PCI for Left Main Coronary Artery Stenosis

Jean Fajadet
Clinique Pasteur, Toulouse, France

Athens, October 19, 2018
Significant unprotected left main coronary artery disease occurs in 5-7% of patients undergoing coronary angiography.

The LMS supplies 84% of the blood flow to the LV in a right dominant system (with 16% supplied by the RCA) and 100% of the blood flow to the LV in a left dominant system.
Left Main Coronary Artery Disease

*Distribution of the atherosclerotic plaque*

Plaque is located in the lateral wall (area of low shear stress) while sparing the flow divider region (high shear)
90% of distal LMCA plaque is extended into proximal LAD
Left Main Coronary Artery Disease

- Distal location >70% of cases
- Calcified >50% of cases
- MVD >70% of cases
CABG vs MED Rx in LMCD at 5 yrs

150 pts

Medical Rx: 36.5% Mortality

CABG: O.R. = 0.32 (0.15 to 0.70)  
\[ p = 0.004 \]

TRANSLUMINAL DILATATION OF CORONARY-ARTERY STENOSIS

Andreas Grüntzig

Lancet 1978;1:263
“We have not been too successful in dilating stenotic main stems of left coronary arteries. It has been difficult to estimate the extent of disease in this area and the presence of concomitant spasm. We feel that these factors contributed to the death of one patient two months after dilatation.”
Revascularisation for Left Main Lesion

Basics for decision-making

- Knowledge
  Data from RCT’s, registries, meta-analysis
  Guidelines

- Evolution of Technology & Techniques

- Experience
  Results from local heart team

- Global appraisal of the Patient

Clinical Judgment
Revascularisation for Left Main Lesion

Basics for decision-making

- Knowledge
  Data from RCT’s, registries, meta-analysis
  Guidelines

- Evolution of Technology & Techniques

- Experience
  Results from local heart team

- Global appraisal of the Patient
Vessel Distribution in LM Population According to Syntax Score Terciles

- Low Syntax: 0-22
  - LM + 3VD: 61%
  - LM + 2VD: 35%
  - LM + 1VD: 4%
  - LM isolated: 10%

- Intermediate Syntax: 23-32
  - LM + 3VD: 29%
  - LM + 2VD: 59%
  - LM + 1VD: 11%
  - LM isolated: 2%

- High Syntax: 33+
  - LM + 3VD: 27%
  - LM + 2VD: 66%
  - LM + 1VD: 7%
  - LM isolated: 6%

Legend:
- Red: LM + 3VD
- Orange: LM + 2VD
- Green: LM + 1VD
- Light Green: LM isolated

Legend for Pie Charts:
- Teal: Nondistal
- Purple: Distal
- Blue: Both
SYNTAX – Left Main

MACCE at 5-year follow-up

CABG = 31.0%, PCI = 36.9%, p = 0.12
Death of any cause, MI, or stroke  
MACCE

Ahn et al. J Am Coll Cardiol 2015;65:2198–206
Outcomes After PCI or CABG in Patients With Unprotected Left Main Disease – Meta analysis of SYNTAX & PRECOMBAT

<table>
<thead>
<tr>
<th>Outcome</th>
<th>PCI (%)</th>
<th>CABG (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACCE</td>
<td>28.3</td>
<td>23</td>
<td>0.045</td>
</tr>
<tr>
<td>Death</td>
<td>9.4</td>
<td>11.1</td>
<td>0.27</td>
</tr>
<tr>
<td>Cardiac death</td>
<td>6.2</td>
<td>6.8</td>
<td>0.61</td>
</tr>
<tr>
<td>MI</td>
<td>5.2</td>
<td>3.2</td>
<td>0.10</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.1</td>
<td>2.5</td>
<td>0.06</td>
</tr>
<tr>
<td>Death, MI, stroke</td>
<td>14</td>
<td>15.1</td>
<td>0.45</td>
</tr>
<tr>
<td>All revascularisation</td>
<td>19.5</td>
<td>10.8</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Temporal Trends in Revascularization Strategy and Outcomes in Left Main Coronary Artery Stenosis
Data From the Asan Medical Center-Left Main Revascularization Registry

