Hybrid Coronary Revascularization (HCR)
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Dr. Michael Chu is a Cardiac Surgeon and Assistant Professor of Surgery at Western University and London Health Sciences Centre. His clinical practice focuses on minimally invasive and robotic hybrid coronary revascularization procedures, valve reconstruction, transcatheter valve technology and complex aortic reconstruction. He has extensive experience with simultaneous hybrid coronary revascularization procedures, complex mitral and tricuspid valve repair and minimally invasive reoperative mitral valve surgery. He is an active researcher and has investigated different valve reconstruction techniques, minimally invasive and robotic mitral surgery, blood conservation strategies and most recently, experimental transcatheter technology.

Cover Photograph: (left to right) Dr. Bob Kiaii, Dr. Patrick Teefy, Dr. Kumar Sridhar, Dr. Michael Chu
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**Important Safety Information**

Not all patients are candidates for beating heart procedures. Some patients may require cardiopulmonary support during surgery.
What is Hybrid Coronary Revascularization (HCR)?

HCR is a revascularization strategy that combines the best advances of Cardiac Surgery and Cardiology. HCR can be defined as minimally invasive left internal thoracic artery to left anterior descending coronary artery bypass graft LITA-LAD (MICS CABG or robotic) with percutaneous coronary intervention (PCI) of the non-LAD territories.

- HCR combines durability of coronary artery bypass surgery (CABG with LITA) to the critical LAD territory with the durability and minimal invasiveness of PCI to non-LAD targets
- HCR is typically performed with a minimally invasive off-pump approach to the LITA-LAD, using a sternal-sparing incision to avoid aortic manipulation and CPB
- Surgical options for LITA-LAD in HCR include direct vision techniques via limited anterolateral thoracotomy, thoracoscopic or robotic-assisted approaches

PROCEDURE STRATEGY – Timing and Staging: Three Options

1. Staged MICS CABG Before PCI

Performing PCI as a separate procedure following CABG allows for optimal antiplatelet therapy plus imaging of the LITA-LAD graft. PCI of high-risk targets is possible if patent LITA-LAD is demonstrated
- Staging may be a day to weeks apart

Advantages
- Can avoid bleeding issues with antiplatelet therapy seen with combined CABG/PCI

Disadvantages
- Conventional CABG fallback is complicated if the PCI result is sub-optimal

2. Staged PCI Before MICS CABG

Performing PCI before surgery is infrequently performed:
- Post-primary PCI (STEMI) of non-LAD vessel with residual LAD disease is best treated with LITA insertion
- Staging is best delayed a minimum of 6 months

3. Single Stage

Provides patient with a complete one-stop revascularization, allowing immediate completion arteriogram of the LITA-LAD graft
- Utilizes a Hybrid OR setting
- Complete revascularization in same setting
- Increased patient convenience
- Patient subjectively will feel disease is completely treated
- Logistical issues involving increased OR time and challenging multi-specialty collaboration
- Reduces risk of inter-stage morbidities

Stage Hybrid Logistics

HCR Candidate

Single Stage Candidate?

YES

NO

Single Stage HCR

Culprit Lesion

LAD 2 Stage HCR with CABG first

Indeterminate 2 Stage HCR with CABG first

Non-LAD 2 Stage HCR with PCI first
Procedural Steps for Single Stage Approach

• MICS CABG procedure first
• Reset room to cardiac catheterization configuration
• LITA graft check
• Confirm hemostasis
• Clopidogrel 600-mg via nasogastric (NG) tube
• Bivalirudin utilized for anticoagulation for surgery and PCI
• PCI performed to non-LAD targets

A New Standard: Considerations for Adapting a Hybrid OR for HCR

The fields of interventional cardiology and cardiovascular surgery are converging and moving more towards minimally invasive procedures. Hybrid ORs are becoming a standard part of cardiovascular programs and offer the potential to transform how an institute’s cardiac care is managed and delivered. HCR in a hybrid OR combines different modalities of treatment into a team approach. There are benefits to building this approach and it’s entirely dependent on the people and resources available to implement a facility and assemble the right teams.

Potential Benefits of a Hybrid OR for HCR:

• Allows for a single stage HCR procedure
• Enables Cardiac Surgeons, Interventional Cardiologists, Anesthesiologists, Nursing and Perfusionists to work simultaneously on one table, in one room and uses a team approach
• Includes a percutaneous catheter-based approach
• Allows for immediate evaluation of the treatment via completion angiogram
• Optimizes surgical/interventional results with reduced trauma in a parallel setup

Patient Selection Consideration for HCR

Inclusion criteria

• Young patients, OR
• Age > 70 with comorbidities
• Prior CVA
• Calcified aorta
• Renal dysfunction
• Diabetes
• PVD (may be performed via radial artery)
• Disabled or deconditioned patients
• Patients at high-risk for conventional surgery

Good candidates for HCR

• Ostial, complex or occluded LAD lesion with simple lesions of other coronary arteries
• Elderly patients, Left Main disease with low Syntax score
• Overweight or diabetic patients
• Comorbidities making sternotomy high-risk
• Younger patients; life expectancy > 10 years and who are not complete PCI candidates
• Patients requiring redo revascularization for multivessel disease and the LITA is not utilized for the LAD

