The Role of Surgical Revascularization for Acute Myocardial Infarction and Cardiogenic Shock in the Contemporary Era

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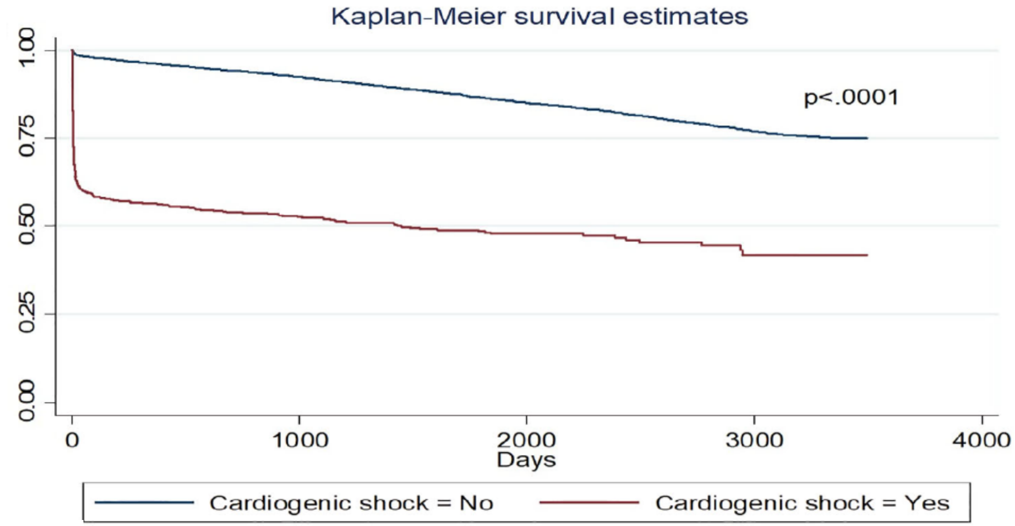
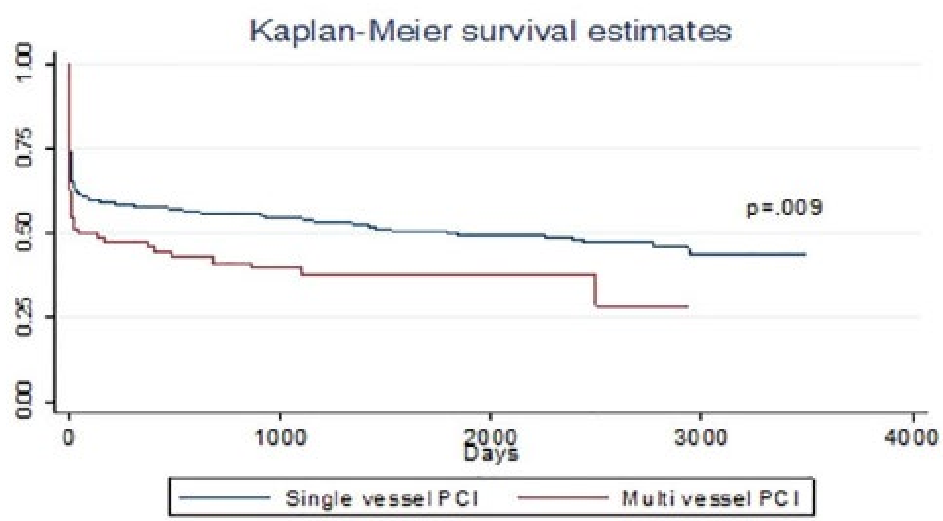
Acute Myocardial Infarction and Cardiogenic Shock

- Over 20 million in the United States have coronary heart disease
- Approximately 720,000 will have a new coronary event annually and 335,000 will have a recurrent event
- Cardiogenic shock complicates approximately 5% of cases with acute myocardial infarction (AMI)
- Mortality due to cardiogenic shock after AMI is high and may exceed 40-50%





AHA Statistical Update, Circulation, 2023

Noaman et al. Catheter Cardiovasc Interv, 2020.

What is the rationale for CABG in patients with acute MI and cardiogenic shock?

CABG for MI and Shock: SHOCK trial

The New England Journal of Medicine

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EARLY REVASCULARIZATION IN ACUTE MYOCARDIAL INFARCTION COMPLICATED BY CARDIOGENIC SHOCK

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CABG for MI and Shock: SHOCK trial

TABLE 2. CHARACTERISTICS OF THE STUDY PATIENTS ACCORDING TO TREATMENT GROUP.*

CHARACTERISTIC	REVASCULARIZATION (N=152)	MEDICAL THERAPY (N=150)
Age (yr)	65.5±10.0	66.2±10.9
Female sex (%)	36.8	27.3
White race, non-Hispanic (%)	72.4	78.7
Prior MI (%)	29.6	35.3
Hypertension (%)	49.0	43.5
Diabetes mellitus (%)	34.2	27.9
Congestive heart failure (%)	4.0	8.2
Renal insufficiency (%)	4.6	6.9
Prior coronary-artery bypass grafting (%)	2.0	10.0
Prior angioplasty (%)	6.7	7.4
Cigarette smoking (%)	52.6	56.8
Eligible for thrombolytic therapy (%)†	94.1	94.6
Transfer admission (%)	55.3	55.3
Anterior index MI (%)	63.6	57.4
Highest total creatine kinase (IU/liter)	3068 (1322–6350)	3464 (1543–5411)
Median time from MI to shock (hr)	5.0 (2.2–12.0)	6.2 (2.4–15.5)
Median time from MI to randomization (hr)	11.0 (5.9–19.4)	12.0 (6.3–21.8)
<6 hr from MI to randomization (%)	25.0	23.7
Lowest systolic blood pressure (mm Hg)‡	66.4±14.3	69.8±11.3
Systolic blood pressure (mm Hg)§	89.0±22.8	86.5±17.4
Diastolic blood pressure (mm Hg)§	53.9±16.8	55.1±13.6
Heart rate (beats/min)§	103.3±22.0	100.1±22.7
Pulmonary-capillary wedge pressure (mm Hg)§¶	24.2±7.1	24.3±7.7
Cardiac index (liters/min/m²)§‖	1.8±0.7	1.7±0.5
Left ventricular ejection fraction (%)**	29.1±10.6	32.5±13.9
Number of diseased vessels (%)††		
≤1	14.0	11.5
2	21.7	24.0
3	64.3	64.6
Left main coronary artery disease (%)‡‡	23.4	17.5

