MINIMALLY INVASIVE AND HYBRID CORONARY REVASCULARISATION: Tips and pitfalls

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Disclosures

Medtronic (Proctor / Consultant)

ABBOTT (Proctor / Consultant)

J&J (Proctor/Consultant)

LivaNova (Advisory Board)

Fehling Instruments (Proctor / Consultant)

Perfusion Services (Proctor / Consultant)
Why “Minimally Invasive”? 

- “He went bankrupt slowly…slowly…then suddenly”
  - (The so called…”Heart Team”)

- Necessity is the mother of invention: technology / disease / patients changed

- For too long: Comfort food – Comfort Surgery
Minimally Invasive Heart Surgery
- A complete and structured Program

MICS heart tumor removal
Single Incision Minimally Invasive Cardiac Surgery (SIMICS) – developed at NUHCS

One-stop Hybrid CABG procedure

3D Minimally Inv. Heart Surgery

Hybrid CABG procedure

McGinn full CABG

Mini-Mitral Valve Surgery

Mini-Tricuspid Valve Surgery, w/o heart arrest

Mini-AVR (mini-thoracotomy)
Off-pump CABG

- Less inflammation caused without CPB
- Physiological blood flow pattern and better perfusion of crucial organs such as the brain and the kidneys
- No aortic clamping required
- More technically demanding
Off-Pump Coronary Artery Bypass (OPCAB)

With experience OPCAB can be performed safely in the vast majority of cases (>90%).
OPCAB: a minimalistic approach
MIDCABG anf MVST
MIDCAB

- Access through a small left anterior thoracotomy

- Arterial grafting of the LITA to the LAD, multivessel approaches to CX (and RCA) possible

- No heart-lung machine required and no aortic clamping
Operational setup
ONLINE LEARNING

Minimally Invasive CABG
MICS CABG Procedure
Dr. Joseph McGinn

Technique Overview
MICS CABG Overview (2:01)
1 Instruments and disposables
2 Patient Selection / Inclusion Criteria (27)
3 Contraindications (35)
4 Patient Positioning
5 Anesthesia
6 Thoracotomy / Incisions (48)
7 Positioning and Stabilization (2:30)

Procedure Video
Introduction with Dr. Joseph McGinn (26)
8 Set-up and Incisions (1:52)
9 MICS Retractor Insertion (1:15)
10 IMH Harvest (2:13)
11 Aorta Preparation for Proximal Anastomosis (5:22)
12 Proximal Anastomosis (2:23)
13 Pericardial Dissection and Positioning of Starfish\textsuperscript{NS} (3:24)
14 Attachment and Placement of Octopus\textsuperscript{NS} Nuvo for Distal Anastomosis (6:30)
15 LIMA-LAD Anastomosis (4:38)
16 Closing the Pericardium and Checking Distals (47)
17 Post Op Care Guide (49)
18 Pain Management (1:43)

Comprehensive MICS CABG Technique Overview

Stabilization and Positioning

\textsuperscript{NS} Starfish\textsuperscript{NS} Positioner
Octopus\textsuperscript{NS} Nuvo Stabilizer

Indications, Safety, and Warnings
Caution: Federal law restricts this device to sale by or on the order of a physician. For a listing of indications, contraindications, precautions, and warnings, please refer to the instructions for use.
OUR PRACTICE at NUHCS:

- Anterolateral Mini-Thoracotomy
- Direct vision IMA takedown
- Off Pump and CPB supported Beating heart (depending on case)
- Arterial and Saphenous Grafts
- Double-Lumen tube and Single Lung ventilation
- Milrinone at the right moment
- Full Heparinisation
- Intercostal Analgesic (OnQ-Pump) for 24-48 hours
OR Lay Out For MIS CABG Cases

- AU Machine
- Suction Machine
- Echo Machine
- Diathermy
- Heart-Lung Machine
- Perfusionist
- Nurse 1
- Main Trolley

A1
A2
S1
S2
S3
Rultract Skyhook surgical retractor system

- Attach to table on the right side of the table
- Place at right shoulder level of patient
- Adjust the attachment while harvesting the distal part of IMA
Harvesting LIMA

Proximal end of IMA

Distal end of IMA
Thoratract Retractor

- Rail clamp
- Long and short mounting rail
- Retractor Tack
- Blades
Mounting Rail

- Long Mounting Rail on Right side of patient - Mid thigh level - for Starfish NS
- Short mounting rail left side of patient - Abdominal level - for Octopus Nuvo
Positioning of Positioner and stabilizer

