Cardiac Anesthesia & Surgery: Past, Present & Future

Davy C. H. Cheng, MD, MSc, FRCPC

Professor & Chair/Chief
Department of Anesthesia & Perioperative Medicine
University of Western Ontario
London, Ontario, Canada

OBJECTIVES

The Past, Present, Future

Cardiac Pharmacology & Technique
Organs Monitoring & Protection
CPB & Coagulation Management
Minimally Invasive Cardiac Surgery

1937 - Dr. John Gibbon employed the first use of heparin in an extracorporeal circuit to successfully perfuse cats.

DEBAKEY ROLLER PUMP

1937 - DeBakey recognized the dependability of the roller pump as a reliable mechanism for milking large volumes of blood along a flexible piece of tubing. It is still used as the premier bloodpumping system in the operating room.

SURGICAL MILESTONES

1938 - Dr Robert Gross, of Boston Children’s Hospital, performed the first successful ligation of a patent ductus on a seven year old female patient.
1940 - Dr. Gordon Murray, of Toronto, described his clinical experience with his surgical approach to the mitral valve using a valvulotome.

REVOLUTION/EVOLUTION IN CARDIAC SURGERY & ANESTHESIA

Inhalation Anesthetic
High Dose Narcotic
Balanced anesthesia/TIVA/Regional Anesthesia
FTCA (1-6 hrs)
Ultra-FTCA (OR, Awake)

EXTRACORPOREAL MILESTONES

1915 - Jay McLean discovered the anticoagulant effect of heparin.
1927 - Dr. Charles Best, Toronto, proceeded to purify heparin and reported on his research.

100 cases
Premedication
Induction
Maintenance
Mortality rate 23%
Morphine or Nembutol & Atropine or Scopolamine (heavy sedation)
Cyclopropane or Vinesthene
Cyclopropane and/or Ether
Spontaneous assisted ventilation
A few patients not intubated
No postoperative chest drain
SURGICAL MILESTONES:
SURFACE HYPOTHERMIA

- Wilfred Bigelow (Toronto): Experimental Hypothermia for Cardiac Surgery
  - American Journal of Physiology, 1950 direct closure of an ASD, under direct vision, utilizing short (6 minute) periods of tolerance to inflow occlusion under the conditions of moderate surface hypothermia.
- C. Walton Lillehei (Minneapolis): had heard Bigelow present his animal research work on hypothermia and went to work in his own lab studying its effect.

CAMPBELL COWAN
BIOLOGIC OXYGENATOR, 1952

- 21 cases
- 3 survivors

WILLIAM T. MUSTARD - TORONTO

- 1951- Dr. Mustard performed his monkey lung experiments. Mustard suspended the monkey lungs inside bell jars, into which pure oxygen was forced and linked the lungs with tubing that connected to a pump. After priming with human blood, Mustard would hook up the patient.

THE PAST – THE ICE AGE

JOHN GIBBON JR. - PHILADELPHIA

- 1953 - May 6, Dr. John Gibbon Jr. performed the world’s first successful closure of an ASD in an 18 year old female while her cardiorespiratory function was maintained by an extracorporeal circuit which consisted of a mechanical heart and lung
  The Gibbon heart lung machine

THE PRESENT - THE CPB AGE
4TH INTERNATIONAL CONGRESS ON THORACIC & CARDIOVASCULAR SURGERY, BEIJING 1997

SIGNIFICANT ADVANCEMENT IN CARDIAC ANESTHESIA

• PAC/TEE/IABP: Cardiac Pharmacology
• CPB Management
• Fast-Track Cardiac Anesthesia & Recovery
• Perioperative Monitoring & Organs Protection
• Antifibrinolytic Drugs – Blood Management
• Post-Operative Pain Relief
• Perioperative Outcomes Improvement and Resource Utilization: EBM

THE PRESENT - THE CPB AGE

“You don’t venture into the woods expecting to find a paved road”

C Walton Lillehei

PRESENT / FUTURE – THE MICS AGE

«And don’t give me any of those local anesthetics. Get me the imported stuff». 
CARDIAC SURGERY
A HISTORICAL VIGNETTE

«Advance in anesthesia, membrane oxygenators, heat exchangers and myocardial protection have challenged surgeons to invent new procedures for all kinds of cardiac anomalies».

