Tidwell interaction confirmed linearity of age in the logit ($p = 0.173$). Family history of coronary artery disease (one exposed patient) and prior antiplatelet therapy (two exposed patients) were not entered into multivariable models because such sparse exposure renders estimates unstable. Stenosis severity and chronic total occlusion were treated as angiographic findings contemporaneous with the outcome rather than as candidate predictors. Within the diabetic subgroup, no multivariable adjustment was attempted given 16 events. The CABG-versus-LM/3VD cross-tabulation exhibited quasi-complete separation, so no odds ratio was estimated for it, and the association was described with exact tests.

Results

Baseline Characteristics

The analytical dataset comprised 101 patients aged 41 to 70 years (mean 56.4 ± 7.9 ; median 58, interquartile range 50 to 63). Three-quarters were male (74, 73.3%; exact 95% CI 63.5 to 81.6). Diabetes mellitus was the most prevalent modifiable risk factor (54 patients, 53.5%), followed by hypertension (59, 58.4%), current smoking (39, 38.6%) and dyslipidemia (18, 17.8%); a documented family history of premature coronary disease was present in a single patient (1.0%) and prior antiplatelet therapy in two (2.0%). Among the 54 diabetic patients, 45 used oral hypoglycemic agents and 33 used insulin. STEMI was the most common presentation (45 patients, 44.6%), followed by NSTEMI (25, 24.8%), unstable angina (15, 14.9%), and stable angina (16, 15.8%); 85 patients (84.2%) presented with an acute coronary syndrome (Table 1).

Table 1. Baseline characteristics of the study population (N = 101).

Characteristic	n	%	Exact 95% CI
Age (years), mean $\pm$ SD	56.4	7.9	median 58 (IQR 50-63); range 41-70
Male sex	74	73.3	63.5-81.6
Diabetes mellitus	54	53.5	43.3-63.5
Hypertension	59	58.4	48.2-68.1
Dyslipidemia	18	17.8	10.9-26.7
Current smoking	39	38.6	29.1-48.8
Family history of CAD	1	1.0	0.0-5.4
Prior antiplatelet therapy	2	2.0	0.2-7.0
Prior lipid-lowering therapy	1	1.0	0.0-5.4
Glucose-lowering: oral agents	45	44.6	34.7-54.8
Glucose-lowering: insulin	33	32.7	23.7-42.7
Presentation: stable angina	16	15.8	9.3-24.4
Presentation: unstable angina	15	14.9	8.6-23.3
Presentation: NSTEMI	25	24.8	16.7-34.3
Presentation: STEMI	45	44.6	34.7-54.8

Acute coronary syndrome	85	84.2	75.6-90.7
Obstructive CAD	77	76.2	66.7-84.1
LM/3VD (primary outcome)	22	21.8	14.2-31.1

Percentages are of N = 101. CI = Clopper-Pearson exact 95% confidence interval; SD = standard deviation; IQR = interquartile range; CAD = coronary artery disease; NSTEMI = non-ST-elevation myocardial infarction; STEMI = ST-elevation myocardial infarction; LM/3VD = left main and/or three-vessel disease. Age is reported as mean with standard deviation, median with interquartile range, and range.

Prevalence and Angiographic Pattern

Obstructive coronary artery disease was present in 77 patients (76.2%; exact 95% CI 66.7 to 84.1), while 24 (23.8%) had angiographically normal coronary arteries. The composite primary outcome, left main and/or three-vessel disease, affected 22 of 101 patients (21.8%; exact 95% CI 14.2 to 31.1). Isolated left main disease did not occur: all six patients with left main involvement (5.9% of the cohort; exact 95% CI 2.2 to 12.5) also had three-vessel disease, rendering the composite identical to three-vessel disease in this cohort. Among the 77 patients with obstructive disease, the left anterior descending artery was involved in 59 (76.6%), the right coronary artery in 44 (57.1%), the left circumflex in 32 (41.6%) and the left main artery in six (7.8%); chronic total occlusion was documented in 21 (27.3%), a stenosis exceeding 70% in 46 (59.7%) and a non-significant stenosis below 70% in 10 (13.0%). One-, two-, and three-vessel disease accounted for 35 (34.7%), 20 (19.8%) and 22 (21.8%) of the total cohort, respectively (Table 2).

Table 2. Prevalence and angiographic pattern of coronary disease in the total cohort (N = 101) and among patients with obstructive disease (n = 77).