Contraindications to HCR (especially simultaneous procedure)

Contraindications to MICS CABG off-pump bypass

• LAD is non-graftable
• LAD is buried or intra-myocardial
• Inability to undergo off-pump beating heart revascularization
• Previous surgery involving left chest cavity
• Left subclavian artery stenosis rendering the LITA unsuitable
• Lack of tolerance of single lung ventilation based on FEV1 < 50% FVC
Contraindications to PCI of non-LAD lesions

- Peripheral vascular disease precluding vascular access - consider radial artery access
- Vessel size < 2.5-mm
- Tortuous calcified vessels felt to preclude stent placement
- Complex disease requiring prolonged procedure time (esp. simultaneous HCR)
- High SYNTAX scores of PCI vessel especially if surgery is a better option
- Fresh thrombotic lesions
- Renal insufficiency
- Contraindication to dual antiplatelet therapy

Other potential contraindications

- Cardiogenic shock
- Malignant arrhythmias
- Hemodynamically unstable
- History of chronic lung disease
- Morbid obesity

Anticoagulation/Antiplatelet Considerations

Staged – MICS CABG 1st

- Heparin with protamine reversal
- Start clopidogrel after CABG – either next day or prior to the PCI (600-mg more than 6 hours prior to PCI)

Staged – PCI 1st

- The usual anticoagulation and antiplatelet for PCI
- Holding of clopidogrel (but continue ASA) for 3-5 days prior to MICS CABG depends on timing and type of stent (DES vs BMS)

Single Stage – Simultaneous HCR (see Figure 1.0)

- ASA pre-procedure
- Prior to ligation of the LITA, give 0.75-mg/kg bolus of bivalirudin, then an infusion of
- 1.75-mg/kg/hr is maintained throughout the surgery and PCI procedure to keep ACT > 300 seconds
- Once the LITA-LAD patency is confirmed, 600-mg clopidogrel is given via NG tube (provided chest tube drainage is minimal)
• PCI performed in hybrid OR
• After 2 hours, bivalirudin is discontinued
• Patients receive an additional 81-mg of ASA, 6 hours following the procedure
• Patients are started on clopidogrel 75-mg daily, starting the day following the procedure

MICS CABG SURGICAL TECHNIQUES

I. Direct ITA Harvest

1. Patient Set-up
   • Lines/Airway – Double lumen ETT with internal jugular central line
   • Positioning is 30 degrees right lateral decubitus with a roll under left shoulder

2. Thoracotomy/Incisions
   Perform a 5 to 7-cm anterolateral mini-thoracotomy
   • Male patients: over the 5th or 6th ICS, 1/3 medial to the nipple
   • Female patients: inframammary incision similar location
   • The medial 2/3 of the window incision is medial to the anterior axillary line
   • While making the incision, deflate the left lung
   • Divide the intercostal muscles laterally to reduce the risk of rib fracture, then divide them medially to avoid damage to the LITA
   • A soft tissue retractor may be placed in the incision to maximize access

3. Direct ITA Harvest
   • Place a large Kelly clamp with a sponge in the 6th ICS to assist with harvesting the LIMA. Use the sponge to push away tissue for better IMA visualization
   • Insert the ThoraTrak™ MICS retractor system into the ICS incision; then hook the ThoraTrak MICS retractor system to the Rultract® to facilitate the LIMA harvest
   • In order to prevent crush injury to the LIMA, make sure the superior portion of the retractor is placed and maintained in the lateral aspect of the incision
   • Care should be taken not to fracture a rib
   • The ThoraTrak MICS retractor system should be cranked slowly, which allows tissue and bone to acclimate to the change in position in order to minimize the potential for rib fracture and pain
   • Start the LIMA harvest at the 3rd ICS using direct vision through the window incision
   • Use an extended electrocautery instrument, endoscopic forceps, suction, endoscopic clip applier and small clips for the harvest
   • Complete the harvest up to the subclavian vein and down past the left 5th ICS
   • Take care to identify and avoid the phrenic nerve
   • During the LIMA harvest, flexing the table may facilitate access to the superior portion of the LIMA
   • Anchor the pedicle of the LIMA with silk ties to maintain the proper orientation
   • Give intravenous bivalirudin or heparin prior to LIMA division

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II. Endoscopic/Robotic Harvesting of the LITA and/or RITA

1. Patient Set-up
   • Positioning is 30 degrees right lateral decubitus with a roll under left chest to allow shoulders to fall

2. Endoscopic Port Insertion
   • The left lung is deflated and in the 5th ICS 12-mm port inserted
   • CO₂ insufflation for intrathoracic pressure 5 to 10-mmHg (watch blood pressure)
   • 30 degree endoscope inserted. Under the guidance of the endoscope, quantity of two 7-mm ports, inserted in the 3rd and 7th ICS
   • Endoscopically or robotically the LITA is harvested from 1st rib to the 6th rib
   • Endoscopically the pericardium is opened and the location of the LAD identified and using a spinal needle the location for the thoracotomy is selected to provide the best access to the LAD
   • Prior to ligation of the LAD, patient is given intravenous bivalirudin or heparin depending on 1 stage or 2 stage procedure

