CLINICAL EVIDENCE REVIEW • ISOLATED CABG

LSV vs LIMA to LAD
10-Year Survival

Clinical Guidelines vs Clinical Judgement

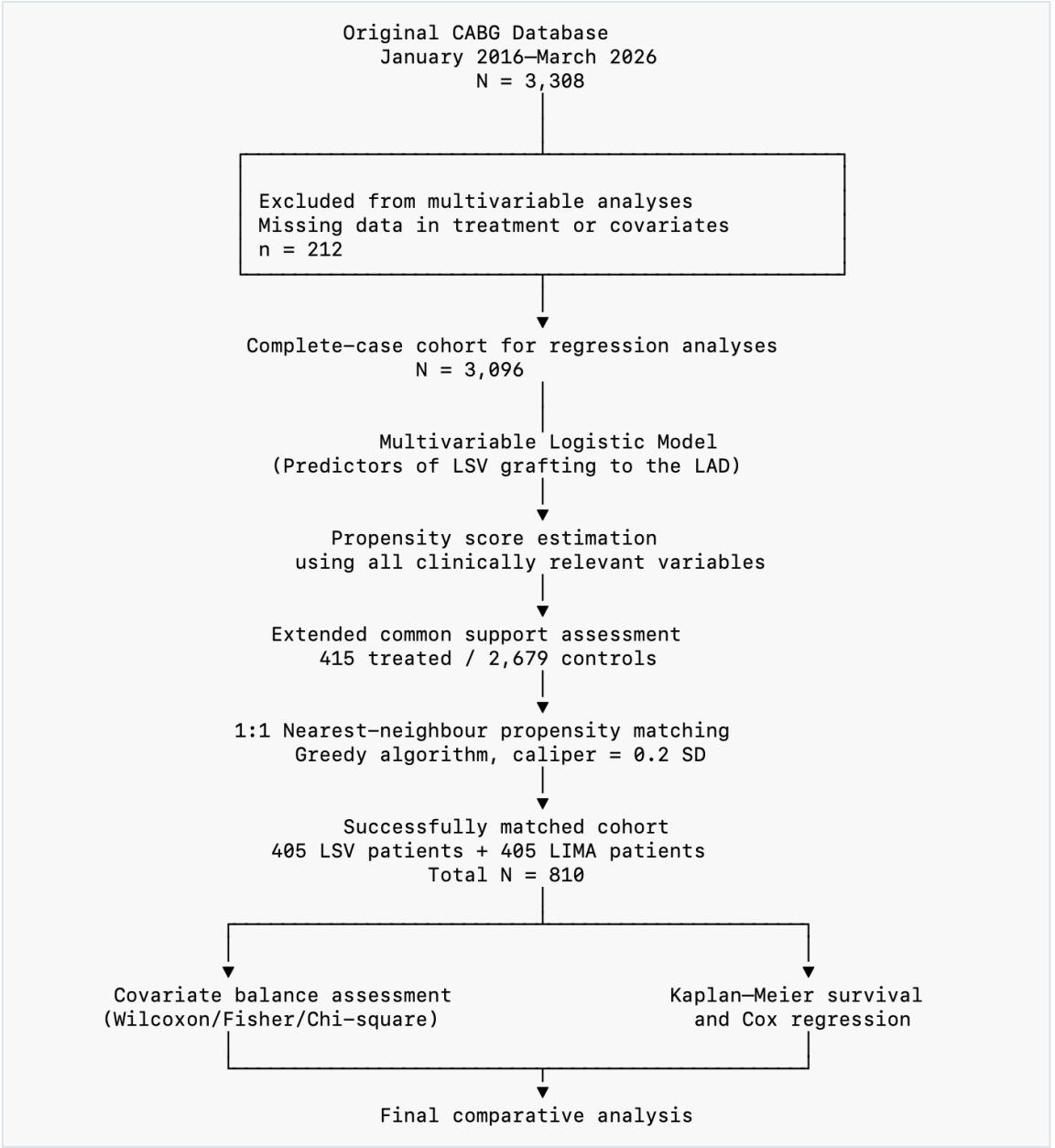
Sotiris Papaspyros • 09/07/2026

N = 3,308 patients • 2016–2026

METHODS

Flowchart of analysis

Patient selection, covariate adjustment, and matching pipeline — from raw database to final comparative analysis.



APPENDIX

Analysis log & reproducible methods

Full SAS workflow — data prep, logistic regression, propensity matching and Cox modelling — provided for reproducibility.

1. Overview
This appendix documents the full statistical workflow used in the study comparing LSV vs LIMA grafting to the LAD.

