How does Coronary Artery Bypass Grafting work?

Gabriel Olivares, MD
Cardiac Surgeon, MHI
CABG Volume STS report 2021

259,162 Procedures

CABG 153,208

Volumen Isolated CABG: STS Database
31,000+ CABG patients randomized versus medical treatment, PCI or different surgical techniques
Natural History Coronary Artery Disease

Coronary Heart Disease in US

Prevalence of CHD by Age and Sex

Percent of population

20-39 40-59 60-79 80+

Males Females

0.6 6.9 22 33.9
0.9 6.6 13.4 21.6

Circulation. 2023;148:e9–e119
Natural History Coronary Atherosclerosis Progression with respect to anatomical location

Impact of Risk Factors on Coronary Atherosclerosis Progression
Impact of Risk Factors on Coronary Atherosclerosis Progression

- **Hyperlipidemia**
- **No hyperlipidemia**

Impact of Risk Factors on Coronary Atherosclerosis Progression

- **CAD**
- **No CAD**

*J Am Heart Assoc. 2022;11:e026396*
Impact of Risk Factors on Coronary Atherosclerosis Progression

Plaque progression (%)

Time from index coronary angiography (Year)

> Four
Three
Two
One
Zero

J Am Heart Assoc. 2022;11:e026396

Natural History Coronary Artery Disease

Major Adverse Cardiovascular Events in 697 patients with ACS

Cumulative Rate (%)

All events 20.4
CL related events 12.9
NCL related events 11.6

Ischemia Trial
3.2 years mean follow-up

All-Cause Mortality

- $3V \geq 70\%$ or $2V \geq 70\%$ w/ prox LAD
- $2V \geq 70\%$ or $3V \geq 50\%$ or $70\%$ prox LAD
- $1V \geq 70\%$ or $2V \geq 50\%$
- $1V \geq 50\%$

Medical Treatment vs CABG
70s RCTs
CABG vs Medical Treatment
Meta-analysis 70s RCT studies

CABG
Medical Treatment

Cumulative Mortality Rate %

Time from Randomization (Years)

Lancet 1994

CASS Study

1 Vessel
2 Vessel
3 Vessel

100
80
60
40
20
0

%

Years

P = .45
P = .40
P = .0094

1 2 3 4 5 6 7
1 2 3 4 5 6 7
1 2 3 4 5 6 7

CABG
Medical
CABG
Medical
CABG
Medical

N Eng J Med 1985
VA Study

High Risk

Low Risk

P = .002

P = .156

CABG
Medical

CABG
Medical

Years

N Eng J Med 1984

ECSS Study

No LAD stenosis

LAD stenosis

P = .2

P = .007

CABG
Medical

CABG
Medical

Years

N Eng J Med 1988
MASS II: Probability of Survival free of total mortality, unstable angina requiring revasc, or Q-wave MI

Probability of Event Free Survival

Month after study entry

P=0.0026


BARI 2D

Freedom from major Cardiovascular events

CABG

Medical

P = 0.01

N Eng J Med 2009
**STICHES: All-Cause Mortality**

![Graph showing event rate over years since randomization for Medical Therapy and CABG, with HR 0.84 (0.73 – 0.97) and P = 0.02.](image)

Evaluation revascularization strategies

Controversy Interpretation Results

MACE vs MACCE
Repeat Revascularization

Myocardial Infarction:
(Definitions & Peri-procedural vs Spontaneous)

All-Cause Mortality vs Cardiac Death

Myocardial Infarction
Rates of Peri-procedural MI according to Definitions: SYNTAX Trial

Impact of Peri-procedural MI on All-cause Mortality expressed as HR

SCAI or EXCEL
At 1 year
PCI arm
CABG arm
At 10 year
PCI arm
CABG arm
Impact of Peri-procedural MI on All-cause Mortality expressed as HR

4th UDMI
At 1 year
PCI arm
CABG arm
At 10 year
PCI arm
CABG arm

Peri-procedural vs Spontaneous

J Am Coll Cardiol 2020;76:1622–39
ACUITY Trial: Impact Spontaneous vs Periprocedural Myocardial Infarction

![ACUITY Trial Graph](image)

Days from Randomization
Cumulative Mortality (%)

Spontaneous MI
Periprocedural MI
PCI without MI

J Am Coll Cardiol 2009;54:477–86

Ischemia Trial
Prognosis of MI types

All-Cause Death

- Procedural MI
- Procedural type 4a or 5 MI
- Procedural MI (INV only)
- Type 4b/c MI
- Type 1 MI

Circulation 2021; 143:790-804
5-year follow-up: Spontaneous Myocardial Infarction

<table>
<thead>
<tr>
<th>Study</th>
<th>CABG</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNTAX</td>
<td>3.8</td>
<td>9.7</td>
</tr>
<tr>
<td>EXCEL</td>
<td>4.7</td>
<td>9.6</td>
</tr>
<tr>
<td>NOBLE</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>FREEDOM</td>
<td>6</td>
<td>13.9</td>
</tr>
</tbody>
</table>