TABLE 3. TREATMENT OF THE STUDY PATIENTS.

TREATMENT	REVASCULARIZATION (N=152)	MEDICAL THERAPY (N=150)
CPR, VT, or VF before randomization (%)*	32.7	23.9
Thrombolytic therapy (%)	49.3	63.3
Inotropes or vasopressors (%)	99.3	98.6
Intraaortic balloon counterpulsation (%)	86.2	86.0
Pulmonary-artery catheterization (%)	93.4	96.0
Left ventricular assist device (%)†	3.6	0.9
Heart transplantation (%)	2.0	0.7
Coronary angiography (%)	96.7	66.7
Angioplasty (%)	54.6	14.0
Stent placed‡	35.7	52.3
Platelet glycoprotein IIb/IIIa receptor antagonist§	41.7	25.0
Coronary-artery bypass grafting (%)	37.5	11.3
Angioplasty or coronary-artery bypass grafting (%)	86.8	25.3
Median time from randomization to revascularization (hr)¶	1.4 (0.6–2.8)	102.8 (79.0–162.0)

*CPR denotes cardiopulmonary resuscitation, VT sustained ventricular tachycardia, and VF sustained ventricular fibrillation. Patients could have had more than one of these factors. Values are based on 113 patients in the revascularization group and 113 in the medical-therapy group.

†Values are based on 111 patients in the revascularization group and 110 in the medical-therapy group.

‡The rate of stent use (for any lesion) was 0 percent in 1993–1994, 19 percent in 1995–1996, and 74 percent in 1997–1998.

§The rate of use of a platelet glycoprotein IIb/IIIa receptor antagonist was 0 percent in 1993–1994, 27 percent in 1995–1996 (estimated), and 59 percent in 1997–1998. Values are based on 60 patients in the revascularization group and 20 in the medical-therapy group.

¶Values in parentheses indicate the interquartile range.

Hochman et al. NEJM, 1999.

CABG for MI and Shock: SHOCK trial

The SHOCK Trial demonstrated lower mortality in patients with AMI/CS that underwent revascularization compared to medical therapy

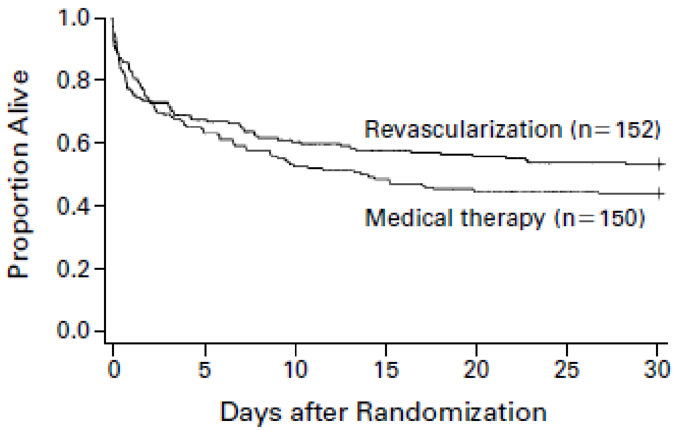


Figure 1. Overall 30-Day Survival in the Study.
The 30-day survival rate was 53.3 percent for patients assigned to revascularization and 44.0 percent for those assigned to medical therapy.

Table 4. Mortality among Study Patients.*

Outcome and Subgroup	Revascularization	Medical Therapy	Difference between Groups (95% CI)	Relative Risk (95% CI)	P Value
	percent (number in subgroup)		percent		
30-day mortality					
Total	46.7 (152)	56.0 (150)	−9.3 (−20.5 to 1.9)	0.83 (0.67 to 1.04)	0.11
Age <75 yr	41.4 (128)	56.8 (118)	−15.4 (−27.8 to −3.0)	0.73 (0.56 to 0.95)	0.01†
Age ≥75 yr	75.0 (24)	53.1 (32)	+21.9 (−2.6 to 46.4)	1.41 (0.95 to 2.11)	
6-mo mortality‡					
Total	50.3 (151)	63.1 (149)	−12.8 (−23.2 to −0.9)	0.80 (0.65 to 0.98)	0.027
Age <75 yr	44.9 (127)	65.0 (117)	−20.1 (−31.6 to −7.1)	0.70 (0.56 to 0.89)	0.003†
Age ≥75 yr	79.2 (24)	56.3 (32)	+22.9 (0.7 to 46.6)	1.41 (0.97 to 2.03)	

*CI denotes confidence interval.

†Appropriate subgroup-analysis P values (for the interaction between treatment and the subgroup variable) are shown. Univariate P values for the comparison between treatments within subgroups were as follows: for 30-day mortality, P=0.02 for patients <75 years of age and P=0.16 for those ≥75 years of age; and for 6-month mortality, P=0.002 for patients <75 years of age and P=0.09 for those ≥75 years of age.