Angiographic finding	Total cohort n (%)	Exact 95% CI	Among obstructive CAD n (%)
Obstructive CAD	77 (76.2)	66.7-84.1	-
Normal coronary arteries	24 (23.8)	15.9-33.3	-
LAD involvement	59 (58.4)	48.2-68.1	59 (76.6)
RCA involvement	44 (43.6)	33.7-53.8	44 (57.1)
LCX involvement	32 (31.7)	22.8-41.7	32 (41.6)
Left main involvement	6 (5.9)	2.2-12.5	6 (7.8)
Chronic total occlusion	21 (20.8)	13.4-30.0	21 (27.3)
Stenosis > 70%	46 (45.5)	35.6-55.8	46 (59.7)
Non-obstructive stenosis (< 70%)	10 (9.9)	4.9-17.5	10 (13.0)
One-vessel disease	35 (34.7)	25.5-44.8	35 (45.5)
Two-vessel disease	20 (19.8)	12.5-28.9	20 (26.0)
Three-vessel disease	22 (21.8)	14.2-31.1	22 (28.6)
LM/3VD (primary outcome)	22 (21.8)	14.2-31.1	22 (28.6)

CI = Clopper-Pearson exact 95% confidence interval; CAD = coronary artery disease; LAD = left anterior descending; RCA = right coronary artery; LCX = left circumflex; LM/3VD = left main and/or three-vessel disease. All six patients with left main involvement also had three-vessel disease, so the composite outcome equals three-vessel disease in this cohort. > 70% and non-obstructive stenosis refer to the maximally stenosed lesion per patient.

Univariable Associations

Patients with LM/3VD were older than those without (median 60, interquartile range 55 to 64, versus 57, interquartile range 50 to 62; Mann-Whitney U = 1112, z = 2.00, p = 0.045, r = 0.20), a difference confirmed by the t-test sensitivity analysis (t = 2.08, df = 99, p = 0.040). STEMI presentation carried a 4.6-fold crude odds of LM/3VD (35.6% versus 10.7%; OR 4.60, 95% CI 1.62 to 13.06; chi-square = 9.04, p = 0.003; phi = 0.30), and diabetes a nearly three-fold crude odds (29.6% versus 12.8%; OR 2.88, 95% CI 1.02 to 8.11; chi-square = 4.19, p = 0.041; phi = 0.20). Dyslipidemia showed a non-significant association of similar magnitude (38.9% versus 18.1%; OR 2.88, 95% CI 0.96 to 8.67; Fisher's exact p = 0.064). Male sex, hypertension and current smoking were not associated with LM/3VD (all p > 0.30). Every LM/3VD event occurred in an acute coronary syndrome patient (25.9% of the 85 acute presentations versus 0% of the 16 stable presentations; Fisher's exact p = 0.020), and across the four-level presentation the outcome rose monotonically from 0% in stable angina through 6.7% in unstable angina and 20.0% in NSTEMI to 35.6% in STEMI (chi-square = 11.52, df = 3, p = 0.009; Cramer's V = 0.338; Monte Carlo p = 0.009) (Table 3, Figure 1). Age per decade was associated with the outcome in unadjusted logistic analysis (OR 1.98, 95% CI 1.02 to 3.84, p = 0.044) (Figure 1).

Table 3. Univariable associations of baseline characteristics with left main and/or three-vessel disease (N = 101).

Characteristic	LM/3VD n (%)	No LM/3VD n (%)	OR (95% CI)	Chi-square	p-value	phi
Age $\geq$ 60 years	14 (63.6)	33 (41.8)	1.071 per year (1.002-1.144)	-	0.044	-
Male sex	18/74 (24.3)	4/27 (14.8)	1.85 (0.56-6.06)	1.05	0.306	0.10
Diabetes mellitus	16/54 (29.6)	6/47 (12.8)	2.88 (1.02-8.11)	4.19	0.041	0.20
Hypertension	11/59 (18.6)	11/42 (26.2)	0.65 (0.25-1.67)	0.82	0.365	0.09
Dyslipidemia	7/18 (38.9)	15/83 (18.1)	2.88 (0.96-8.67)	-	0.064 (F)	0.19
Current smoking	8/39 (20.5)	14/62 (22.6)	0.88 (0.33-2.36)	0.06	0.806	0.02
STEMI presentation	16/45 (35.6)	6/56 (10.7)	4.60 (1.62-13.06)	9.04	0.003	0.30
Stable vs acute presentation	0/16 (0.0)	22/85 (25.9)	11.69 (0.67-203.02)	-	0.020 (F)	-