Starfish® NS Heart Positioner

Octopus® Nuvo Tissue Stabilizer
MIS Instruments
Minimally Invasive Direct Coronary Artery Bypass Surgery (MIDCAB)

ALEXIS SOFT TISSUE RETRACTOR – APPLIED MEDICAL
Harvesting of LIMA through Left Thoracotomy Approach
Exposure of Ascending Aorta and Right Atrial Appendage
The Intraop Setup
OUR SETUP for MIDCABG / MVST and HYBRID
OUR SETUP for MIDCABG / MVST and HYBRID
Our setup for MIDCABG
Bailout: MICS CABG with Cardioplegia
Postoperative lactate level

RESULTS
Results – Postoperative Lactate Level

- The average postoperative serum lactate level in all the patients was 3.18 (range: 0.50—15.60)

- Exploratory analysis suggested that patients who underwent MICS CABG had a significantly lower average postoperative lactate level as compared with those who underwent open CABG
  - Mean±SD: 2.24±1.36 mmol/L vs 3.35±2.35 mmol/L

- Confirmatory analysis showed that patients who were operated with MICS had a significantly lower postoperative lactate level
  - Coefficient: -1.10 mmol/L; 95% C.I.: -1.82—-0.39, p-value: 0.002
A unit increase in the level of lactate could be associated with a 12% increase in the occurrence of new arrhythmia as demonstrated by the odds ratio, although the result was non-significant.

- Adjusted odds ratio: 1.12
- 95% C.I.: 1.00—1.26
- p-value: 0.059
Internal Mammary Artery Anastomosis and The Proximal Anastomosis
Off-Pump Coronary Artery Bypass Grafting Through Left Antero-Lateral Thoracotomy (Thora-CAB)

Advantage of ThoraCAB:

• Low Incidence of Haemodynamic Instability – less manipulation of heart
• Minimal Pain – Intercostal Cryothermy
• Low Incidence of A-Fib
• Faster Convalescence
• Fewer Restriction – No Driving Restriction
• Reduce Blood Requirements
• Avoidance of Mediastinitis & Sternal Dehiscence
• Improve Cosmetic Outcome
Off-Pump Coronary Artery Bypass Grafting Through Left Antero-Lateral Thoracotomy (Thora-CAB)

**Absolute Contra-Indication:**
- Emergency Surgery
- Haemodynamic Instability
- Extremely Obese Patients
- Severe Pectus Excavatus
- Severe Pulmonary Disease

**Relative Contra-Indication**
- Ejection Fraction <20%
- Severe Peripheral Vascular Disease – Femoral and/or subclavian / Absent of Femoral Pulse Bilaterally
- Severe LVH with Depressed LVEF OR Dilated Cardiomyopathy who require grafts to all three Coronary Arteries
- Haemodialysis – Using Left Sided AV Fistula
HYBRID CABG
Hybrid Coronary Revascularization
COST

![Bar chart showing cost comparison between HYBRID and OPCAB procedures.](Image)

- **Intraoperative Costs**
- **Postoperative Costs**

$p=NS$

- $p<0.001$
- $p<0.001$

**Total Cost ($)**

- HYBRID
- OPCAB
Patient Satisfaction

HYBRID:
- 83%
- 17%

OPCAB:
- 42%
- 33%
- 12.5%
- 12.5%

Satisfaction Score:
- 6
- 5
- 4
- 3

$p=0.002$
Time back to work

\[ p = 0.002 \]
Inflammatory and Hypercoagulability parameters

- **HYBRID**
- **OPCAB**

* $p \leq 0.05$
** $p \leq 0.01$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HYBRID</th>
<th>OPCAB</th>
<th>% Transcardiac Change</th>
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<tr>
<td>F1.2</td>
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<td>FXII-a</td>
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<td>Myoglobin</td>
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<td>IL-8</td>
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Clinical Scenarios
CASE SCENARIO 1 – THE STRAIGHT FORWARD CASE (S)
Marathon Runner / Patient
MICS (McGinn) and Hybrid CABG
65 year old diver…
MIDCABG love
Clinical Scenario 2

• 70 years old Indian male
• History of hypertension and dyslipidemia
• Diagnosed with triple vessel disease and planned for minimally invasive CABG
  • 2D Echo: EF 40-45%, no significant valvular disease
  • Weight: 57.8Kg, Height: 162cm, BMI: 22
Coronary angiogram

RAO view of left system

LAO view of left system
Coronary angiogram

RCA: small

Retrograde filling of PDA from left system
CXR
CT scan (sagittal view) – diffuse ascending aortic calcification
Case Scenario 3

