Technologies & Innovation in Cardiothoracic Health Care (Surgical Perspective)

Paneer Selvam Krishna Moorthy
Department of Cardiothoracic Surgery, National Heart Institute (IJN), Kuala Lumpur, Malaysia
World History of Cardiothoracic Surgery
“Any surgeon who wishes to preserve the respect of his colleagues would never attempt to suture the heart”
- From a speech by Christian Albert Theodor Billroth at the Vienna Medical Society Meeting, 1880

“So surgery of the heart has probably reached the limits set by Nature to all surgery; no new method, and no new discovery, can overcome the natural difficulties that attend a wound of the heart”
Revolution of Cardiac Surgery
The first surgery on the heart itself was performed by Norwegian surgeon Axel Cappelen on 4 September 1895 at Rikshospitalet in Kristiania, now Oslo. He ligated a bleeding coronary artery in a 24-year-old man who had been stabbed in the left axillae and was in deep shock upon arrival. Access was through a left thoracotomy.

The first successful surgery of the heart, performed without any complications, was by Dr. Ludwig Rehn of Frankfurt, Germany, who repaired a stab wound to the right ventricle on September 7, 1896.
In 1925, operations on the heart valves were unknown. Henry Souttar operated successfully on a young woman with mitral stenosis.

He made an opening in the appendage of the left atrium and inserted a finger into this chamber in order to palpate and explore the damaged mitral valve. The patient survived for several years.

Souttar's physician colleagues at that time decided the procedure was not justified and he could not continue.
1953 John Gibbon realised his 20-year vision and performed the first successful operation on a human using the heart-lung machine. The patient, Cecelia Bavolek, whose heart was connected to the machine for 45 minutes, recovered fully from the operation.
In the 1980s, researchers at St Thomas’s Hospital found that by cooling the heart to below 28°C and treating it with the right cocktail of chemicals, the heart could be stopped for many hours while intricate surgeries were performed, and then restarted with minimal damage.

A similar cocktail of chemicals is now used to keep hearts healthy while they are transported for transplantation.
DR. DWIGHT E. HARKEN
“Father of Heart Surgery”

The first surgeon to have repeated success with heart surgery.

“We discovered that the heart wasn’t such a mysterious and untouchable thing after all.”
Innovative Factors

Cardiopulmonary Bypass

Diagnostic Tools

Improvements

Surgical Techniques & Tools & Prosthesis

Post-operative cares
Diagnostic Tools
Modern Cardiopulmonary Bypass
<table>
<thead>
<tr>
<th>Incision Location</th>
<th>Sternotomy</th>
<th>Lower Sternum</th>
<th>Mini-Thoracotomy</th>
<th>Mini-Thoracotomy</th>
<th>Port Min-Thoracotomy</th>
<th>Port Min-Thoracotomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incision Size</td>
<td>12+ cm</td>
<td>8+ cm</td>
<td>5-8 cm</td>
<td>6-8 cm</td>
<td>4-6 cm</td>
<td>2-4 cm</td>
</tr>
<tr>
<td>Visualization</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Video-Assistant</td>
<td>Video-Assistant</td>
</tr>
</tbody>
</table>

**Minimal Incision Approach**
Tools in MICS
Hybrid OR
Effects of Innovations

- Refinement of the diagnosis
- Improvement in Surgical Techniques
- Decrease in mortality and morbidity
- Early recovery and shorter hospital stay
- Early return to functional status
- Low cost
Any Innovations in Cardiothoracic Surgery in Malaysia?
Division of Cardiology, Medical Department, General Hospital Kuala Lumpur (GHKL)

Department of Cardiology, GHKL

Department of Cardiology
Department of Cardiothoracic Surgery
Department of Anesthesiology

Royal Prince Alfred Hospital, Sydney
Royal Alexandra Hospital, Sydney

April 1982:  Cardiac catheterization and angiogram
1\textsuperscript{st} open heart surgery: surgical closure of ASD

Sept 1982:  1\textsuperscript{st} coronary artery bypass surgery in Malaysia
1984: KLINIK KARDIOLOGI & KLINIK PEMBEDAHAAN JANTUNG

INSTITUT JANTUNG NEGARA
National Heart Institute
THE TURNING POINT

1 am 18th Jan 1989:

24th Jan 1989: CABGs performed

July 1992: IJN started operations

Sept 1992: corporatized

12th June 1993: Official Opening
OPEN HEART SURGERY (ADULTS/PAEDS)