2. Data Preparation
Data imported into SAS. Missing values excluded (final N=3096 for Cox, 3308 original).

3. Descriptive Analysis
PROC FREQ and summary statistics used to describe baseline variables.

4. Logistic Regression (Treatment Model)
PROC LOGISTIC used to model predictors of LSV_to_LAD.

```
proc logistic data=work.import;
class Gender Smoking DM LMSmorethan50 HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3 Previous_MI
Previous_PCI CrCl_Category;
model LSV_to_LAD(event='1') = Age_at_op EuroII BMI Extent_of_coronary_disease Gender Smoking DM LMSmorethan50
HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3 Previous_MI Previous_PCI CrCl_Category;
run;
```

5. Propensity Score Matching
```
proc psmatch data=work.import;
class LSV_to_LAD Gender Smoking DM LMSmorethan50 HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3
Previous_MI Previous_PCI CrCl_Category;
psmodel LSV_to_LAD(TREATED='1') = Age_at_op EuroII BMI Extent_of_coronary_disease Gender Smoking DM
LMSmorethan50 HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3 Previous_MI Previous_PCI CrCl_Category;
match method=nearest(k=1) caliper=0.2;
output out=matched_dataset matchid=_MatchID ps=_PS_;
run;
```

6. Balance Assessment
PROC NPAR1WAY and PROC FREQ used. No significant differences post-matching.

7. Survival Analysis (Matched)
```
proc phreg data=work.matched_final;
model Time*Status(0)=LSV_to_LAD;
run;
```

8. Full Cohort Cox Model
```
proc phreg data=work.import;
class LSV_to_LAD Gender Smoking DM LMSmorethan50 HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3
Previous_MI Previous_PCI CrCl_Category;
model Time*Status(0)=LSV_to_LAD Age_at_op EuroII BMI Extent_of_coronary_disease Gender Smoking DM
LMSmorethan50 HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3 Previous_MI Previous_PCI CrCl_Category;
run;
```

9. Proportional Hazards Testing
```
proc phreg data=work.import;
model Time*Status(0)=LSV_to_LAD Age_at_op EuroII BMI Extent_of_coronary_disease Gender Smoking DM
LMSmorethan50 HTN HighChol Urgency preop_IABP EF_cat CCS3 NYHA3 Previous_MI Previous_PCI CrCl_Category;
assess ph / resample;
run;
```