- 62 year old Indian male
- Diabetes, heavy smoker, COPD (moderately severe)
- Peripheral Vascular Disease (non – occlusive)
- TVD, presented with ACS, discharged and rehospitalised with unstable angina.
- TVD, only proximal LAD (+Intermedius) flow-limiting disease, otherwise diffuse distal disease. Sent by Cardiologist for MIDCAB.
Preop Angiography
Hybrid Revascularisation Case Study
Case Summary

• 69 / Chinese / Gentleman
• Past Medical History
  • Diabetes mellitus
  • Hyperlipidemia
• Presented with CCS class 2 angina
• Coronary angiogram done: Triple vessel disease
  • oLAD 80%
  • pCx 70%
  • RCA – long segments proximal to mid and distal stenosis of 80%
• TTE showed preserved LVEF of 60%
• U/S carotids normal
• CT thorax normal
• Hybrid Revascularisation strategy was adopted
• Planned for MIDCAB (LIMA-LAD) followed by intraoperative coronary angiogram with percutaneous coronary intervention to LCx and RCA stenoses
Pre-op Coronary Angiogram
Intra-Op Coronary Angiogram
LIMA-LAD Graft
5 Fr EBU 3.5 guide catheter, PressureWire X. Baseline Pd/Pa 81/80=1.01. Following IC GTN 200 mcg & IV adenosine @ 140 ug/kg/min, taking weight of 60 kg, FFR=0.97.
6 Fr JR4 guide catheter, PressureWire X. Baseline Pd/Pa 78/81=0.97. Following IC GTN 200 mcg & IV adenosine @ 140 ug/kg/min, FFR=0.92.
Progress

• Successfully underwent MIDCAB LIMA-LAD via left anterior mini-thoracotomy

• Intra-operative findings
  • Coronary angiogram confirmed good flow and distal runoff in LIMA-LAD graft
  • Functional evaluation of LCx and RCA stenoses performed
    • LCx FFR: 0.97
    • RCA FFR: 0.92

• No PCI was performed for stenoses of LCx and RCA which were functionally not significant

• Fit for discharge on 4th post-operative day
- The Good Surgeon Knows HOW to operate
- The Very Good Surgeon knows WHEN to operate
- The Excellent Surgeon knows WHEN NOT to operate
VDOs,

Bundled payments and

the ....cost factor
## Length of Stay

<table>
<thead>
<tr>
<th>Mitral Valve</th>
<th>MIS</th>
<th>Median</th>
<th>Open</th>
<th>Median</th>
<th>p value</th>
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<tbody>
<tr>
<td>Total Stay</td>
<td>9.2+/− 4.8 days</td>
<td>7 days</td>
<td>14.4+/− 7.1 days</td>
<td>12 days</td>
<td>&lt; 0.001</td>
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<tr>
<td>ICU/HD</td>
<td>3.5+/− 2.2 days</td>
<td>2 days</td>
<td>5.3+/− 2.8 days</td>
<td>5 days</td>
<td>0.001</td>
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<tr>
<td>GW</td>
<td>6.9+/− 3.7 days</td>
<td>5 days</td>
<td>10.1+/− 6.5 days</td>
<td>8 days</td>
<td>0.005</td>
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<th>Aortic Valve</th>
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<tr>
<td>Total Stay</td>
<td>7.3+/− 2.9 days</td>
<td>7 days</td>
<td>9.8+/− 3.5 days</td>
<td>10 days</td>
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<tr>
<td>ICU/HD</td>
<td>2.6+/− 0.8 days</td>
<td>2 days</td>
<td>3.2+/− 1.3 days</td>
<td>3 days</td>
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<tr>
<td>GW</td>
<td>5.6+/− 2.8 days</td>
<td>5 days</td>
<td>7.6+/− 2.9 days</td>
<td>7 days</td>
<td>0.033</td>
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<th>Median</th>
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<tr>
<td>Total Stay</td>
<td>7.0+/− 7.5 days</td>
<td>5 days</td>
<td>10.4+/− 14.0 days</td>
<td>6 days</td>
<td>0.100</td>
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<tr>
<td>ICU/HD</td>
<td>2.6+/− 1.1 days</td>
<td>2 days</td>
<td>4.1+/− 5.1 days</td>
<td>3 days</td>
<td>0.005</td>
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<tr>
<td>GW</td>
<td>5.4+/− 7.3 days</td>
<td>4 days</td>
<td>7.4+/− 12.3 days</td>
<td>5 days</td>
<td>0.208</td>
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PATIENT’S BILL
# MVR Costs