**SOURCE FROM:**
- YEARLY CT REPORT 1992-2014
- OT CENSUS -2015
CLOSE HEART SURGERY (ADULTS/PAEDS)

**SOURCE FROM:**
- YEARLY CT REPORT 1992-2014
- OT CENSUS -2015
Coronary Artery Bypass Grafting
Evolution of Coronary Surgery

- **May 2, 1960**  Goetz  RITA to RCA  Tantalum ring  Pt died in 8 months of AMI

- **April 4, 1962**  Sabiston  SVG to RCA  Suture  Pt died 3 days later

- **Feb. 24, 1964**  Kolesov  LITA to LCx  Suture  No angina at 3 years’ follow-up

- **Nov 23, 1964**  Garrett, DeBakey  SVG to RCA  Suture  No angina at 7 years’ follow-up (The case first reported in 1973)

- **March 22, 1967**  Kolesov  LITA to LAD  Stapling  No angina at 3 years’ follow-up

- **May 9, 1967**  Favaloro  SVG to RCA  Suture  Successful

- **Feb 29, 1968**  Green  LITA to LAD  Suture  Successful
New Approaches to Coronary Bypass Surgery

- Arterial Graft
- Off Pump
- Imaging
- Graph flow monitoring
Coronary Bypass Surgery

* Arterial grafts

- Autologous
  - Internal thoracic artery
  - Right gastroepiploic artery
  - Inferior epigastric artery
  - Radial artery
  - Splenic artery
  - Gastro-duodenal artery
  - Left gastric artery
  - Intercostal artery
- Nonautologous
  - Bovine internal thoracic artery
Off-pump Coronary Artery Bypass (OPCAB)
Coronary Bypass Surgery

- MID-CABG and MICS
Cardiac Valve Replacement
Surgical Treatment of Valvular Heart Disease

Reconstruction Or Replacement
All 4 valves can be replaced
Ideal Prosthetic Valve

* Excellent hemodynamic characters – unimpeded forward flow with minimal transvalvular gradient upon opening and produce a competent valve with minimal regurgitation upon closing
* Non thrombogenic
* Resistance to infection
* Non destructive to blood elements
* Durable
* Easy to implant
* Readily available at reasonable cost
Types of Prosthetic Heart Valves

- Mechanical
  - Bileaflet (St Jude) (A)
  - Single tilting disc (Medtronic Hall) (B)
  - Caged-ball (Starr-Edwards) (C)

- Biologic
  - Stented
    - Porcine xenograft (Medtronic Mosaic) (D)
    - Pericardial xenograft (Carpentier-Edwards Magna) (E)
  - Stentless
    - Porcine xenograft (Medtronic Freestyle) (F)
    - Pericardial xenograft
    - Homograft (allograft)

- Percutaneous
  - Expanded over a balloon (Edwards Sapiens) (G)
  - Self-expandable (Core Valve) (H)

EVALUATION OF PROSTHETIC VALVE FUNCTION-METHODS AND CLINICAL UTILITY

Circulation 2009, 119:1034-1048

National Heart Institute
Pulmonary Autograft (Ross Procedure)
Valve Reconstruction
All 4 valves can be reconstructed
# Mitral Valve Repair – Various Techniques

<table>
<thead>
<tr>
<th>Carpentier type</th>
<th>Aetiology</th>
<th>Repair technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Normal leaflet motion</td>
<td>Annular dilatation</td>
<td>Ring annuloplasty (may be rigid, flexible, partially flexible), sliding annuloplasty</td>
</tr>
<tr>
<td>Leaflet perforation</td>
<td></td>
<td>Repair using glutaraldehyde fixed pericardium</td>
</tr>
<tr>
<td>II. Increased leaflet motion</td>
<td>Chordal elongation</td>
<td>Chordal shortening, +/- quadrangular resection of prolapsing redundant leaflet</td>
</tr>
<tr>
<td>Chordal rupture</td>
<td></td>
<td>Chordal substitution (Teflon sutures) or transfer</td>
</tr>
<tr>
<td>Papillary muscle elongation</td>
<td></td>
<td>Chordal shortening</td>
</tr>
<tr>
<td>Papillary muscle rupture</td>
<td></td>
<td>Suturing papillary muscle to left ventricular free wall</td>
</tr>
<tr>
<td>III. Restricted leaflet motion</td>
<td>Ischaemic papillary muscle base</td>
<td>Commissurotomy (division of areas of fusion between two leaflets)</td>
</tr>
<tr>
<td>Fibrosis of leaflet</td>
<td></td>
<td>Fenestration of subvalvular apparatus</td>
</tr>
<tr>
<td>Fibrosis of subvalvular apparatus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Br J Cardiol © 2004 Sherbourne Gibbs, Ltd.