10. Key Findings
No independent association between LSV_to_LAD and survival after adjustment and matching.

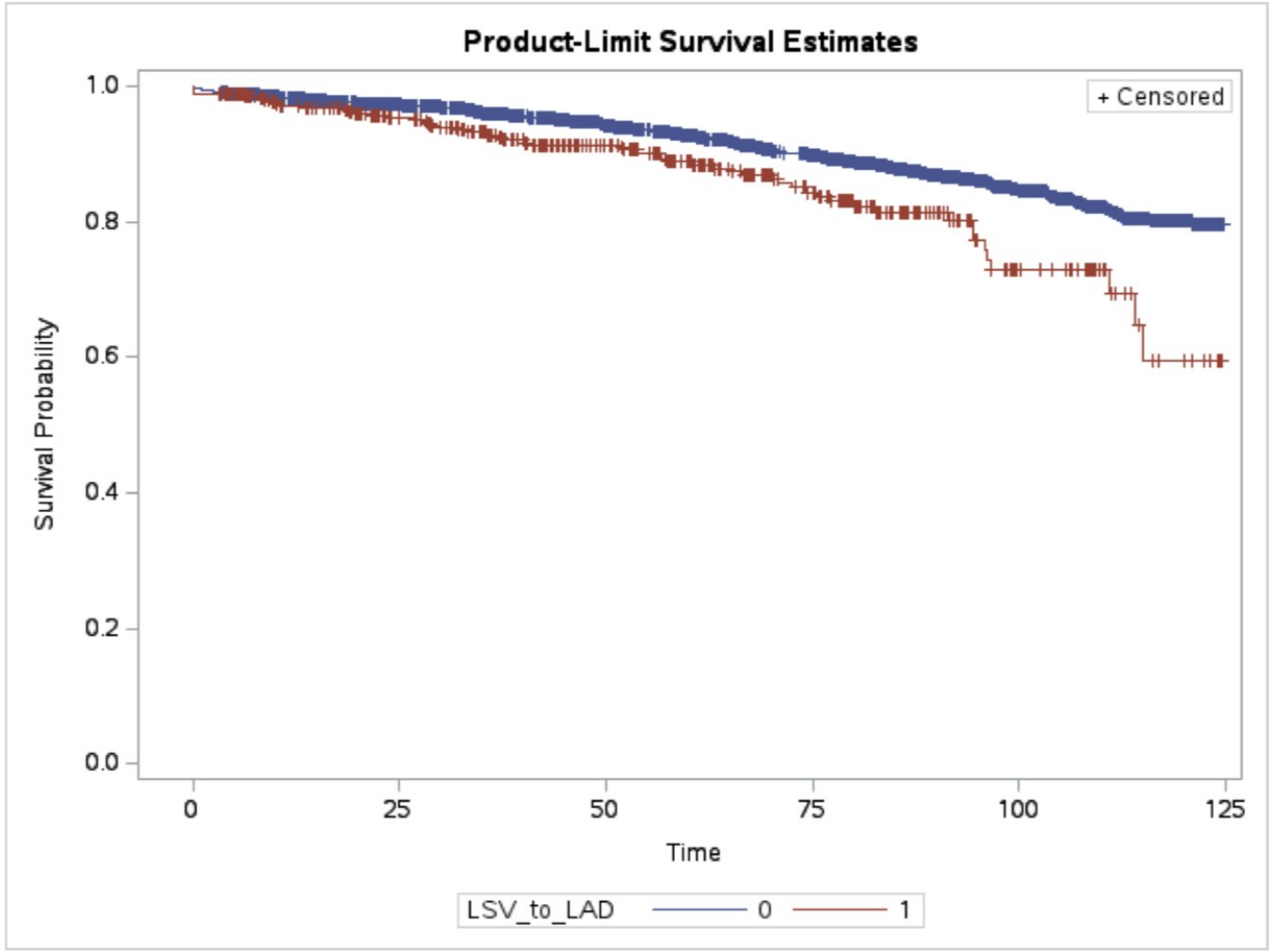
UNADJUSTED SURVIVAL

LSV to LAD showed worse survival than LIMA

In the raw cohort, the vein-graft group separated early and stayed below the LIMA curve throughout follow-up.

LOG-RANK TEST

p = 0.0002 $\chi^2 = 14.19$



BASELINE COMPARABILITY

Are the LIMA and LSV groups comparable?

Continuous variables

LSV vs LIMA

- **Higher age** 66.9 vs 64.2
- **Higher EuroSCORE II** 2.91 vs 1.69
- **Lower BMI** 28.9 vs 29.2
- **Longer XClamp** 57.6 vs 55.6
- **Longer CPB** 103.5 vs 98.0
- **Fewer grafts** 2.84 vs 3.17
- **Longer LOS** 10.3 vs 8.2
- **Longer Total LOS** 17.0 vs 14.9

Clear imbalance

Categorical, significant

- **Gender** more males, p<0.0001
- **Urgency** more urgent, p<0.0001
- **Pre-op IABP** more common, p<0.0001
- **EF category** worse EF, p<0.0001
- **CCS class 3** more severe, p<0.0001
- **NYHA 3** differs, p=0.0024
- **Previous MI** more common, p=0.0008
- **Previous PCI** more common, p=0.0199
- **CrCl** worse renal fn, p<0.0001

No difference

Balanced at baseline

- **Smoking**
- **Diabetes (DM)**
- **LMS >50%**
- **Hypertension**
- **High cholesterol**
- **Hypothyroid**
- **Poor mobility**
- **Emphysema / COPD**
- **Neuro history / PVD**

PATIENT COHORT

Baseline characteristics

The LSV group is consistently higher-risk across age, EuroSCORE, EF, IABP use and renal function.

Variable	LSV (n=416)	LIMA (n=2680)	p-value
Age_at_op	higher	lower	<0.001
EuroII	higher	lower	<0.001
BMI	similar	similar	NS
Gender	different	—	0.0003
Smoking	similar	similar	NS
Diabetes (DM)	similar	similar	NS
LMS >50%	more frequent	less	0.04
HTN	similar	similar	NS
HighChol	similar	similar	NS
Urgency	trend	—	0.07
preop IABP	higher	lower	<0.001
EF category	worse	better	<0.001
CCS3	higher	lower	0.0019
NYHA3	different	—	<0.001
Previous PCI	higher	lower	0.033
CrCl category	worse	better	0.026

PREDICTORS OF LSV USE

Binary logistic regression for LSV use

Which pre-operative factors are independently associated with receiving LSV to LAD?