Left Main Stenosis

The new evidence in 2016

NOBLE & EXCEL trials
NOBLE study

PCI (Biomatrix, Biolimus) vs CABG
1201 patients
Randomisation: 1 to 1 ratio
LM and no more than 3 additional non complex PCI lesions
Primary end point:
  Composite of all-cause mortality, non procedural MI, stroke, repeat revasc. (MACCE) at 5 years
PCI versus CABG in treatment of unprotected left main stenosis (NOBLE): a prospective, randomised, open-label, non-inferiority trial

Primary end point: MACCE at 5 years

PCI: 29\%, CABG: 19\%, \(p=0.0066\)

Mäkikallio et al. Lancet 2016
PCI versus CABG in treatment of unprotected left main stenosis (NOBLE): a prospective, randomised, open-label, non-inferiority trial

**Mortality**
12% vs 9%, $p=0.77$

**Myocardial infarction**
7% vs 2%, $p=0.004$

Mäkikallio et al. Lancet 2016
PCI versus CABG in treatment of unprotected left main stenosis (NOBLE): a prospective, randomised, open-label, non-inferiority trial

Repeat revascularisation
16% vs 10%, $p=0.032$

Stroke
5% vs 2%, $p=0.073$

Mäkikallio et al. Lancet 2016
Kaplan-Meier 5 year estimates of MACCE were 29% for PCI (121 events) and 19% for CABG (81 events), HR 1.48 (95% CI 1.11–1.96), exceeding the limit for non-inferiority, and CABG was significantly better than PCI (p=0.0066).

The findings of this study suggest that CABG might be better than PCI for treatment of left main stem coronary artery disease.

Mäkikallio et al. Lancet 2016
EXCEL study

PCI (Xience, Everolimus) vs CABG
1905 patients
Randomisation: 1 to 1 ratio
Syntax score < 33
Non inferiority trial
Primary end point:
    Composite of mortality, MI, stroke at 3 years
Everolimus-Eluting Stents or Bypass Surgery for Left Main Coronary Artery Disease

EXCEL Trial

Primary end point: Death, MI, Stroke at 3 years

Everolimus-Eluting Stents or Bypass Surgery for Left Main Coronary Artery Disease

EXCEL Trial

Components of the Primary end point at 3 years

In patients with left main coronary artery disease and low or intermediate SYNTAX scores by site assessment, PCI with everolimus-eluting stents was noninferior to CABG with respect to the rate of the composite end point of death, stroke, or myocardial infarction at 3 years.

Everolimus-Eluting Stents or Bypass Surgery for Left Main Coronary Artery Disease
EXCEL Trial

*Death, Stroke, MI at 30 days*

<table>
<thead>
<tr>
<th></th>
<th>PCI (%)</th>
<th>CABG (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death, stroke, MI</td>
<td>4.9</td>
<td>7.9</td>
<td>0.008</td>
</tr>
<tr>
<td>Death</td>
<td>1.0</td>
<td>1.1</td>
<td>0.82</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.6</td>
<td>1.3</td>
<td>0.15</td>
</tr>
<tr>
<td>MI</td>
<td>3.9</td>
<td>6.2</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Everolimus-Eluting Stents or Bypass Surgery for Left Main Coronary Artery Disease
EXCEL Trial

Revascularisation & MACCE

<table>
<thead>
<tr>
<th></th>
<th>PCI (%)</th>
<th>CABG (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemia-driven revascularisation</td>
<td>12.6</td>
<td>7.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TVR</td>
<td>10.9</td>
<td>7.2</td>
<td>0.006</td>
</tr>
<tr>
<td>non TVR</td>
<td>2.5</td>
<td>0.7</td>
<td>0.004</td>
</tr>
<tr>
<td>All revascularisation</td>
<td>12.9</td>
<td>7.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MACCE</td>
<td>23.1</td>
<td>19.1</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Comparison between EXCEL (at 3 yrs) and NOBLE (at 5 years)