Percentages are row percentages (outcome frequency within each exposure level). OR = univariable odds ratio (Woolf method; Haldane-Anscombe 0.5 correction where a cell contained zero, indicated by OR 11.69). F = Fisher's exact test (expected cell count below five). Age is modelled continuously per year in univariable logistic regression (OR 1.071 per year, 95% CI 1.002-1.144, $p = 0.044$; OR 1.98 per decade, 95% CI 1.02-3.84); the Age $\geq$ 60 row shows outcome frequencies for context. Age differed between groups (median 60 [IQR 55-64] vs 57 [50-62]; Mann-Whitney $U = 1112$, $z = 2.00$, $p = 0.045$, $r = 0.20$; t-test sensitivity: $t = 2.08$, $df = 99$, $p = 0.040$). Across the four-level presentation, the outcome rose from 0% (stable angina) through 6.7% (unstable angina) and 20.0% (NSTEMI) to 35.6% (STEMI) (chi-square = 11.52, $df = 3$, $p = 0.009$; Cramer's $V = 0.338$; Monte Carlo $p = 0.009$). Family history (one exposed patient; Fisher $p = 0.218$) and prior antiplatelet therapy (two exposed; Fisher $p = 1.000$) were too sparse for stable estimation.

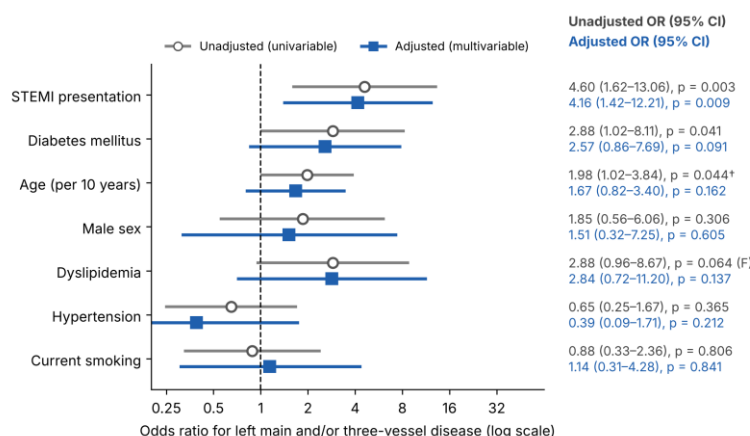


Figure 1. Forest plot of univariable associations with left main and/or three-vessel disease. Odds ratios with exact 95% confidence intervals (Woolf method; Haldane-Anscombe correction where a cell contained zero). Age is shown per decade of life. Unadjusted p-values are identical to those reported in Table 3 (Pearson chi-square test, or Fisher's exact test [F] where any expected cell count was below five; age [t] from univariable logistic regression); adjusted estimates are from Model A (STEMI, diabetes, age) and Model B (remaining predictors) in Table 4.

Multivariable Model

In the pre-specified parsimonious model (age, diabetes, STEMI), STEMI presentation remained the strongest independent predictor of LM/3VD (adjusted OR 4.16, 95% CI 1.42 to 12.21, Wald $p = 0.009$), while diabetes showed an independent association just beyond conventional significance (adjusted OR 2.57, 95% CI 0.86 to 7.69, $p = 0.091$) and age was attenuated (OR 1.05 per year, 95% CI 0.98 to 1.13, $p = 0.161$). The model fit was adequate (likelihood-ratio chi-square = 14.99, $df = 3$, $p = 0.002$; Nagelkerke R-squared = 0.212; Hosmer-Lemeshow $p = 0.909$) with 80.2% classification accuracy, driven by high specificity (96.2%) at the cost of sensitivity (22.7%). In the full seven-predictor protocol model, constrained by an events-per-variable ratio near three, diabetes was the only independently significant predictor (OR 3.59, 95% CI 1.01 to 12.69, $p = 0.047$) and STEMI was attenuated (OR 2.68, $p = 0.102$). When the model was restricted to the 77 patients with obstructive disease, no predictor remained significant (all $p > 0.11$), indicating that much of the univariable signal reflects the contrast between any obstructive disease and normal arteries rather than high-risk anatomy among already-diseased patients (Table 4).

Table 4. Binary logistic regression models for left main and/or three-vessel disease.