‡The data are based on 300 patients; 2 patients (0.7 percent) were lost to follow-up.

Hochman et al. NEJM, 1999.

CABG for MI and Shock: SHOCK trial CABG vs PCI

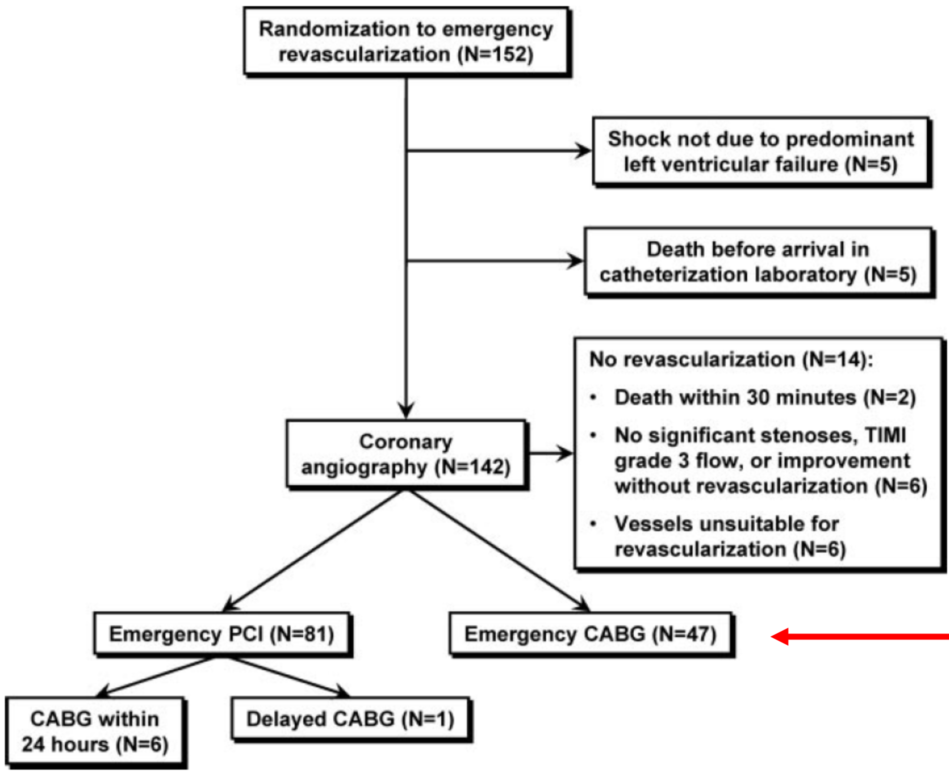
Interventional Cardiology

Comparison of Percutaneous Coronary Intervention and Coronary Artery Bypass Grafting After Acute Myocardial Infarction Complicated by Cardiogenic Shock

Results From the Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock (SHOCK) Trial

Harvey D. White, DSc, FCSANZ; Susan F. Assmann, PhD; Timothy A. Sanborn, MD;
Alice K. Jacobs, MD; John G. Webb, MD; Lynn A. Sleeper, ScD;
Cheuk-Kit Wong, MD, FCSANZ; James T. Stewart, MD, FCSANZ;
Philip E.G. Aylward, MD, FCSANZ; Shing-Chiu Wong, MD; Judith S. Hochman, MD

CABG for MI and Shock: SHOCK trial CABG vs PCI



Recommendations were made for intervention but decision made at the discretion of the care team

White et al., Circulation, 2005.

CABG for MI and Shock: SHOCK trial CABG vs PCI

TABLE 1. Baseline Demographics of Emergency Revascularization Patients With Cardiogenic Shock Resulting From Predominant Left Ventricular Failure

	PCI (n=81)	CABG (n=47)	*P*
Age, y*	64.8±10.2	65.3±9.8	0.75
Age ≥75 y, %	12.3	12.8	1.00
Male, %	63.0	70.2	0.45
Race, %			0.43
White	80.2	83.0	
Black	4.9	4.3	
Asian	6.2	10.6	
Unknown	8.6	2.1	
Smoker, %	56.5	51.1	0.70
Previous hypertension, %	52.5	51.1	1.00
Diabetes, %	26.9	48.9	0.02
Elevated cholesterol level, %	40.4	40.0	1.00
Peripheral vascular disease, %	13.8	21.2	0.39
Previous renal failure, %	4.9	6.5	0.70
Previous heart failure, %	5.1	2.1	0.65
Previous AMI, %	24.7	36.2	0.22
Previous CABG, %	3.7	0.0	0.30
Previous PCI, %	10.3	6.4	0.53
AMI location, %			<0.01
Anterior	62.0	57.4	
Inferior	36.7	27.7	
Other	1.3	14.9	

*Mean±SD.

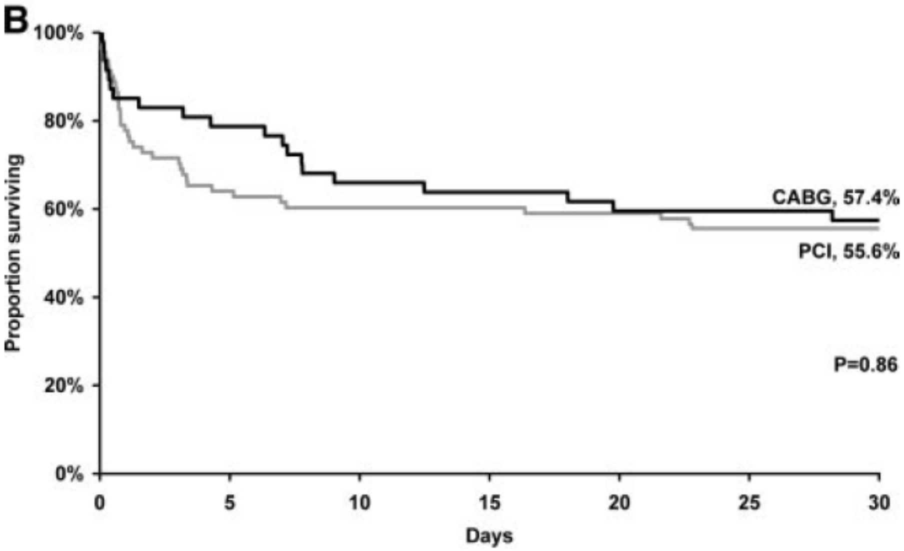
TABLE 3. Revascularization Modality Shown According to Extent and Severity of Coronary Disease