- **Annulus**
- **Leaflet**
- **Chordae**
- **Papillary Muscle**
Mitral valve Repair – Various Techniques
Mitral Valve Repair - Techniques
**SOURCE FROM:**
- MV REPAIR DATABASE 1992-2012
- TRAKCARE 2013-2014
- CT REGISTRY 2015
Is rheumatic aetiology a predictor of poor outcome in the current era of mitral valve repair? Contemporary long-term results of mitral valve repair in rheumatic heart disease†

Mohd Azhari Yakub*, Jeswant Dillon, Paneer S. Krishna Moorthy, Kiew Kong Pau and Mohd Nazeri Nordin

Department of Cardiothoracic Surgery, National Heart Institute, Kuala Lumpur, Malaysia

* Corresponding author. Department of Cardiothoracic Surgery, National Heart Institute, 145 Jalan Tun Razak, 50400 Kuala Lumpur, Malaysia. Tel: +60-3-26178500; fax: +60-3-26920336; e-mail: azhariyakub@ijn.com.my (M.A. Yakub).

Received 13 September 2012; received in revised form 19 December 2012; accepted 28 December 2012
Leaflet extension in rheumatic mitral valve reconstruction†

Jeswant Dillon*, Mohd Azhari Yakub, Mohd Nazeri Nordin, Pau Kiew Kong and Paneer S. Krishna Moorthy

Department of Cardiothoracic Surgery, National Heart Institute, Kuala Lumpur, Malaysia

* Corresponding author. Department of Cardiothoracic Surgery, National Heart Institute, 145 Jalan Tun Razak, 50400 Kuala Lumpur, Malaysia. Tel: +60-3-26178200; fax: +60-3-26006229; e-mail: jeswant@ijn.com.my (J. Dillon).

Received 13 September 2012; received in revised form 1 December 2012; accepted 16 December 2012
Aortic Valve Reconstruction

<table>
<thead>
<tr>
<th>AI Class</th>
<th>Normal cusp motion with FAA dilatation or cusp perforation</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i.a</td>
<td>i.b</td>
<td>i.c</td>
<td>i.d</td>
</tr>
<tr>
<td>Mechanism</td>
<td>[Diagram of cusp motion]</td>
<td></td>
<td>[Diagram of cusp motion]</td>
<td></td>
</tr>
<tr>
<td>Repair Techniques (Primary)</td>
<td>STJ remodeling</td>
<td>Aortic Valve sparing: Reimplantation or Remodeling with SCA</td>
<td>Patch Repair</td>
<td>Prolapse Repair</td>
</tr>
<tr>
<td>(Secondary)</td>
<td>SCA</td>
<td>STJ Annuloplasty</td>
<td>SCA</td>
<td>SCA</td>
</tr>
<tr>
<td>(Primary)</td>
<td>Ascending aortic graft</td>
<td></td>
<td>SCA</td>
<td>Plication</td>
</tr>
</tbody>
</table>

National Heart Institute
Aortic Valve Reconstruction

INSTITUT National Heart Institute

SYNTHETIC GRAFT

AORTIC VALVE

Floppy valve leaflet

Aortic valve

INSTITUT National Heart Institute
Ozaki's Method: Aortic Valve Reconstruction with Autologous Pericardium
How to do?? - cutting

Pericardium is excised

The excised pericardium is treated with 0.6% glutaraldehyde solution

The each cusps and commissure distance is measured with Original sizing apparatus

How to do?? -stitch

Draw cusps and put dots according to the corresponding window on the template. And, Cut them.

Cusps are sutured downward on annulus from the corresponding window.

Completion

Completely Reconstructed Aortic Valve

February 2016 to October 2106: 10 cases done in IJN
Surgical Approaches to the Heart Valves
Conventional Median Sternotomy

Minimally Invasive Surgery

Figure 1: Step Wise Reduction of Sternal Trauma

A: Full sternotomy incision; B: Hemi upper sternotomy with 'T' incision; C: Upper hemisternotomy with 'T' incision; D: Non-sternal incision – right anterior mini-thoracotomy. 1,2,3 intercostal spaces.