Term/statistic	B	S.E.	Wald chi-square	OR (95% CI)	p-value
MODEL A (primary): age, diabetes, STEMI presentation - N = 101, 22 events					
Age (years)	+0.051	0.036	1.96	1.05 (0.98-1.13)	0.161
Diabetes mellitus	+0.944	0.559	2.85	2.57 (0.86-7.69)	0.091
STEMI presentation	+1.426	0.549	6.75	4.16 (1.42-12.21)	0.009
Constant	-5.582	2.167	6.64	-	0.010
MODEL B (sensitivity): all 7 protocol predictors - N = 101, 22 events (EPV approx. 3)					
Age (years)	+0.060	0.040	2.31	1.06 (0.98-1.15)	0.128
Male sex	+0.414	0.800	0.27	1.51 (0.32-7.25)	0.605
Diabetes mellitus	+1.278	0.644	3.93	3.59 (1.01-12.69)	0.047
Hypertension	-0.939	0.753	1.56	0.39 (0.09-1.71)	0.212
Dyslipidemia	+1.043	0.701	2.21	2.84 (0.72-11.20)	0.137
Current smoking	+0.135	0.673	0.04	1.14 (0.31-4.28)	0.841
STEMI presentation	+0.987	0.604	2.67	2.68 (0.82-8.76)	0.102
Constant	-6.159	2.532	5.92	-	0.015
MODEL C (sensitivity): obstructive-CAD patients only - N = 77, 22 events					
Age (years)	+0.046	0.039	1.36	1.05 (0.97-1.13)	0.244
Male sex	+0.483	0.724	0.45	1.62 (0.39-6.70)	0.505
Diabetes mellitus	+0.910	0.574	2.51	2.48 (0.81-7.66)	0.113
STEMI presentation	+0.827	0.580	2.03	2.29 (0.73-7.12)	0.154
Constant	-5.058	2.584	3.83	-	0.050
MODEL FIT STATISTICS					
Model A: LR chi-square (df = 3)	14.99		p = 0.002	Nagelkerke R-squared = 0.212	HL p = 0.909
Model B: LR chi-square (df = 7)	19.34		p = 0.007	Nagelkerke R-squared = 0.268	HL p = 0.345
Model C: LR chi-square (df = 4)	7.04		p = 0.134	Nagelkerke R-squared = 0.125	HL p = 0.739
Model A classification	accuracy 80.2%		sensitivity 22.7%	specificity 96.2%	TP 5, FP 3, FN 17, TN 76
Model B classification	accuracy 79.2%		sensitivity 31.8%	specificity 92.4%	TP 7, FP 6, FN 15, TN 73

Omnibus model tests use the likelihood-ratio chi-square; Hosmer-Lemeshow (HL) goodness-of-fit uses 10 groups. OR = exp(B). B = regression coefficient; S.E. = standard error; Wald = Wald chi-square; LR = likelihood ratio; TP/FP/FN/TN = true/false positives/negatives at a 0.5 cut-off. Model A (parsimonious) is pre-specified as primary because 22 events cannot support seven predictors (events-per-variable approx. 3); its variance inflation factors are 1.03-1.06. In Model A, STEMI presentation is the strongest independent predictor and diabetes shows an independent association just beyond conventional significance. In the CAD-only model (C), no predictor remains significant, indicating that much of the univariable signal reflects the contrast between obstructive CAD and normal arteries rather than high-risk anatomy among already-diseased patients.

Presentation, Extent and Management

Angiographic extent rose stepwise with clinical acuity (chi-square = 75.15, df = 9, $p < 0.001$; Cramer's V = 0.498; Monte Carlo $p < 0.001$): all 16 stable-angina patients had normal coronary arteries, one-vessel disease predominated in unstable angina (53.3%) and NSTEMI (44.0%), and three-vessel disease was concentrated in STEMI, which accounted for 16 of the 22 three-vessel patients (72.7%). Age increased monotonically across extent groups (Kruskal-Wallis $H = 11.73$, $p = 0.008$), with Bonferroni-adjusted Dunn contrasts significant for normal versus two-vessel ($p = 0.038$) and normal versus three-vessel disease ($p = 0.012$); Spearman correlation confirmed a moderate monotonic age-extent association ($\rho = 0.334$, $p < 0.001$). Management was strongly determined by anatomy (extent by management: chi-square = 82.14, df = 4, $p < 0.001$; Cramer's V = 0.730): PCI predominated in one-vessel disease (26/35, 74.3%), two-vessel disease was managed almost exclusively by PCI (19/20, 95.0%), and every three-vessel-disease patient was referred for CABG (22/22, 100.0%); ten patients with obstructive disease (13.0%) received medical treatment alone. The association between CABG referral and LM/3VD showed quasi-complete separation (all 22 CABG patients had LM/3VD; Fisher's exact $p < 0.001$; $\phi = 1.000$), so no odds ratio is estimable, and this pattern is reported descriptively as guideline-concordant routing of high-risk anatomy to surgery (Table 5, Figures 2 and 3). Presentation was likewise strongly associated with management strategy (chi-square = 82.75, df = 9, $p < 0.001$; Cramer's V = 0.523).