Strongest positive predictors

- **EF <20%** — OR 12.4 *(31–50%: 2.37, <30%: 4.35)*
- **Pre-op IABP** — OR 4.82 *(critically ill)*
- **Emergency surgery** — OR 2.30 *(urgency matters)*

Comorbidity & disease burden

- **Age** — OR 1.035 per year
- **CrCl 60–89** — OR 1.78
- **CCS ≥3** — OR 1.56
- **Previous PCI** — OR 1.35

MODEL QUALITY

- **Global p < 0.0001** model is strong
- **c-statistic = 0.725** good discrimination

WHAT THIS TELLS US

Surgeons selectively used vein grafts in the sickest patients — low EF, critically ill, and emergent cases — setting up the confounding seen in the raw survival curve.

ADJUSTED MODEL

Multivariable predictors of LSV use

Odds ratios with 95% confidence intervals for each independent predictor of receiving a vein graft.

Variable	OR (95% CI)	p-value
Age_at_op	1.035 (1.019–1.051)	<0.001
Gender	0.587 (0.440–0.783)	0.0003
LMS >50%	0.779 (0.611–0.992)	0.043
Urgency (high)	2.298 (1.126–4.689)	0.022
preop IABP	4.823 (2.336–9.956)	<0.001
EF category	up to 12.4	<0.001
CCS3	1.563 (1.179–2.073)	0.0019
NYHA3	0.565 (0.424–0.753)	<0.001
Previous PCI	1.348 (1.024–1.775)	0.033
CrCl category	1.777 (1.165–2.709)	0.0076

CONFOUNDING CONTROL

Propensity score matching

1:1 nearest-neighbour greedy matching (caliper 0.2 SD) produced 405 well-balanced pairs.

The PSMATCH Procedure

Data Information	
Data Set	WORK.IMPORT
Output Data Set	WORK.MATCHED_DATASET
Treatment Variable	LSV_to_LAD
Treated Group	1
All Obs (Treated)	416
All Obs (Control)	2680
Support Region	Extended Common Support
Lower PS Support	0.016695
Upper PS Support	0.909943
Support Region Obs (Treated)	415
Support Region Obs (Control)	2679

Propensity Score Information

	Treated (LSV_to_LAD = 1)						Control (LSV_to_LAD = 0)						Treated - Control
Observations	N	Weight	Mean	Standard Deviation	Minimum	Maximum	N	Weight	Mean	Standard Deviation	Minimum	Maximum	Mean Difference
All	416		0.2175	0.1581	0.0206	0.9163	2680		0.1215	0.0889	0.0159	0.8908	0.0961
Region	415		0.2159	0.1545	0.0206	0.8726	2679		0.1215	0.0888	0.0169	0.8908	0.0944
Matched	405		0.2026	0.1303	0.0206	0.7968	405		0.2018	0.1281	0.0210	0.7765	0.0008
Weighted Matched	405	405.00	0.2026	0.1303	0.0206	0.7968	405	405.00	0.2018	0.1281	0.0210	0.7765	0.0008

Matching Information	
Distance Metric	Logit of Propensity Score
Method	Greedy Matching
Control/Treated Ratio	1
Order	Descending
Caliper (Logit PS)	0.171317
Matched Sets	405
Matched Obs (Treated)	405
Matched Obs (Control)	405
Total Absolute Difference	1.929463

MATCH DIAGNOSTICS

Balance after matching

After matching, every pre-operative variable is balanced — all p-values are non-significant.

CONTINUOUS VARIABLES

All key pre-op variables balanced

Age p = 0.5876

EuroSCORE II p = 0.7181

BMI p = 0.2048

Extent of CAD p = 0.5365

CATEGORICAL VARIABLES

Gender	p = 0.7300
Smoking	p = 0.6586
Diabetes (DM)	p = 0.8451
LMS >50%	p = 0.4488
Hypertension	p = 0.4053
High cholesterol	p = 0.3862
Urgency	p = 0.9032
Pre-op IABP	p = 0.3063
EF category	p = 0.9932
CCS class 3	p = 0.7887
NYHA 3	p = 1.0000
Previous MI	p = 0.3904
Previous PCI	p = 0.8025
CrCl category	p = 0.6613

LIFETEST PROCEDURE

Testing survival homogeneity

Log-rank, Wilcoxon and likelihood-ratio tests of equality across strata in the matched cohort.