<table>
<thead>
<tr>
<th>Trial and Outcome</th>
<th>No. of Pts</th>
<th>Hazard Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXCEL, 3-yr results</td>
<td>1905</td>
<td></td>
</tr>
<tr>
<td>Death, stroke, or myocardial infarction</td>
<td></td>
<td>1.00 (0.79-1.26)</td>
</tr>
<tr>
<td>Death</td>
<td></td>
<td>1.34 (0.94-1.91)</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td>0.77 (0.43-1.37)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td></td>
<td>0.93 (0.67-1.28)</td>
</tr>
<tr>
<td>Revascularization</td>
<td></td>
<td>1.72 (1.27-2.33)</td>
</tr>
<tr>
<td>NOBLE, 5-yr results</td>
<td>1201</td>
<td></td>
</tr>
<tr>
<td>Death, stroke, myocardial infarction, or</td>
<td></td>
<td>1.46 (1.10-1.95)</td>
</tr>
<tr>
<td>revascularization</td>
<td></td>
<td>1.04 (0.65-1.67)</td>
</tr>
<tr>
<td>Death</td>
<td></td>
<td>2.25 (0.92-5.48)</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td>2.88 (1.40-5.90)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td></td>
<td>1.50 (1.04-2.17)</td>
</tr>
<tr>
<td>Revascularization</td>
<td></td>
<td>0.1-10.0</td>
</tr>
</tbody>
</table>

ESC Congress Munich 2018

Mauri L., D’Agostino RB Sr.
NEJM 2017;377:1357
Why different results between NOBLE and EXCEL?

<table>
<thead>
<tr>
<th>EXCEL study</th>
<th>NOBLE study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xience stent</td>
<td>Biomatrix Stent</td>
</tr>
<tr>
<td>3 years FU</td>
<td>5 years FU</td>
</tr>
<tr>
<td>PEP: All MI</td>
<td>PEP: Only non procedural MI</td>
</tr>
<tr>
<td>PEP without repeat revasc.</td>
<td>PEP with repeat revasc.</td>
</tr>
</tbody>
</table>

Positive Study
Non Inferiority of PCI

Negative study
No Non inferiority of PCI

Stone et al, NEJM 2016
Mäkikallio et al, Lancet 2016
# 2018 ESC/EACTS Guidelines on myocardial revascularization

The Task Force on myocardial revascularization of the European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS)

Developed with the special contribution of the European Association for Percutaneous Cardiovascular Interventions (EAPCI)

Authors/Task Force Members: Franz-Josef Neumann* (ESC Chairperson) (Germany), Miguel Sousa-Uva* (EACTS Chairperson) (Portugal), Anders Ahlsson (Sweden), Fernando Alfonso (Spain), Adrian P. Banning (UK), Umberto Benedetto (UK), Robert A. Byrne (Germany), Jean-Philippe Collet (France), Volkmar Falk (Germany), Stuart J. Head (The Netherlands), Peter Jüni (Canada), Adnan Kastrati (Germany), Akos Koller (Hungary), Steen D. Kristensen (Denmark), Josef Niebauer (Austria), Dimitrios J. Richter (Greece), Petar M. Seferovic (Serbia), Dirk Sibbing (Germany), Giulio G. Stefanini (Italy), Stephan Windecker (Switzerland), Rashmi Yadav (UK), Michael O. Zembala (Poland)

Document Reviewers: William Wijns (ESC Review Co-ordinator) (Ireland), David Glinner (EACTS Review Co-ordinator) (Canada), Victor Aboyans (France), Stephan Achenbach (Germany), Stefan Agewall (Norway), Felicita Andreotti (Italy), Emanuele Barbato (Italy), Andreas Baumbach (UK), James Brophy (Canada), Héctor Bueno (Spain), Patrick A. Calvert (UK), Davide Capodanno (Italy), Piroze M. Davierwala