Table 5. Clinical presentation in relation to angiographic extent of disease and revascularisation strategy.
5a. Presentation x extent of disease (N = 101)

Presentation	Normal	One-vessel	Two-vessel	Three-vessel	Total
Stable angina	16 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	16
Unstable angina	5 (33.3)	8 (53.3)	1 (6.7)	1 (6.7)	15
NSTEMI	3 (12.0)	11 (44.0)	6 (24.0)	5 (20.0)	25
STEMI	0 (0.0)	16 (35.6)	13 (28.9)	16 (35.6)	45
Total	24	35	20	22	101

5b. Presentation x management strategy (N = 101)

Presentation	No obstructive CAD	Medical treatment	PCI	CABG	Total
Stable angina	16 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	16
Unstable angina	5 (33.3)	4 (26.7)	5 (33.3)	1 (6.7)	15
NSTEMI	3 (12.0)	5 (20.0)	12 (48.0)	5 (20.0)	25
STEMI	0 (0.0)	1 (2.2)	28 (62.2)	16 (35.6)	45
Total	24	10	45	22	101

5c. Extent of disease x management strategy (obstructive CAD only, n = 77)

Extent	Medical treatment	PCI	CABG	Total
One-vessel (n = 35)	9 (25.7)	26 (74.3)	0 (0.0)	35
Two-vessel (n = 20)	1 (5.0)	19 (95.0)	0 (0.0)	20
Three-vessel (n = 22)	0 (0.0)	0 (0.0)	22 (100.0)	22
Total (n = 77)	10	45	22	77

5d. CABG referral vs LM/3VD (quasi-complete separation)

Group	LM/3VD absent	LM/3VD present	Total
CABG referral	0 (0.0)	22 (100.0)	22
Non-CABG	55 (100.0)	0 (0.0)	55

Values are n (row %). PCI = percutaneous coronary intervention; CABG = coronary artery bypass grafting; LM/3VD = left main and/or three-vessel disease. 5a: chi-square = 75.15, df = 9, $p < 0.001$ (Monte Carlo exact $p < 0.001$); Cramer's V = 0.498. All 16 stable-angina patients had normal coronary arteries; three-vessel disease was concentrated in STEMI (16/22, 72.7%). 5b: chi-square = 82.75, df = 9, $p < 0.001$ (Monte Carlo exact $p < 0.001$); Cramer's V = 0.523. 5c: chi-square = 82.14, df = 4, $p < 0.001$ (Monte Carlo exact $p < 0.001$); Cramer's V = 0.730 - a near-deterministic pattern with every three-vessel-disease patient (22/22, 100%) referred for CABG. 5d: Fisher's exact $p < 0.001$; chi-square = 77.00; phi = 1.000. Because every CABG-referred patient had LM/3VD and no non-CABG patient did, the odds ratio is not estimable (quasi-complete separation); this reflects guideline-concordant routing of high-risk anatomy to surgery rather than a testable predictor association. Age increased monotonically across extent groups (Kruskal-Wallis $H = 11.73$, $p = 0.008$; Spearman rho = 0.334, $p < 0.001$).