Rank Statistics		
LSV_to_LAD	Log-Rank	Wilcoxon
0	-1.4942	-308.00
1	1.4942	308.00

Covariance Matrix for the Log-Rank Statistics		
LSV_to_LAD	0	1
0	28.2112	-28.2112
1	-28.2112	28.2112

Covariance Matrix for the Wilcoxon Statistics		
LSV_to_LAD	0	1
0	8159013	-8159013
1	-8159013	8159013

Test of Equality over Strata			
Test	Chi-Square	DF	Pr > Chi-Square
Log-Rank	0.0791	1	0.7785
Wilcoxon	0.0116	1	0.9141
-2Log(LR)	0.1179	1	0.7313

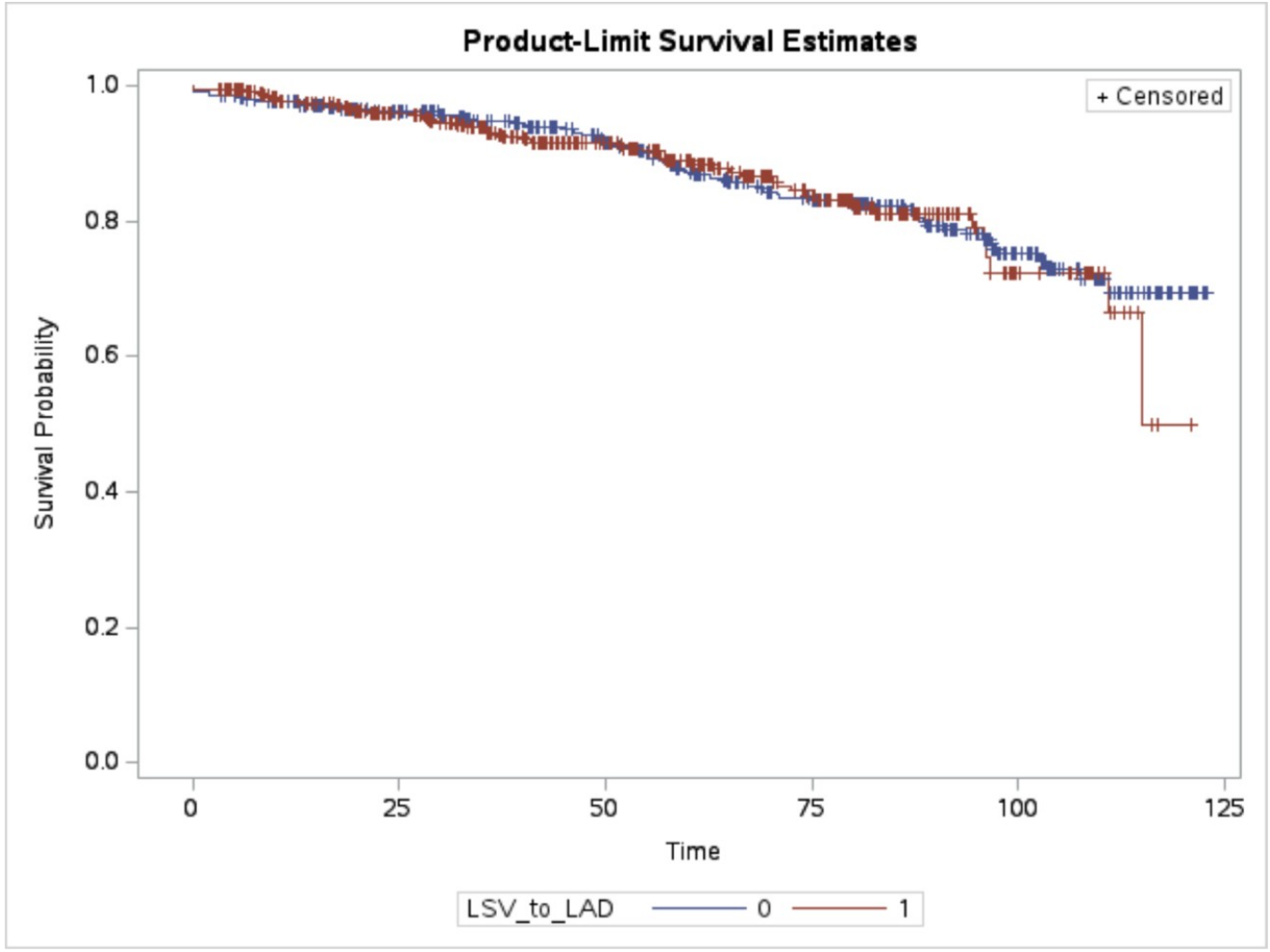
MATCHED SURVIVAL

The curves converge once risk is balanced

In the 405 matched pairs, the Kaplan–Meier curves overlap for the full follow-up period.