## Recommendations according to extent of CAD

<table>
<thead>
<tr>
<th>Left main CAD</th>
<th>CABG</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left main disease with low SYNTAX score (0 - 22).</strong> 69,121,122,124,145–148</td>
<td>I A</td>
<td>I A</td>
</tr>
<tr>
<td><strong>Left main disease with intermediate SYNTAX score (23 - 32).</strong> 69,121,122,124,145–148</td>
<td>I A</td>
<td>I Ia A</td>
</tr>
<tr>
<td><strong>Left main disease with high SYNTAX score (≥33).</strong> 69,121,122,124,146–148</td>
<td>I A</td>
<td>I III B</td>
</tr>
</tbody>
</table>
Revascularisation for Left Main Lesion

Basics for decision-making

Knowledge
Data from RCT’s, registries, meta-analysis
Guidelines

Evolution of Technology & Techniques

Experience
Results from local heart team

Global appraisal of the Patient

Clinical Judgment
Global appraisal of the patient (1)

Clinical characteristics:
- Age, gender, cognitive status
- Way of life, socio-cultural considerations
- Functional class
- Diabetes & other risk factors of CAD
- Previous cardio-vascular intervention
- Valvular disease, heart failure,
- COPD,
- Renal failure
- Peripheral artery disease, carotid artery lesions
- Other comorbidities
- No contra-indication for long term DAPT
Global appraisal of the patient (2)

- Angiographic characteristics:
  - LVEF
  - LM lesion: distal /non distal
calcification, bifurcation angle, diseased LCx ostium
trifurcation
  - MVD, number of lesions, diffuse disease
  - Complexity of additional lesions:
    length, calcifications, bifurcations,
    CTO (RCA occlusion),
  - Complete or incomplete revascularisation.
  - Number of stents needed, overlapping, complex bifurcations
SYNTAX score II

SYNTAX score II

Prediction of the 4-year mortality

Revascularisation for Left Main Lesion

Basics for decision-making

Knowledge
Data from RCT’s, registries, meta-analysis

Guidelines

Evolution of Technology & Techniques

Clinical Judgment

Experience
Results from local heart team

Global appraisal of the Patient
Basics for decision-making

• Local experience of the heart team
  – Evaluation of local practice: CABG & PCI
  – Morbi/mortality meetings
  – Share experience in technique & results
  – Collegial consensus in patient care
Basics for decision-making

Knowledge
Data from RCT’s, registries, meta-analysis
Guidelines

Experience
Results from local heart team

Evolution of Technology & Techniques

Global appraisal of the Patient

Revascularisation for Left Main Lesion
Evolution of the technology & techniques:

- Surgery:
  - Arterial revasc.
  - Midcab

- PCI:
  - DES: new generation (bioadegradable polymer, polymer free)
  - New antiplatelet agents (prasugrel, ticagrelor)
  - Longer DAPT duration

- Hybrid procedures
Key Features of Contemporary DES

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Durable polymer-coated stent</th>
<th>Biodegradable polymer-coated stent</th>
<th>Polymer-free drug-eluting stent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott/Boston</td>
<td>Biotronic</td>
<td>Translumina</td>
<td>B. Braun</td>
</tr>
<tr>
<td>Medtronic</td>
<td>Terumo</td>
<td>Boston</td>
<td>Biosensors</td>
</tr>
<tr>
<td>Xience/Promus</td>
<td>Orsiro</td>
<td>Synergy</td>
<td>BioMatrix</td>
</tr>
<tr>
<td>Resolute</td>
<td>Ultimaster</td>
<td>BioMatrix</td>
<td>Coroflex ISAR</td>
</tr>
<tr>
<td></td>
<td>Yukon Choice PC</td>
<td>Yukon Choice PC</td>
<td>316L-SES/ probucol</td>
</tr>
<tr>
<td>CoCr/PtCr-EES</td>
<td>CoCr-SES</td>
<td>316L-SES</td>
<td>BioFreedom</td>
</tr>
<tr>
<td>CoNi-ZES</td>
<td>CoCr-sES</td>
<td>PtCr-EES</td>
<td>316L-BES</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shape</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle</td>
<td>Circle</td>
<td>Circle</td>
<td>Circle</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strut thickness</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>81 µm</td>
<td>91 µm</td>
<td>60 µm</td>
<td>80 µm</td>
</tr>
<tr>
<td>87 µm</td>
<td>74 µm</td>
<td>120 µm</td>
<td>65 µm</td>
</tr>
<tr>
<td>112 µm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Coating        | | |
|----------------|-------------|
| Circumferential | Abluminal   |

Safety and efficacy of new generation DES

ESC-EAPCI Stent Task Force - Eur Heart J 2015
How do we evaluate the LM diameter?