	PCI (n=81), %	CABG (n=47), %	*P*
≥50% Stenosis in left main coronary artery	13.0	41.3	0.001
3-Vessel disease	60.3	80.4	0.03
Either left main or 3-vessel coronary disease	60.3	82.6	0.01
No left main coronary disease			
Number of diseased vessels			0.08
1	22.4	3.7	
2	23.9	25.9	
3	53.7	70.4	
Number of additional occlusions (other than infarct-related artery)			0.41
0	70.3	56.0	
1	21.9	36.0	
2	7.8	8.0	
Number of >90% stenoses in non–infarct-related arteries			0.36
0	64.1	48.0	
1	26.6	40.0	
2	9.4	12.0	

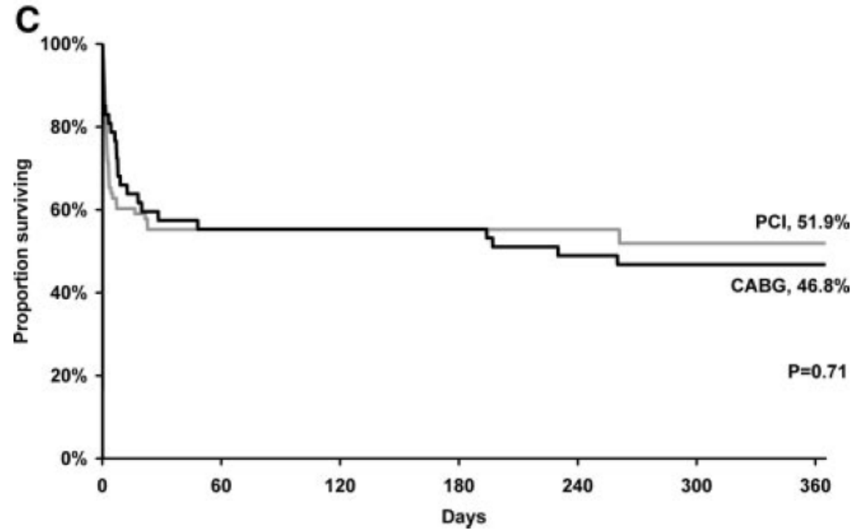
White et al., Circulation, 2005.

CABG for MI and Shock: SHOCK trial CABG vs PCI

30-Day Survival



1-Year Survival



White et al., Circulation, 2005.

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Temporal Trends in Predictors of Early and Late Mortality After Emergency Coronary Artery Bypass Grafting for Cardiogenic Shock Complicating Acute Myocardial Infarction

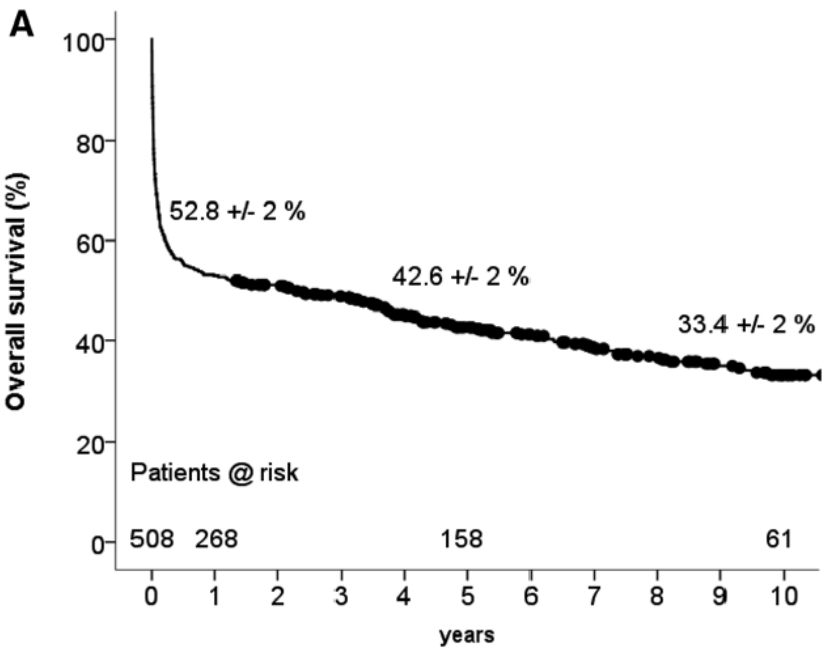


Table 4. Multivariable Predictors of In-Hospital Mortality

Variables	Odds Ratio	95% CI	*P*
Serum lactate >4 mmol/L	4.78	2.88–7.95	0.0001
STEMI	2.10	1.36–3.26	0.001
Age >75 y	2.01	1.06–3.85	0.03
LVEF <30%	1.83	1.15–2.91	0.01
LVEF ≥50%	0.48	0.24–0.97	0.04
2000–2004*	2.44	1.41–4.21	0.001
2005–2009*	1.32	0.73–2.36	0.35

Davierwala et al, Circulation, 2016.