NO SURVIVAL DIFFERENCE

p = 0.7785 Wilcoxon 0.9141



INTERIM SYNTHESIS

What the study says so far

UNADJUSTED ANALYSIS

LSV appeared worse log-rank p = 0.0002

AFTER ACCOUNTING FOR BASELINE DIFFERENCES

Matched KM **p = 0.7785**

Matched Cox **HR 1.054, p = 0.7777**

INTERPRETATION

The apparent unadjusted disadvantage of LSV seems to be explained by:

- older age
- worse EF
- emergency status
- more IABP use
- worse renal function
- overall higher-risk case mix

— not by the conduit itself.

ADJUSTED FULL COHORT

Cox regression in the full cohort

PRIMARY TREATMENT EFFECT — LSV vs LIMA

HR 1.262

95% CI 0.924–1.723 • p = 0.1433

Not an independent predictor of mortality

CONSISTENT ACROSS METHODS

Matched Cox: **HR 1.054, p = 0.7777**

Full cohort: **HR 1.262, p = 0.1433**

INTERPRETATION

The estimate trends slightly above 1, but the CI crosses 1 and is not significant. The worse unadjusted survival is largely explained by confounding and baseline risk imbalance — not conduit choice.

LONG-TERM MORTALITY

Multivariable Cox regression

Adjusted hazard ratios for long-term mortality. LSV_to_LAD is non-significant (HR 1.262, p=0.143); age, EuroSCORE, diabetes, EF and renal function drive risk.

Variable	HR (95% CI)	p-value
LSV_to_LAD	**1.262 (0.924–1.723)**	**0.143**
Age_at_op	1.059 (1.041–1.076)	<0.001
EuroII	1.060 (1.015–1.106)	0.0086
DM (moderate)	1.428 (1.120–1.821)	0.004
DM (severe)	2.244 (1.510–3.335)	<0.001
EF_cat (moderate)	1.808 (1.050–3.115)	0.033
CrCl_category	1.601 (1.097–2.336)	0.015

KEY FINDINGS

Summary

1. 3,308 patients: 416 LSV to LAD, 2,680 LIMA to LAD.
2. Unadjusted KM survival was worse in the LSV group (log-rank p=0.0002).
3. Logistic regression identified age, EF, urgency, IABP, CCS, renal function and previous PCI as predictors of LSV use.
4. Full-cohort Cox: LSV not independently associated with mortality (HR 1.26, 95% CI 0.92–1.72, p=0.14).
5. Propensity matching yielded 405 well-balanced pairs with no baseline differences.
6. Matched cohort: no survival difference (log-rank p=0.78; Cox HR 1.05, 95% CI 0.73–1.52).

Bottom line: once baseline risk is accounted for, conduit type is not independently associated with long-term survival.

WHAT THE GUIDELINES SAY

Guidelines: ESC 2018 & US 2021

ESC / EACTS 2018 — Procedural aspects

Recommendations on procedural aspects of coronary artery bypass grafting

Recommendations	Class[a]	Level[b]
General considerations		
Complete myocardial revascularization is recommended.[c] [131,132]	I	B
Minimization of aortic manipulation is recommended.[508,509,544,545]	I	B
Routine intraoperative graft flow measurement should be considered.[516,517]	IIa	B
CT scans of the ascending aorta should be considered in patients over 70 years of age and/or with signs of extensive generalized atherosclerosis.	IIa	C
Prior to aortic manipulation, epiaortic ultrasound should be considered to identify atheromatous plaques and select the optimal surgical strategy.	IIa	C
Conduit selection		
Arterial grafting with IMA to the LAD system is recommended.[453,454,546]	I	B
An additional arterial graft should be considered in appropriate patients.[467,482,547–551]	IIa	B
The use of the radial artery is recommended over the saphenous vein in patients with high-grade coronary artery stenosis.[d] [482,549,550,552,553]	I	B
BIMA grafting should be considered in patients who do not have a high risk of sternal wound infection.[e] [467,547,548,551]	IIa	B
Vessel harvesting		
Skeletonized IMA dissection is recommended in patients with a high risk of sternal wound infection.[471,484,485]	I	B
Endoscopic vein harvesting, if performed by experienced surgeons, should be considered to reduce the incidence of wound complications.[490,493,494,500,554]	IIa	A
No-touch vein harvesting should be considered when an open technique is used.[506,507,555,556]	IIa	B
Minimally invasive techniques		
Off-pump CABG and preferably no-touch techniques on the ascending aorta, by experienced operators, are recommended in patients with significant atherosclerotic aortic disease.[508,509,544,557–559]	I	B
Off-pump CABG should be considered for subgroups of high-risk patients by experienced off-pump teams.[525,557–560]	IIa	B
Where expertise exists, minimally invasive CABG through limited thoracic access should be considered in patients with isolated LAD lesions or in the context of hybrid revascularization.[143,534,535,561]	IIa	B
Hybrid procedures, defined as consecutive or combined surgical and percutaneous revascularization, may be considered in specific patient subsets at experienced centres.[536,561–563]	IIb	B