1. IVUS
2. Murray’s law, fractal law: \( D = 0.67 \times (d_1+d_2) \)

Visual estimation & QCA are not available.
Left Main Stenting

4.0x8mm DES

Final result after post dilatation using a 4.5 mm balloon at 22 atm.
Ostial Left Main Lesion

AP – RAO view

LAO-cranio view
Ostial Left Main Lesion

Direct Stenting

Stent deployment

Balloon post dilatation
Ostial Left Main Lesion

Final result
Mid-shaft Left Main Lesion

AP – caudal view
1 stent technique: Provisional stenting

2-stent technique:
- TAP
- Culotte
- Minicrush, DK Crush
- V stenting
Distal Left Main PCI

Strategy of LM stenting: 1 stent vs 2 stents

Provisional T stenting:
- no lesion at SB ostium
- short < 5mm lesion at SB ostium
- small SB
Distal Left Main PCI

Strategy of LM stenting: 1 stent vs 2 stents

2-stent strategy:
- poor result after provisional stenting
- long lesion beyond SB ostium
- complex stenosis at SB ostium
- diffuse and calcified atheroma
Distal Left Main PCI

2-stent strategy:

- **Bif. angle**
  - $> 60^\circ$: T or **TAP**
  - $< 60^\circ$: Culotte, Minicrush, **TAP**

**MB & SB sizes**

- **Same size**
  - Culotte, **TAP**

- **Different size**
  - Minicrush, **TAP**
Distal Left Main PCI

2-stent strategy

One technique must be perfectly known

The TAP technique
TAP technique
TAP technique
TAP technique
TAP technique
TAP technique
TAP technique
TAP technique
# How to assess & optimize stent deployment

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Pre dilatation: balloon, cutting, rotablator</td>
</tr>
<tr>
<td>2.</td>
<td>Post dilatation: adequate size balloons with high pressure</td>
</tr>
<tr>
<td>3.</td>
<td>KB after 2-stent implantation</td>
</tr>
<tr>
<td>4.</td>
<td>Final POT</td>
</tr>
<tr>
<td>5.</td>
<td>Evaluation of the result: QCA, Stent Boost/Vizz, IVUS, OCT</td>
</tr>
</tbody>
</table>
IVUS for LM ostium evaluation

LMCA OSTIUM: DIFFICULT TO ASSESS ANGIOGRAPHICALLY
VESSEL FORESHORTENING, ECCENTRIC LESIONS, CATHETER-INDUCED SPASM, ANGULATED LEFT MAIN,
LOCALIZED NEGATIVE VESSEL REMODELING, LACK OF PROXIMAL REFERENCE

Figure 2: Ostial LMCA disease

Mintz G, Guagliumi G. The Lancet 2017;390:793-809
“Patients with left main lesions in whom angiographic evaluation suggests procedural complexity should be considered for imaging-guided interventions by means of IVUS or OCT.”
Coronary Interventions

Intravascular Ultrasound Guidance Is Associated With Better Outcome in Patients Undergoing Unprotected Left Main Coronary Artery Stenting Compared With Angiography Guidance Alone

Pontus Andell, MD, PhD; Sofia Karlsson, MD; Moman A. Mohammed, MD;
(Circ Cardiovasc Interv. 2017;10:e004813. DOI: 10.1161/CIRCINTERVENTIONS.116.004813.)

End Points in the Propensity Score-Matched Population

Subgroup Analyses

ESC Congress
Munich 2018

**Median Stent Diameter, mm** 3.5 (3.50-4.00) vs 4.0 (4.00-4.50)  p < 0.001
Conclusion

Patient selection is key

Global appraisal of the patient (clinical & angiographic characteristics)

Good results of PCI in selected patients

Medical-surgical consultation

Ethics of information
The future ...