CABG for MI and Shock: real world results

Early Clinical Outcomes of Surgical Myocardial Revascularization for Acute Coronary Syndromes Complicated by Cardiogenic Shock: A Report From the North-Rhine-Westphalia Surgical Myocardial Infarction Registry

Oliver J. Liakopoulos, MD; G. Schlachtenberger, MD; Daniel Wendt, MD; Yeong-Hoon Choi, MD; Ingo Slottosch, MD; Henryk Welp, MD; Wolfgang Schiller, MD; Sven Martens, MD; Armin Welz, MD; Markus Neuhäuser, PhD; Heinz Jakob, MD; Thorsten Wahlers, MD; Matthias Thielmann, MD

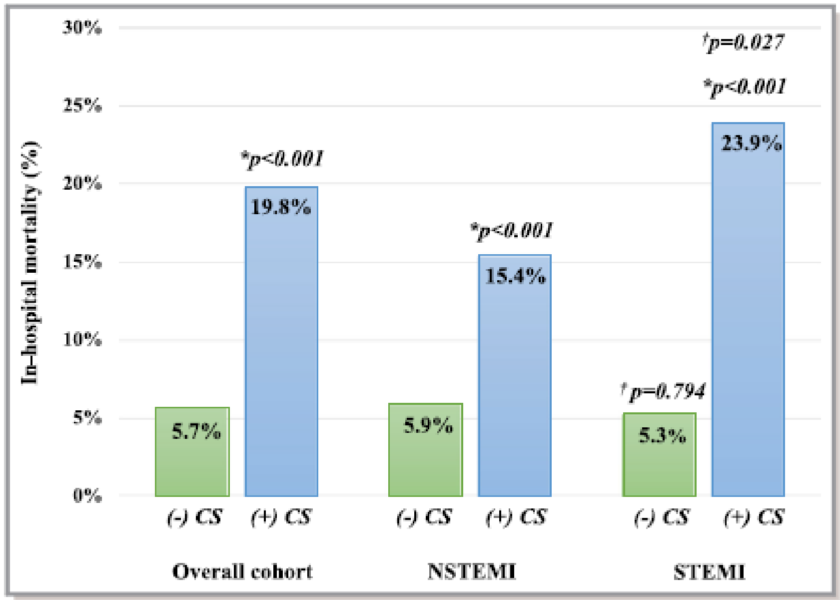


Figure 1. In-hospital mortality stratified by the presence of cardiogenic shock. * indicates *P* value compared with the corresponding ACS group without CS; † indicates *P* value compared with the corresponding NSTEMI group; ACS indicates acute coronary syndrome; + or – CS, with or without cardiogenic shock; NSTEMI, non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction.

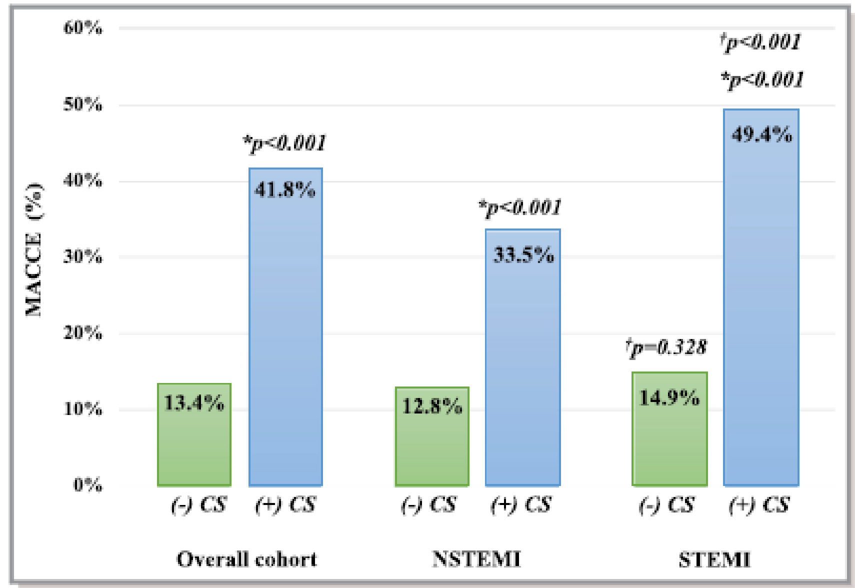


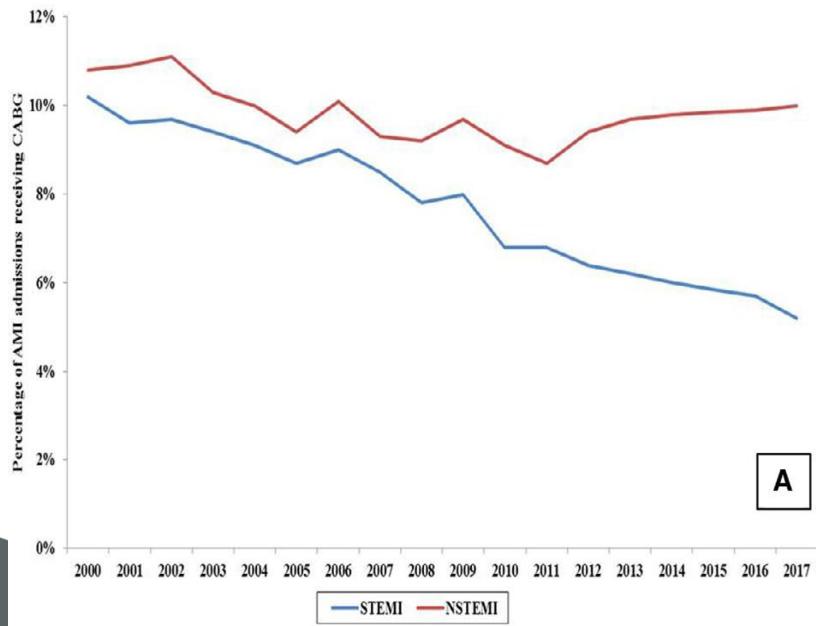
Figure 2. Major adverse cardiocerebral events (MACCEs) stratified by the presence of cardiogenic shock. * indicates *P* value compared with the corresponding ACS group without CS; † indicates *P* value compared with the corresponding NSTEMI group; + or – CS indicates with or without cardiogenic shock; NSTEMI, non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction.