Cumulative Incidence (%)

Spontaneous Myocardial Infarction: Left Main RCTs

HR 2.35 (95% CI 1.71 – 3.23)
P<0.0001

Follow-up (Years)

Lancet 2021; 398: 2247–57
LAD: MI Locations vs Graft Insertions

Density

Millimeters (mm)

MI Locations

Graft Insertion

Am Heart J 2010;160:195-201
All-cause Mortality

Systematic review CABG vs PCI

All-cause Mortality

Mean Follow-up 3.8 years

HR 1.20
95% CI 1.06-1.37
p=0.0038

PCI

CABG

11.2%
9.2%

Follow-up (Years)

Lancet 2018; 391: 939–48
All-cause Mortality: Multivessel Disease

Mean Follow-up 3.8 years

HR 1.28
95% CI 1.09-1.49
p=0.0019

PCI

CABG

11.5%
8.9%

Cumulative Mortality (%)
Follow-up (Years)

Lancet 2018; 391: 939–48

All-cause Mortality: Patients with Diabetes

Mean Follow-up 3.8 years

HR 1.44
95% CI 1.20-1.74
p=0.0001

PCI

CABG

15.7%
10.7%

Cumulative Mortality (%)
Follow-up (Years)

Lancet 2018; 391: 939–48
Left Main:
All-cause Mortality

Cumulative Incidence (%)

Follow-up (Years)

PCI
CABG

HR 1.10 (95% CI 0.91 – 1.32)
P=0.33

Cumulative Incidence (%)

Follow-up (Years)

PCI
CABG

Probability 85.7% that mortality with PCI >CABG

Total mortality difference (PCI – CABG)

Lancet 2021; 398: 2247–57

Lancet 2021; 398: 2247–57
EXCEL: Piecewise analysis for the MACE (All-cause mortality, stroke, myocardial infarction)


EXCEL: Piecewise analysis for the MACE (All-cause mortality, stroke, myocardial infarction)

**EXCEL: Piecewise analysis for the MACE (All-cause mortality, stroke, myocardial infarction)**

- **CABG**
  - 0.8% at 1 month
  - 4.9% at 12 months
  - 15.1% at 60 months
- **PCI**
  - 4.1% at 1 month
  - 3.8% at 12 months
  - 9.7% at 60 months

**HR 1.61 (1.23-2.12)**

*N Engl J Med 2019;381:1820-30*

---

**All-cause Mortality**

**EXCEL trial**

- **PCI**
  - 0% at 0-30 days
  - 2% at 30 days - 1 year
  - 8% at 1 year - 5 years
- **CABG**
  - 2% at 0-30 days
  - 4% at 30 days - 1 year
  - 4% at 1 year - 5 years

**HR 1.57 (1.12–2.19)**

*N Engl J Med 2019;381:1820-30*
Results as a Team

PCI / CABG Ratio

Balance ratio
Better outcomes

Rene Favaloro
Optimal medical therapy at 5 years after CABG

![Graph showing all-cause mortality over years since randomization for Non-APD and APD groups.](image)

Log-rank $p=0.001$

- Non-APD: 25%
- APD: 10.4%
Optimal medical therapy at 5 years after CABG

All-Cause Mortality (%)

Years Since Randomization

Log-rank p=0.001

Non-Statin

Statin

27.6%

9.8%

J Am Coll Cardiol 2021;78:27–38
10-Year Survival
Patients Three-Vessels Disease

% 1 2 3 4 5 6 7 8 9 10
70 80 90 100

P<0.0001

ITA 82.6%
SVG 71%


Bilateral Internal Thoracic Arteries
Survival and Reoperation

Survival (%)
Reoperation (%/year)

P< .0001

BITA SITA

High Risk of DSWI

- Female
- Medically treated DM
- PAD
- MI

Deep SWI

Radial Artery vs Saphenous Vein Graft

6 RCTs, Mean Follow-up 60 months

MACCE   Death   MI   Repeat   Occlusion

P=0.01   P=0.68   P=0.04   P<0.001

N Eng J Med 2018
**RAPCO Study: RITA vs Radial**

**Graft Failure**

- **HR 0.45 (95% CI 0.23 – 0.88)**
- **p=0.018**

*Circulation. 2020;142:1330–1338*
Long Term Graft Patency
ITA & SVG patency by coronary system

ITA Patency at 10 years
MHI: Second Arterial Graft

<table>
<thead>
<tr>
<th></th>
<th>BITA</th>
<th>Radial</th>
</tr>
</thead>
<tbody>
<tr>
<td>STS</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>2021</td>
<td>9.52</td>
<td>8.6</td>
</tr>
<tr>
<td>2022</td>
<td>11.86</td>
<td>10.8</td>
</tr>
<tr>
<td>2023 (Q1-Q3)</td>
<td>14.24</td>
<td>16.3</td>
</tr>
</tbody>
</table>

83