## Private

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<tbody>
<tr>
<td><strong>Total Bill</strong></td>
<td>$65.6k +/- $43.3k</td>
<td>$44.1k +/- $27.3k</td>
<td>0.238</td>
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<tr>
<td><strong>Patient's Bill</strong></td>
<td>$28.3k +/- $16.4k</td>
<td>$19.7k +/- $12.8k</td>
<td>0.642</td>
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## Subsidised

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<tr>
<td><strong>Total Bill</strong></td>
<td>$13.6k +/- $8.0k</td>
<td>$11.2k +/- $7.8k</td>
<td>0.253</td>
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<tr>
<td><strong>Patient's Bill</strong></td>
<td>$2.7 +/- $5.4k</td>
<td>$1.5k +/- $1.7k</td>
<td>0.493</td>
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## Overall

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<th></th>
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<tr>
<td><strong>Total Bill</strong></td>
<td>$20.6k +/- $17.7k</td>
<td>$21.0k +/- $24.6k</td>
<td>0.937</td>
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<td><strong>Patient's Bill</strong></td>
<td>$8.2k +/- $6.3k</td>
<td>$9.1k +/- $13.7k</td>
<td>0.895</td>
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CABG Costs

<table>
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<th>Subsidised</th>
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</thead>
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<tr>
<td><strong>Total Bill</strong></td>
<td>$30.8k +/- $6.9k</td>
<td>$32.7k +/- $8.8k</td>
<td>0.621</td>
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<tr>
<td><strong>Patient's Bill</strong></td>
<td>$12.4k +/- $15.0k</td>
<td>$13.7k +/- $15.5k</td>
<td>0.865</td>
</tr>
</tbody>
</table>

**Overall**

<table>
<thead>
<tr>
<th></th>
<th>MIS</th>
<th>Open</th>
<th>p-value</th>
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<tbody>
<tr>
<td><strong>Total Bill</strong></td>
<td>$16.4k +/- $11.0k</td>
<td>$14.3k +/- $11.5k</td>
<td>0.416</td>
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<tr>
<td><strong>Patient's Bill</strong></td>
<td>$3.9k +/- $9.5k</td>
<td>$2.9k +/- $8.6k</td>
<td>0.770</td>
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</table>
Subsidised vs Private: MICS = 28-48% vs. Median Sternotomy: 11-15%
The Heart Team - Euphemism
The Heart Team (MDT) in 2017
When I don’t go MICS

1. Very flat-chested pts with verticalized hearts
2. Very pycnic habitus with severe obesity and high standing diaphragms
3. Extremely low EF
4. Severely impaired RV function
5. Very severe PHT (>90 mmHg)
6. Inaccessible, combined pathology
7. Severely calcified aorta
8. Severe adhesions
Basic Principles of Surgery from the side

1. Don’t be fanatic about it
2. Don’t drive a Ferrari next day you get your drivers license; Start simple: easy cases first
3. MICS Heart Surgery is …Heart Surgery first
   4. Consider cost
   5. Train your team
   6. Individualize approach and access
7. Don’t compromise the quality of repair for the fancy of MICS
8. Avoid extreme Anatomy, very flat-chested tiny patients
   9. Don’t turn Minimal into Maximal
10. Take good informed consent
The NO-MICS surgeons: why?


- Have you ever tried and reversed to classical Cardiac Surgery and why?

- Too much headaches? Effort? Bad outcomes?
The Li-bra: MDT in 2036
Prominent Tip: Training and Simulation

CoE in MICS and Hybrid ASTC Sim Center
MICS Simulation Centre

Legend:
- **Blue**: MICS Masstricht MV simulator
- **Orange**: Beating Heart simulator
- **Red**: Heart Case
- **Beige**: MICS Thorax
- **Green**: VATS Trainer

Diagram:
- Screen
- Storage
- Discussion Table
- Audio/Visual
- TEVAR Simulator
MICS MVR Simulation

https://www.youtube.com/watch?v=saGGNLbU4tI
The Medtronic MICS CABG simulators
The Chamberlain Torsos and Simulators

https://www.thecgroup.com
Beating Heart CABG simulators

The Beat S1 – made in Japan

Endoscopic Vein Harvest Simulator (Macquet)
VATS SIMULATION
TEVAR/TAVI Simulation
- We are Asia’s only program that is coupled with a fully equipped and relevant wet-, as well as small- and large animal laboratory, which develops groundbreaking technology.
A superb the Research team
Paco de Lucia
THANK YOU