National Heart Institute
Mitral Valve Surgical Options

Conventional
Open-chest or Sternotomy

Minimal Incision
Thoracotomy
Aortic Valve Replacement
Surgical Options

Conventional

Open-chest or Sternotomy

Minimal Incision

Right Anterior Thoracotomy

Mini-sternotomy

National Heart Institute
Repair/Replacement or Aortic Valve Repair/Replacement
Robotic Valve Surgery
Additional Combined Approaches
TAVI/TAVR

- TAVR is recommended in patients
- Who meet an indication for AVR (Section 3.4)
- Who have a Prohibitive risk for surgical AVR
- A predicted post TAVR survival greater than 12 months (71,72). (Level of Evidence: B)

- Consensus of Heart Valve Team
TAVI PROCEDURE

**SOURCE FROM TAVI DATABASE**

- **2009**: 3 patients
- **2010**: 8 patients
- **2011**: 7 patients
- **2012**: 6 patients
- **2013**: 14 patients
- **2014**: 5 patients
- **2015**: 10 patients

Number of patients (N)
Aortic Surgery
Approaches to the Aortic Root Replacement

- Bentall’s
  - David & Yacoub

- Surgical mortality < 10%

- Aortic valve repair, using the re-implantation technique or remodelling with aortic annuloplasty, is recommended in young patients with aortic root dilation and tricuspid aortic valves.

- For repair of acute Type A AD, an open distal anastomotic technique avoiding aortic clamping (hemiarch/complete arch) is recommended.

- In patients with connective tissue disorders requiring aortic surgery, the replacement of aortic sinuses is indicated.
Approaches to the Ascending Aorta/Arch

Surgical mortality < 10%
Replacement of thoracoabdominal aorta
TEVAR

Figure 1. Approved thoracic stent grafts: C-TAG (A), TX2 ProForm (B), Valiant (C), Relay (D).
Hybrid Approach
Technically Challenging

Strategies for treatment of combined Disease of the aortic arch & descending aorta

- Two Stage
- Elephant Trunk procedure
  - Single Stage
    (Clam-shell, Sternotomy + Thoracotomy)
  
  New techniques:

- Frozen Elephant Trunk (Hybrid)
ET procedure for treatment of combined disease of the aortic arch & descending aorta

Stage 1

Surgical completion

Stage 2

Endovascular completion

Borst HG et al. Extensive aortic replacement using the elephant trunk prosthesis

INSTITUT JANTUNG NEGARA
National Heart Institute
FET Procedure

The Frozen elephant trunk technique uses a stented section of graft. This potentially allows the procedure to be carried out in one stage, dependant on the length of affected vessel.

_Dake et al._ The first generation of endovascular stent grafts for patients with aneurysms of the descending aorta. JTCVS 1998

Thoraflex Hybrid Plexus Stented Distal Graft
CT Images

- 5.6 cm
- 6.6 cm
- 5.0 cm
- 5.0 cm
- 4.0 cm
- 3.0 cm
- 2.5 cm
- 5.0 cm
- 6.7 cm
- 3.0 cm
Total Arch Replacement (Frozen Elephant Trunk)

<table>
<thead>
<tr>
<th></th>
<th>No of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 2016 to Nov 2016</td>
<td>5</td>
</tr>
</tbody>
</table>
Congenital Heart Surgery
Arterial Switch Operation

Coronary arteries are detached from the aortic valve and connected to the pulmonic valve.

© 2004 - Duplication not permitted
Congenitally corrected Transposition: Double switch operation

- Venous Switch via Mustard or Senning
- Great vessel Switch
- Closure of VSD
Damus-Kaye-Stansel & Norwood, as procedures.

Figure 44-11 Damus-Kaye-Stansel operation for complete transposition of the great arteries (D-TGA) plus ventricular septal defect (VSD) plus aortic stenosis.
Mitral Valve Reconstruction in Children

Contemporary long-term outcomes of an aggressive approach to mitral valve repair in children: is it effective and durable for both congenital and acquired mitral valve lesions?

Mohd Azhari Yakub, Paneer Selvam Krishna Moorthy*, Sivakumar Sivalingam, Jeswant Dillon and Pau Kiew Kong

Author Affiliations Department of Cardiothoracic Surgery, National Heart Institute, Kuala Lumpur, Malaysia

*Corresponding author. Department of Cardiothoracic Surgery, National Heart Institute, 145 Jalan Tun Razak, 50400 Kuala Lumpur, Malaysia. Tel: +60-3-26178505; fax: +60-3-26928418; e-mail: paneer@ijn.com.my (P.S. Krishna Moorthy).