3. LITA-LAD Anastomosis (Applies to Direct and Robotic Harvest Techniques)
   • The LITA-LAD anastomosis is performed under direct vision through the mini-thoracotomy
   • Only soft tissue retraction is generally required, minimizing trauma
   • Open the pericardium down to the diaphragm and towards the right pleura
   • With the LITA visible through the incision, place the Octopus™ Nuvo Tissue Stabilizer through the 6th ICS if LITA directly harvested or 5th ICS if LITA is endoscopically harvested and stabilize the LAD using suction
   • Once stabilized, the LAD is occluded and the bypass is grafted using standard instruments
   • In some instances, it may be necessary to use a Starfish™ NS Heart Positioner placed through a sub-xiphoid portal in order to position the anastomotic site in the thoracotomy window
Anesthesia Considerations

- An intrathecal block with epimorphine is used for pain control
- Defibrillator pads on the left scapula and inferior and medial to the right breast
- Perform intubation with a double lumen endotracheal tube to deflate the left lung. Alternatively, a single lumen endotracheal tube (ETT) and bronchial blocker may be placed under fiber-optic guidance
- Lines are routine and include an arterial line and PA catheter (PAC). If peripheral access is limited, at least a 16-gauge IV should be placed. A triple lumen catheter is placed along with the PAC – “double stick”
- After intubation, place a bronchial blocker into the mainstream bronchus with fiberoptic guidance. Place the proximal end of the balloon approximately 1 to 2-cm below the carina
- Warming blanket should be used to avoid hypothermia
- \( \text{CO}_2 \) insufflation for intrathoracic pressure 5 to 10-mmHg (watch blood pressure)
- Hemodynamic support for OPCAB surgery is necessary

Perfusion Considerations

The need for extracorporeal support is rare. A supported coronary revascularization would only require a system with a venous reservoir, arterial pump, oxygenator and filter. It is recommended that the extracorporeal support system and devices be on standby.

- The use of a cell saver is recommended
- Percutaneous cannulae are necessary if femoral cannulation is utilized for hemodynamic support

Single-Lung Ventilation

- Deliver approximately 10 cc/kg of tidal volume prior to and during single-lung ventilation. Tidal volume may need to be decreased as large tidal volumes can cause shifting of the mediastinum, which may cause the MICS retractor to slip
- Keep the \( \text{O}_2 \) saturation greater than 90%. If the saturation begins to decrease:
  - Add continuous positive airway pressure (CPAP) of 5-cm \( \text{H}_2\text{O} \) to the deflated lung. This can be performed through the bronchial blocker by inserting a 7 ETT connector into the barrel of a 3-cc syringe. Insert the syringe tip into the lumen of the bronchial blocker. Attach the 7 ETT connector to a CPAP circuit
  - CPAP can be increased, but if it is increased too much, it will cause the lung to inflate and obscure the surgeon’s view
Post-Op Considerations

Discharge and Follow-Up Recommendation
- Discharge once stable between 2 to 4 days
- Clopidogrel, aspirin, and other cardiac medications as indicated at discharge
- Clear instructions on the importance of dual antiplatelet therapy; call office if there is a need to change
- Follow up in 6 weeks
- Follow up in 6 months, consider angiography to assess patency of the graft/stent
- Annual follow-up

HCR Surgical Instruments and Disposable Surgical Instruments
- ThoraTrak™ MICS Retractor System
- Rultract® Skyhook Surgical Retractor System™
- Bedrail mounted instrument holder

Single-shafted instruments:
- Chest tube passer
- Curved scissors
- Curved mini needle holder
- Mini potts scissors: 45° and 125°
- DeBakey mini grasper
- Mini (ITS) holding forceps
- Clip applying forceps, small and medium sizes

Disposables
- Octopus™ Nuvo Tissue Stabilizer
- Starfish™ NS Heart Positioner (if needed)
- Bio-Medicus™ Percutaneous Cannulae Kit
- Disposables for Robotic ITA Take-Down (if Robotic ITA harvest)

London Health Sciences Centre – Ultra Fast Track

STABLE
- Minimum chest tube drainage

YES

Extubate in OR
- Transfer to step down unit or ward

Aggressive Chest Physio
- If fit D/C in 2 to 3 days ASA/Plavix®

NO

Transfer to ICU intubated
- Monitor chest tube drainage

Aggressive Chest Physio
- Not suitable for early D/C then D/C in 3 to 4 days ASA/Plavix®

Extubate in ICU once stable
- Transfer to regular ward next day

Non-Fast Track

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Bio-Medicus™ Femoral Cannulae
Care and caution should be taken to avoid damage to vessels and cardiac tissue during cannulation or other cardiac surgery procedures. For a listing of indications, contraindications, precautions and warnings, please refer to the Instructions for Use. **Caution:** Federal law (USA) restricts this device to sale by or on the order of a physician.

Octopus™ Nuvo Tissue Stabilizer
Starfish™ NS Heart Positioner
ThoraTrak™ MICS Retractor System

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