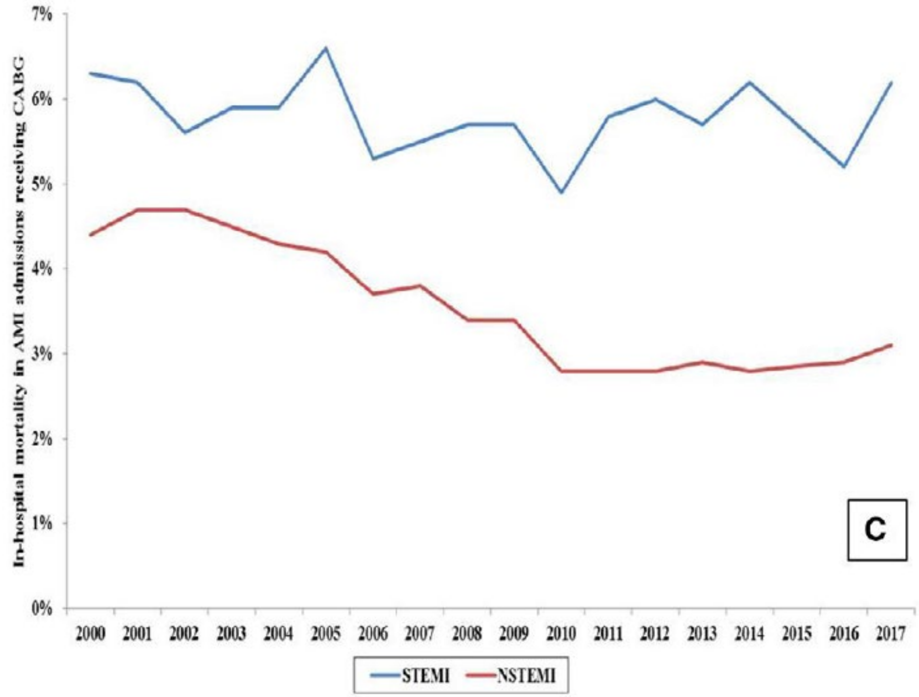
Liakopoulos et al, J Am Heart Assoc, 2019.

CABG for MI and Shock: patterns of use

Temporal Trends, Clinical Characteristics, and Outcomes of Emergent Coronary Artery Bypass Grafting for Acute Myocardial Infarction in the United States

Sri Harsha Patlolla, MBBS;* Ardaas Kanwar, BA;* Wisit Cheungpasitporn, MD; Rajkumar P. Doshi, MD, MPH; John M. Stulak, MD; David R. Holmes, Jr, MD; Malcolm R. Bell, MD; Mandeep Singh, MD, MPH; Saraschandra Vallabhajosyula, MD, MSc





Patlolla et al, J Am Heart Assoc, 2021.

CABG for MI and Shock: when is it indicated?

Table 2
Key Class I European and North American Guidelines on CABG in Cardiogenic Shock

	European	North American
Revascularization	• Emergency echocardiography is indicated to assess LV and valvular function and exclude mechanical complications. • Emergency invasive evaluation is indicated in patients with acute heart failure or cardiogenic shock complicating ACS. • Emergency PCI is indicated for patients with cardiogenic shock owing to STEMI or NSTE-ACS if coronary anatomy is amenable. • Emergency CABG is recommended for patients with cardiogenic shock if the coronary anatomy is not amenable to PCI.	• Placement of a pulmonary artery catheter is indicated, preferably before the induction of anesthesia or surgical incision, in patients in cardiogenic shock undergoing CABG. • Emergency CABG is recommended in patients with acute MI in whom (1) primary PCI has failed or cannot be performed, (2) coronary anatomy is suitable for CABG, and (3) persistent ischemia of a significant area of myocardium at rest and/or hemodynamic instability refractory to nonsurgical therapy is present. • Emergency CABG is recommended in patients with cardiogenic shock and who are suitable for CABG irrespective of the time interval from MI to onset of shock and time from MI to CABG.
Mechanical complications	• Emergency surgery for mechanical complications of acute MI is indicated in case of hemodynamic instability. • Patients with mechanical complication after acute MI require immediate discussion by the heart team.	• Emergency CABG is recommended in patients undergoing surgical repair of a postinfarction mechanical complication of MI, such as ventricular septal rupture, mitral valve insufficiency owing to papillary muscle infarction, and/or rupture or free wall rupture.
Failed PCI	No specific recommendation	• Emergency CABG is recommended after failed PCI for hemodynamic compromise in patients without impairment of the coagulation system and without a previous sternotomy.
Salvage CABG	No specific recommendation	• CABG is recommended in patients with resuscitated sudden cardiac death or sustained ventricular tachycardia thought to be caused by significant CAD (>50% stenosis of left main coronary artery and/or >70% stenosis of 1, 2, or all 3 epicardial coronary arteries) and resultant myocardial ischemia

Abbreviations: CABG, coronary artery bypass graft; CAD; LV, left ventricular; MI, myocardial infarction; NSTE-ACS; PCI, percutaneous coronary intervention; STEMI.