• Received September 20, 2014.
• Revision received January 28, 2015.
• Accepted February 17, 2015.
Thoracic Surgery
Thoracotomy
VATS Lobectomy
VATS
Hyperhidrosis
### What level should we perform surgery?

<table>
<thead>
<tr>
<th>Hyperhidrosis</th>
<th>Denervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craniofacial</td>
<td>T2</td>
</tr>
<tr>
<td>Palmar</td>
<td>T2-T3</td>
</tr>
<tr>
<td>Axillary</td>
<td>T2-T4 or T3-T4</td>
</tr>
<tr>
<td>Heart (Long QTS)</td>
<td>T1-T4</td>
</tr>
</tbody>
</table>
Surgery for Heart and Lung Failure
Heart Failure

1. Drug Therapy
2. Re-synchronization Therapy
3. Heart Transplantation
4. Internal Mechanical Circulatory Assistance
   A. Pulsatile Assist Devices
   B. Continuous Flow Devices
   C. Counterpulsation Devices
5. External Mechanical Circulatory Assistance
   A. Anstadt Cup
   B. Acorn Device
   C. Myocor Device
   D. PeriCor Device
6. Surgery
   A. CABG
   B. Cardiomyoplasty
   C. Mitral Annuloplasty
   D. SAVR Procedures (Dor)
   E. CABG, Mitral Annuloplasty, SAVR
A MEDICAL FIRST

BOY GETS MECHANICAL HEART

Device buys 15-year-old more time while awaiting a transplant

KOA LEMPOR, Malaysia... A 15-year-old boy gets a mechanical heart to buy himself some time while awaiting a transplant.

The pioneering procedure is also a first for the country.

The surgery was performed by a team of doctors and surgeons at the National Heart Institute (IKTM), an affiliate of the National University of Malaysia.

The mechanical heart, known as the HeartMate II, was inserted into the boy's chest while he was on a heart-lung machine.

The boy's heart was then temporarily stopped while the mechanical device was fitted in.

The heart was then restarted, with the mechanical heart continuing to provide the necessary blood flow.

The boy is expected to recover and return to a normal life with the mechanical heart providing a temporary solution while he awaits a heart transplant.

The National Heart Institute is a world leader in the use of mechanical hearts and has previously performed similar procedures.

The mechanical heart is a temporary solution for patients who are awaiting a heart transplant, providing a vital bridge to recovery.

Medical experts around the world have praised the pioneering surgery, highlighting the importance of continued research and development in the field of mechanical hearts.

The boy, who is currently recovering, is expected to lead a normal life for many years with the mechanical heart functioning effectively.

The National Heart Institute has a strong reputation for innovation and excellence in cardiac care, and this latest achievement is a testament to their commitment to improving the lives of patients with heart conditions.

The story is a reminder of the incredible advances being made in the field of cardiac surgery, and the hope that they bring for patients facing heart failure.

The mechanical heart is a temporary solution, but it provides a lifeline for patients who are awaiting a transplant, offering a chance for them to continue their lives despite their medical challenges.

The National Heart Institute's role in pioneering this surgery is a major milestone in the advancement of cardiac care, and it has set a new standard for the treatment of heart failure.
Medium and Long Term VAD
VAD Statistic of 24 VAD patients from 2005-2016

1. **Type of VAD device used**
   - Thoratec - 6 (2 IVAD & 4 PVAD)
   - HeartMate II - 8
   - HeartWare - 9
   - HeartMate 3 - 1
Heart – Lung Transplant
### Procedure: Heart Transplant
- Year: 1997
- Total Cases: 25 pts
- Description: 26 surgeries (1 redo)

### Procedure: Lung Transplant
- Year: 2005
- Total Cases: 6 pts
- Description: (1 single lung tx 5 double lungs tx)

### Procedure: Heart & Lung Transplant
- Year: 2007
- Total Cases: 4 pts
Is Innovations essential?
“I see all scientists at the bottom of a pool and if someone tires to break through the surface, they hold his legs. But if he breaks free and gets through, they cheer. True innovation and real creativity are rewarded only after they prove to be successful.”

- Craig Venter, Human Genome Project, 2008
The Essence of Innovation

“Innovation is the ability to see change as a challenge — not a threat.”

“Find something that everybody accepts as being true .... and prove it to be wrong.”

Denton A. Cooley, MD
Thank You