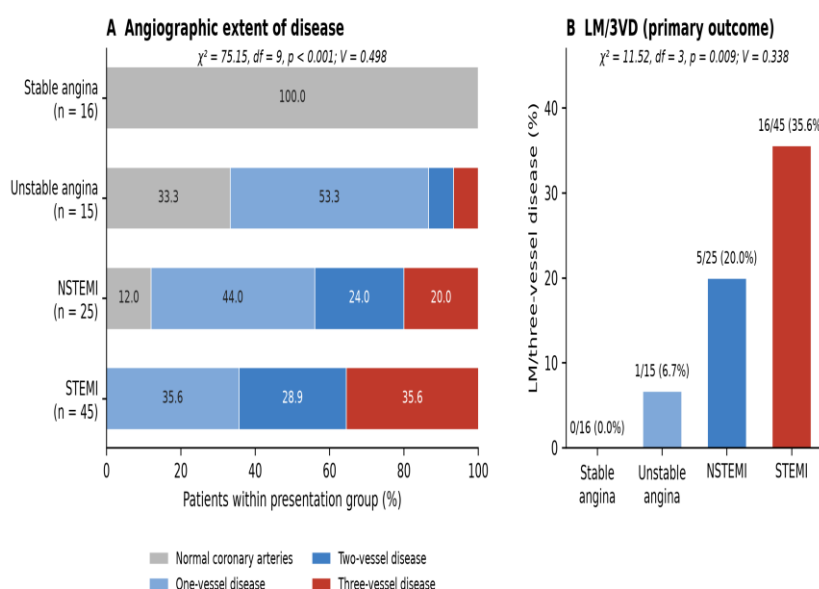


Figure 2. Angiographic extent of coronary artery disease by clinical presentation (N = 101). Chi-square = 75.15, df = 9, $p < 0.001$; Cramer's V = 0.498.

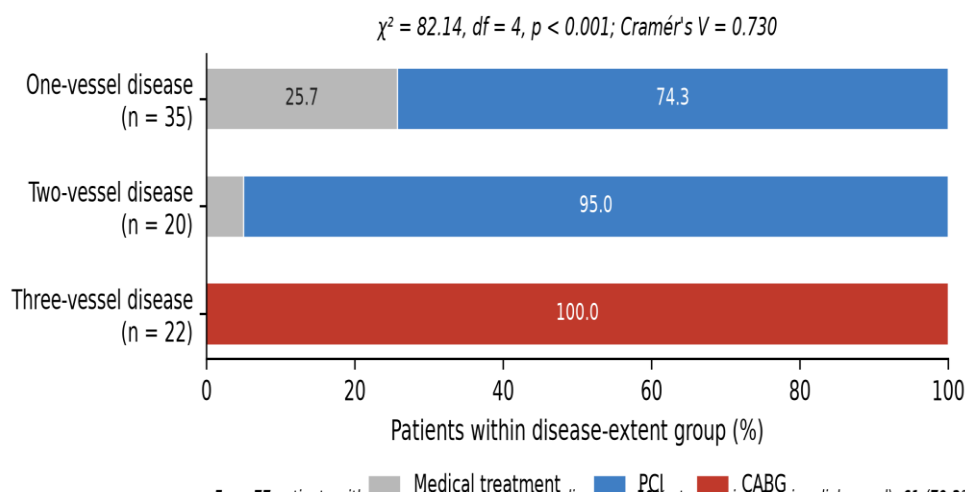


Figure 3. Revascularisation strategy by angiographic extent among patients with obstructive coronary artery disease (n = 77). Chi-square = 82.14, df = 4, $p < 0.001$; Cramer's V = 0.730. Note: 61 of 77 patients with obstructive disease were male.

Diabetic Subgroup

Among the 54 diabetic patients (16 with LM/3VD), the glucose-lowering regimen was strongly associated with the primary outcome ($\chi^2 = 11.43$, $df = 3$, $p = 0.010$; Cramer's V = 0.460; Monte Carlo $p = 0.007$): LM/3VD occurred in 13 of 26 patients on combined oral plus insulin therapy (50.0%), two of seven on insulin alone (28.6%), one of 19 on oral agents alone (5.3%) and none of the two on neither. Insulin-treated diabetic patients were more likely to have LM/3VD than those not on insulin (15/33, 45.5%, versus 1/21, 4.8%; OR 16.67, 95% CI 2.00 to 139.14; $\chi^2 = 10.19$, $p = 0.001$, Yates $p = 0.004$, Fisher's exact $p = 0.002$) and were older (59.8 versus 54.0 years; Mann-Whitney U = 478.5, $p = 0.019$), whereas oral-agent use alone was not associated with the outcome (31.1% versus 22.2%; Fisher's exact $p = 0.709$). The Spearman correlation between insulin use and LM/3VD within the diabetic subgroup was moderate ($\rho = 0.434$, $p = 0.001$). Because the subgroup contained only 16 events and diabetes duration and glycemic control were not recorded, these observations are hypothesis-generating and were not adjusted further (Table 6, Figure 4).

Table 6. Left main and/or three-vessel disease by glucose-lowering regimen and insulin status among diabetic patients (n = 54).