Inbrahim et al, Journal of Cardiothoracic and Vasc Anesthesia, 2019.

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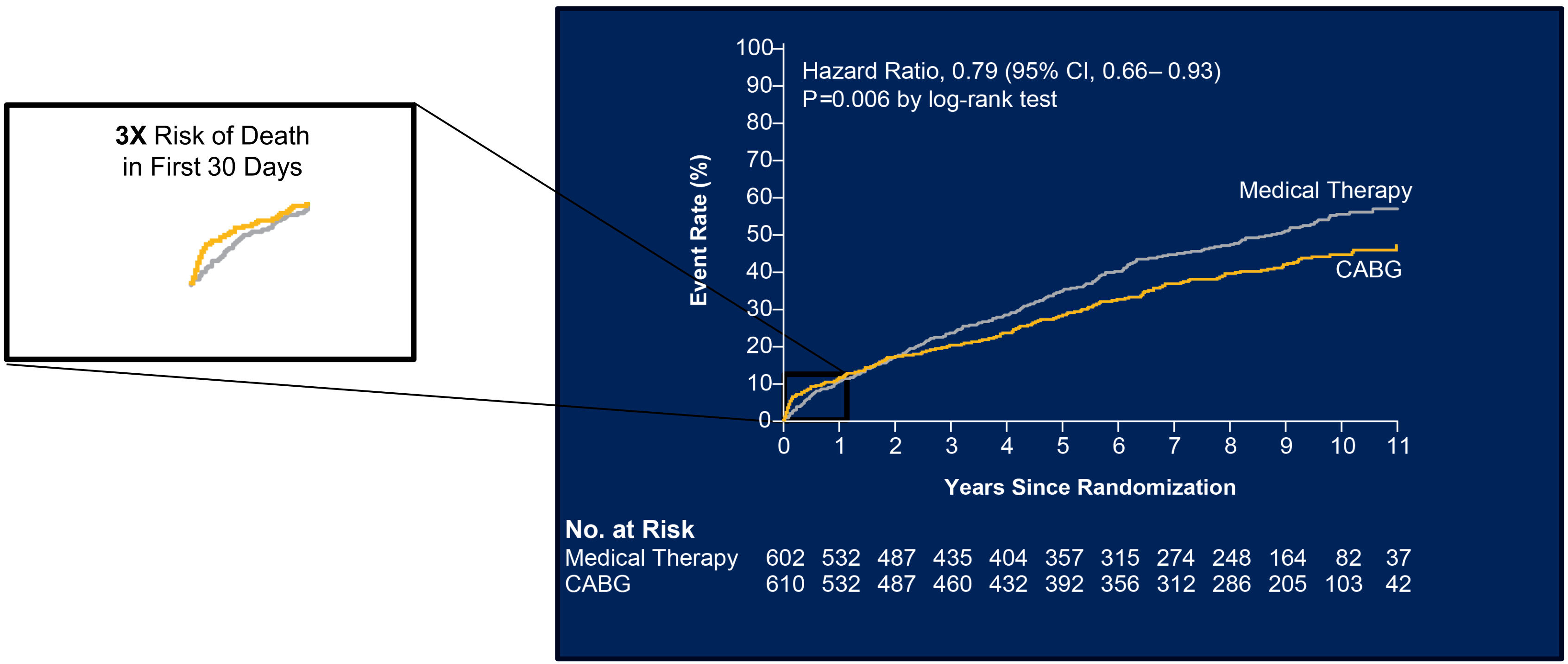
Identifying the Early Hazard Of Surgery

“When patients are treated with CABG and intensive medical therapy for coronary artery disease and left ventricular dysfunction, they are exposed to an early risk as a result of the surgical intervention.”

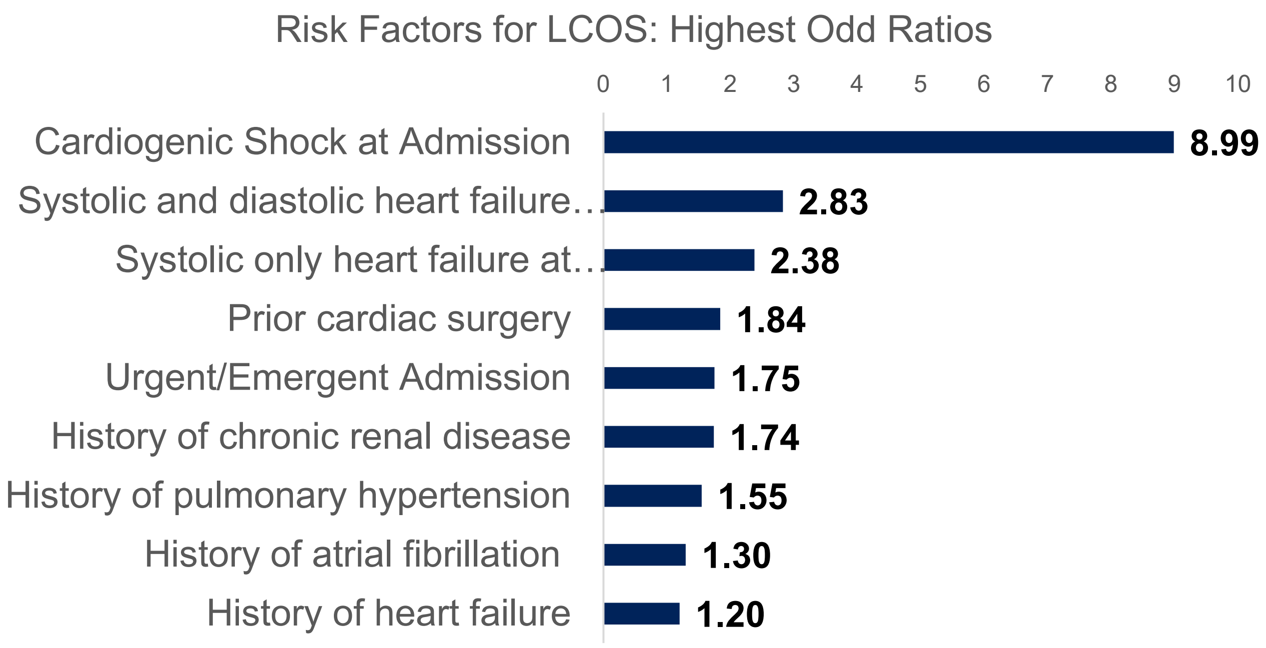
STICH Trial Death from Cardiovascular Causes