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BIMA = bilateral internal mammary artery; CABG = coronary artery bypass grafting; CT = computed tomography; IMA = internal mammary artery; LAD = left anterior descending coronary artery.
[a]Class of recommendation.
[b]Level of evidence.
[c]Definitions of complete revascularization are provided in section 5.3.1.3.
[d]Particularly in patients with poor vein grafts. The radial artery should not be used if previously catheterized, if the Allen test is positive or if calcific degeneration is present.
[e]Patients with diabetes mellitus, chronic pulmonary obstructive disease, previous mediastinal radiation, and obesity, particularly when multiples of these are present.

US 2021 — Bypass conduits in CABG

12.2. Bypass Conduits in Patients Undergoing CABG

Recommendations for Bypass Conduits in Patients Undergoing CABG
Referenced studies that support the recommendations are summarized in Online Data Supplement 37.

COR	LOE	Recommendations
1	B-R	1. In patients undergoing isolated CABG, the use of a radial artery is recommended in preference to a saphenous vein conduit to graft the second most important, significantly stenosed, non–LAD vessel to improve long-term cardiac outcomes.[1-3]
1	B-NR	2. In patients undergoing CABG, an IMA, preferably the left, should be used to bypass the LAD when bypass of the LAD is indicated to improve survival and reduce recurrent ischemic events.[4-9]
2a	B-NR	3. In patients undergoing CABG, bilateral IMA (BIMA) grafting by experienced operators can be beneficial in appropriate patients to improve long-term cardiac outcomes.[3,10-12]

References from guidelines

453. Boylan MJ, Lytle BW, Loop FD, et al. Surgical treatment of isolated LAD coronary stenosis: LITA vs venous autograft at 18–20 years. J Thorac Cardiovasc Surg 1994;107:657–662.

454. Sabik JF III, Blackstone EH, Gillinov AM, et al. Influence of patient characteristics and arterial grafts on freedom from coronary reoperation. J Thorac Cardiovasc Surg 2006;131:90–98.

546. Hlatky MA, Boothroyd DB, Reitz BA, et al. Adoption and effectiveness of internal mammary artery grafting in CABG among Medicare beneficiaries. J Am Coll Cardiol 2014;63:33–39.

4. Zeff RH, Kongtahworn C, Iannone LA, et al. Internal mammary artery vs saphenous vein graft to the LAD: prospective randomized 10-year study. Ann Thorac Surg 1988;45:533–536.

6. Loop FD, Lytle BW, Cosgrove DM, et al. Influence of the internal-mammary-artery graft on 10-year survival and other cardiac events. N Engl J Med 1986;314:1–6.

7. Cameron A, Davis KB, Green G, et al. Coronary bypass surgery with internal-thoracic-artery grafts — effects on survival over a 15-year period. N Engl J Med 1996;334:216–219.

8. Tatoulis J, Buxton BF, Fuller JA. The right internal thoracic artery: the forgotten conduit — 5,766 patients and 991 angiograms. Ann Thorac Surg 2011;92:9–15.

9. Magruder JT, Young A, Grimm JC, et al. Bilateral internal thoracic artery grafting: does graft configuration affect outcome? J Thorac Cardiovasc Surg 2016;152:120–127.

SUPPORTING EVIDENCE

Why LIMA is preferred for the LAD

Landmark observational data — CASS registry and large CABG series — show improved survival and patency with LIMA-LAD versus a vein graft.

2. Data supporting the LIMA versus an SVG for grafting of the LAD are derived almost exclusively from observational studies reported 25 to 35 years ago.[5-7] In the CASS (Coronary Artery Surgery Study) registry, survival was improved in patients who received the LIMA-LAD compared with the SVG group after multivariable adjustment.[7] In another series of nearly 6000 patients undergoing CABG, LIMA grafting reduced deaths, recurrent infarction, rehospitalization for cardiac events, and repeat revascularization.[6] In this study, postoperative angiography revealed substantially higher LIMA patency. A single small RCT also found improved cardiac event–free survival at 10 years in the LIMA arm.[4,5]

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An independent cohort shows the same pattern