Regimen	n	LM/3VD n (%)	Exact 95% CI for %
Oral agents only	19	1 (5.3)	0.1-26.0
Insulin only	7	2 (28.6)	3.7-70.0
Oral + insulin	26	13 (50.0)	29.9-70.1
Neither	2	0 (0.0)	0.0-84.2
Total	54	16 (29.6)	18.0-43.6

Insulin-treated vs non-insulin-treated diabetic patients

Comparison	Statistic	Value	p-value
Insulin (n = 33) vs no insulin (n = 21): LM/3VD	45.5% vs 4.8%; OR (95% CI)	16.67 (2.00-139.14)	0.001
Chi-square (Yates-corrected)	chi-square	10.19 (8.33)	0.001 (0.004)
Fisher's exact	-	-	0.002
Oral agents only vs no oral agents: LM/3VD	31.1% vs 22.2%; Fisher's exact	-	0.709
Age, insulin vs no insulin (years)	Mann-Whitney U	59.8 vs 54.0; U = 478.5	0.019
Spearman rho (insulin x LM/3VD within diabetics)	rho	0.434	0.001
Regimen x LM/3VD (4-level)	chi-square (df = 3)	11.43; V = 0.460	0.010 (MC p = 0.007)

Regimen x LM/3VD: chi-square = 11.43, df = 3, p = 0.010; Cramer's V = 0.460; Monte Carlo exact p (10,000 tables) = 0.007. Insulin-treated patients: 15/33 (45.5%) with LM/3VD versus 1/21 (4.8%) of those not on insulin; OR 16.67 (95% CI 2.00-139.14); chi-square = 10.19, p = 0.001; Yates p = 0.004; Fisher's exact p = 0.002. Insulin-treated patients were older (59.8 vs 54.0 years; Mann-Whitney U = 478.5, p = 0.019). Oral-agent use alone was not associated with the outcome (31.1% vs 22.2%; Fisher's exact p = 0.709). The Spearman rank correlation between insulin use and LM/3VD within the diabetic subgroup was moderate (rho = 0.434, p = 0.001). With only 16 events and no data on diabetes duration or glycemic control, these exploratory observations were not adjusted further and are hypothesis-generating. CIs for regimen rows are Clopper-Pearson exact intervals.

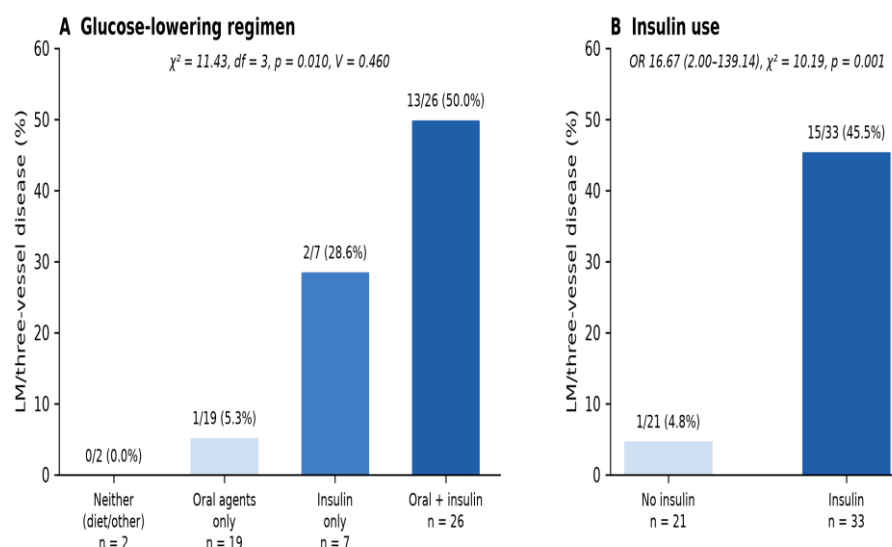


Figure 4. Prevalence of left main and/or three-vessel disease by glucose-lowering regimen among the 54 diabetic patients. Chi-square = 11.43, df = 3, p = 0.010; Cramer's V = 0.460; Monte Carlo exact p = 0.007.

Discussion

In this single-centre Libyan cohort of 101 consecutive diagnostic angiography patients, left main and/or three-vessel disease affected one in five patients (21.8%), and STEMI presentation was its strongest independent clinical predictor, conferring a fourfold adjusted odds ratio. Diabetes mellitus showed a consistent independent association of borderline

significance, and within diabetic patients, insulin-containing regimens marked a strikingly high-risk phenotype, with half of those on combined oral plus insulin therapy harbouring left main or three-vessel disease. Management was dictated almost deterministically by anatomy: every three-vessel-disease patient was referred for surgery. The stepwise gradient of anatomic burden with clinical acuity, from exclusively normal arteries instable angina to three-vessel disease concentrated in STEMI, is biologically coherent: plaque rupture and thrombotic occlusion superimposed on diffuse atherosclerosis are more likely in patients whose underlying disease is already extensive.