Velazquez, E. et al. (2016). N Engl J Med, 374(16), 1511-20.

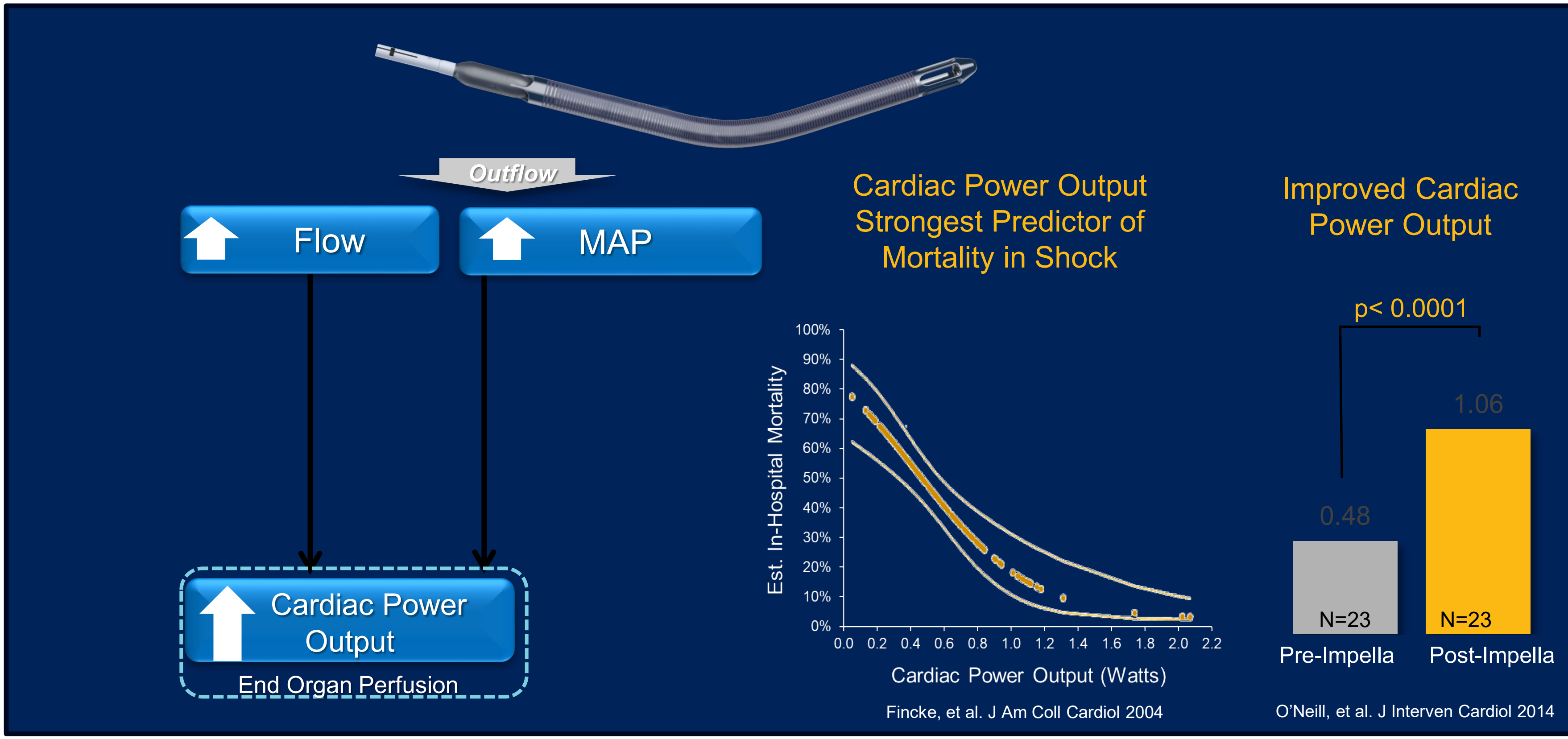
Identifying the Early Hazard Of Surgery

Identifying certain risk factors that can contribute to LCOS may inform the decision on treatment options



Duncan, A. et al. (2022). J Thorac Cardiovasc Surg, 163(5), 1890-1898.e10

Mitigating risks of CABG in cardiogenic shock: mechanical circulatory support



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Summary

- AMI complicated by cardiogenic shock is common and associated with a high mortality.
- Results from the shock trial demonstrate that early revascularization is beneficial in AMI/CS and that mortality with CABG may approximate that seen with PCI.
- Real world data shows that mortality after CABG for AMI/CS is high.
- PCI is the mainstay of treatment for AMI/CS, but CABG is indicated for those not amenable to PCI, failed PCI, or for patients undergoing surgery for mechanical complications.
- Left ventricular unloading may be useful to mitigate low cardiac output syndrome in the perioperative period, but further study is required.