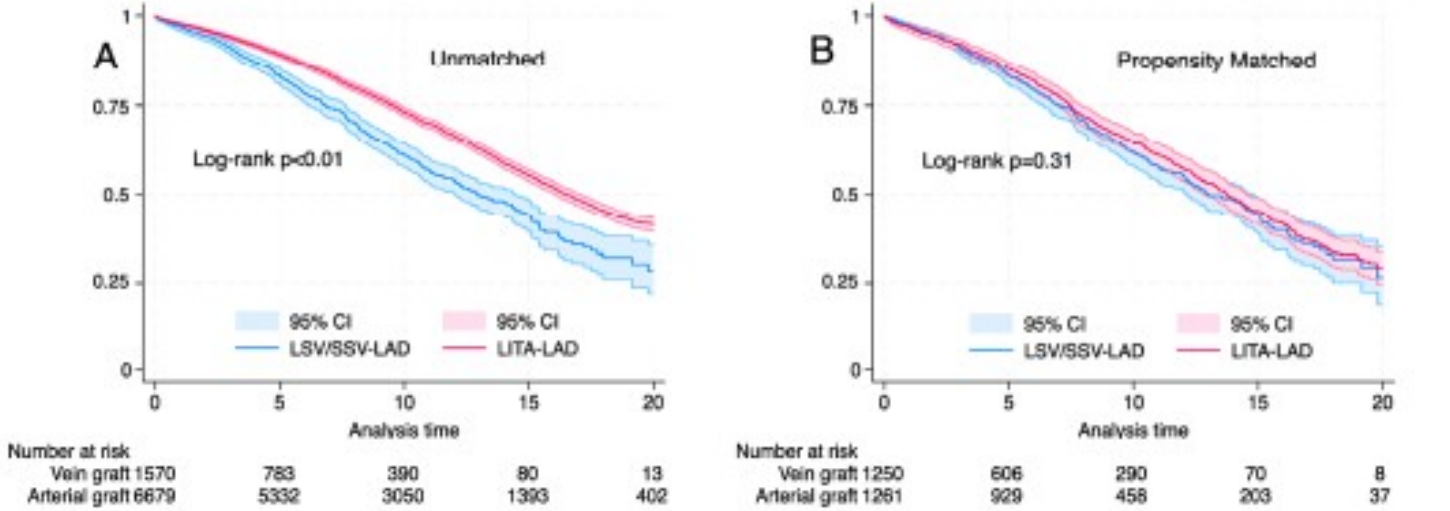


Figure 2. Kaplan–Meier graph showing the long-term survival based on conduit (left internal thoracic artery or saphenous vein graft). (**A**) Unmatched cohort, log rank $p < 0.001$, Wilcoxon; $p < 0.001$. (**B**) Propensity matched cohort log rank $p = 0.31$, Wilcoxon $p = 0.35$.

SAME SIGNAL, LARGER SERIES

Unmatched: **log-rank p<0.01**

Propensity matched: **p=0.31**

The unmatched gap disappears after matching — mirroring our result.

Luthra S, Masraf H, Mohamed ME, Malvindi PG, Sef D, Miskolczi S, Velissaris T. Left Internal Thoracic Artery versus Saphenous Vein Grafts to LAD after Isolated CABG. Life 2024, 14, 385. https://doi.org/10.3390/life14030385

THE BROADER QUESTION

Clinical guidelines vs clinical judgement

Clinical practice guidelines

Developed by multidisciplinary panels from systematic reviews of evidence and risk/benefit. They reduce cognitive bias and unwarranted variation — bodies like NICE set standards that promote the highest quality of care.

Clinical judgement

The clinician's real-time assessment — recognizing cues, prioritizing hypotheses, and tailoring a plan under uncertainty. It weighs the patient's values, comorbidities and real-world complexity that a general guideline cannot capture.

THE INTERPLAY IN PRACTICE

Guidelines are **advice, not orders.** Under the GMC framework, a clinician may justifiably depart from a guideline in a patient's best interest — after discussing the reasoning — but blindly following one against contrary indicators can itself create liability.

THE BREAKDOWN

The map, the driver, and the law

Guidelines — the map

Built from population averages. They show the best-known route for the typical patient, but can't see the road right in front of you.

Judgement — the driver

Guidelines only on their own is cookbook medicine; judgement alone is "how I've always done it." Safe care needs both — the map sets the boundaries, the driver navigates within them.

IN THE EYES OF THE LAW

Guidelines are **not the law.** The test is not "did the clinician follow the guideline?" but "did they meet the standard of care?" Under the **"two schools of thought"** doctrine, a course supported by a respectable minority of peers is defensible even against a mainstream guideline — and what is documented in the record decides the case.

THE BOTTOM LINE

Medicine is an art as well as a science. Courts do not expect clinicians to practise like robots programmed by guidelines: deviation is entirely defensible when backed by a rational scientific basis, supported by expert peers, and clearly documented in the patient's chart.