Our observation that STEMI retained a four-fold independent odds ratio after adjustment for age and diabetes aligns with the anatomic complexity captured by the SYNTAX framework, in which left main and multi-vessel involvement dominate risk scoring [4, 5], and with guideline positioning of high-risk anatomy as a key determinant of revascularisation modality [2, 41]. The diabetic findings deserve emphasis. Diabetes was the only independently significant predictor in the full protocol model, and the insulin-treated subgroup carried a crude odds ratio of 16.67 for high-risk anatomy. This gradient across glucose-lowering regimens, from 5.3% with oral agents alone to 50.0% with combined oral plus insulin therapy, plausibly reflects both disease duration and severity of the metabolic phenotype, since insulin requirement generally signals longer-standing or more difficult diabetes. Our inability to adjust for duration and glycosylated haemoglobin, which were not recorded, limits inference; nevertheless, the magnitude and internal consistency of the signal, including a moderate rank correlation within the subgroup, suggest that insulin-treated diabetic patients presenting for angiography deserve particular scrutiny. This finding resonates with trial evidence that diabetic patients with multi-vessel disease derive superior outcomes from surgical revascularisation [17, 18, 20], a population our data suggest can be anticipated, at least in part, from the glucose-lowering regimen alone. The management pattern we observed, with universal CABG referral for three-vessel disease and PCI predominance in one- and two-vessel disease, mirrors contemporary recommendations to route complex, extensive disease to surgery and focal disease to percutaneous treatment [30, 41], as established by the landmark trials of complex and left main revascularisation [10-13].

The quasi-complete separation between CABG referral and left main and three-vessel disease ($\phi = 1.000$) should be interpreted as a descriptive property of guideline-concordant care rather than a testable predictor association: anatomy determined management, and the two variables are therefore not statistically separable. Two further observations warrant comment. First, all 16 stable-angina patients in this cohort had normal coronary arteries, an atypical pattern for a diagnostic catheterisation population. Previous work has identified predictors of angiographically normal coronaries, including younger age and fewer traditional risk factors [42]; our stable-angina group conforms to this profile in relative terms, though its uniformity more likely reflects the referral case-mix of this laboratory than the natural history of stable coronary disease, a case-mix effect well described in Western series [27, 28]. Second, the single-centre Libyan context situates our findings within an emerging regional literature documenting a heavy and distinctive risk-factor burden, with smoking prominent among men and diabetes prominent among women [26]; our cohort extends that picture from disease presence to disease extent. The study's strengths include a complete, verified dataset with no missing values; independent recomputation of every reported statistic from the raw data; a pre-specified analysis plan with primary and sensitivity models; and transparent handling of sparse data through exact and Monte Carlo testing. Its limitations must temper interpretation. The cross-sectional design precludes causal inference: associations between presentation, regimen and anatomy are temporal by construction, since presentation precipitated the angiogram that revealed the anatomy.

The sample size, with 22 outcome events, limited multivariable modelling, as reflected in the events-per-variable ratio near three for the full protocol model [36, 37]; the parsimonious primary model was chosen accordingly, and its confidence intervals remain wide. Single-centre enrolment over one year restricts generalizability, and the atypical stable-angina pattern cautions against extrapolating our presentation-specific prevalences to other settings. Laboratory risk-factor quantification (lipid fractions, glycosylated haemoglobin, creatinine), symptom duration, left ventricular function and follow-up outcomes were not recorded, precluding their adjustment or analysis. The diabetic-subgroup analysis is exploratory, and the insulin odds ratio, with a confidence interval spanning two orders of magnitude, is imprecise by construction. Finally, family history and prior antiplatelet exposure were too sparse to model at all.

Conclusion

In this Libyan diagnostic angiography cohort, left main and three-vessel disease affected 21.8% of patients and was independently predicted by STEMI presentation, with diabetes mellitus showing a borderline independent association and insulin-treated diabetes marking a distinctly high-risk subgroup in whom the prevalence of such anatomy approached one in two. The anatomic burden rose stepwise with clinical acuity, and management followed anatomy almost deterministically, with universal surgical referral for three-vessel disease. These findings suggest that clinical presentation and the diabetic treatment regimen, both available before catheterisation, can sharpen anticipation of high-risk anatomy and support early heart-team involvement for ST-elevation patients and insulin-treated diabetic patients. External validation in larger, multi-centre North African cohorts with laboratory risk-factor data is warranted.

Conflict of interest. Nil

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