Norman Shumway
Can J Cardiol 21: 1066-1068, 2005

SIGNIFICANT ADVANCEMENT IN CARDIAC ANESTHESIA

- PAC/TEE/IABP: Cardiac Pharmacology
- CPB Management: F-P, Cerebral
- Fast-Track Cardiac Anesthesia & Recovery
- Perioperative Monitoring & Organs Protection
- Antifibrinolytic Drugs – Blood Management
- Post-Operative Pain Relief
- Perioperative Outcomes Improvement and Resource Utilization: EBM

TODAY TO TOMORROW

Cardiac Pharmacology & Technique
Organs Monitoring & Protection
CPB & Coagulation Management
Minimally Invasive Cardiac Surgery

INCREASING RISK FACTORS IN CABG PATIENTS

Any Adverse Event 9.8% 8.6%

POSTOPERATIVE OUTCOME (%)

1) Ivanov et al. Can J Cardiol 2006; 22: 221-7
2) STS Report 2006

<table>
<thead>
<tr>
<th>Profile (%)</th>
<th>Toronto (n &gt; 12 K)</th>
<th>STS (n &gt; 600 K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>62</td>
<td>65</td>
</tr>
<tr>
<td>Female</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>Urgent Sx</td>
<td>42</td>
<td>45.3</td>
</tr>
<tr>
<td>Emergent Sx</td>
<td>2.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Redo Sx</td>
<td>9.5</td>
<td>8.2</td>
</tr>
<tr>
<td>NYHA Class IV</td>
<td>48</td>
<td>21</td>
</tr>
<tr>
<td>Triple VD/LM</td>
<td>46/14</td>
<td>74.9/26</td>
</tr>
<tr>
<td>DM</td>
<td>23</td>
<td>35.7</td>
</tr>
<tr>
<td>PVD</td>
<td>12</td>
<td>15.6</td>
</tr>
<tr>
<td>Hypertension</td>
<td>48</td>
<td>76.6</td>
</tr>
<tr>
<td>Renal Dialysis</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>5.1</td>
<td>5.3</td>
</tr>
<tr>
<td>COPD</td>
<td>4.3</td>
<td>19.2</td>
</tr>
</tbody>
</table>
Harmel MH, Lamont A: Anesthesia in the surgical treatment of congenital pulmonic stenosis

100 cases
Mortality rate 23%

Premedication
Morphine or Nembutol & Atropine or Scopolamine (heavy sedation)

Induction
Cyclopropane or Vinesthene

Maintenance
Cyclopropane and/or Ether
Spontaneous assisted ventilation
A few patients not intubated
No postoperative chest drain

EDWARD LOWENSTEIN, M.D.

- Morphine Doses (0.5 to 3.0 mg per kilogram of body weight)

EDWARD LOWENSTEIN, M.D.

“...It is challenging to describe briefly the milieu and circumstances that set the stage for a new concept of anesthesia for our most dreadfully ill patients. At least three things were necessary:

- An environment that tolerated and even encouraged radically creative solutions;
- A clinical problem that caused an unacceptably high death rate;
- A cast of characters with imagination, vision, courage, and clinical credibility”

DOSE–RESPONSE RELATIONSHIP OF ISOFLURANE AND HALOTHANE VERSUS CORONARY PERFUSION PRESSURES

- Safety: morbidity & mortality
  J Thorac Cardiovasc Surg
  112:755-64, 1996
- Cost benefits, improve resource utilization
  Anesthesiology 85: 1300-10, 1996
- Cost reduction in one year follow up
  Anesthesiology 98: 651-7, 2003

FAST TRACK CARDIAC ANESTHESIA & RECOVERY
**FTCA: REMIFENTANYL VS FENTANYL**
PRDB MULTI-CENTERS STUDY

Propofol induction and infusion, VCB/NBX, REMI 1 ug/kg/min vs FENT 10 ug/kg, ISO

<table>
<thead>
<tr>
<th></th>
<th>REMI (n = 150)</th>
<th>FENT (n=154)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exubation (h)</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Less Monitor (h)</td>
<td>7.8</td>
<td>7.0</td>
</tr>
<tr>
<td>ICU LOS (d)</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Hospital LOS (d)</td>
<td>5.0</td>
<td>4.9</td>
</tr>
</tbody>
</table>


**IMPACT OF THE OPENING OF A SPECIALIZED CARDIAC SURGERY RECOVERY UNIT ON POSTOP OUTCOMES**

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Hospital Mortality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004/5</td>
<td>2.1 ± 3.0%</td>
<td>17/967 (1.8%)</td>
</tr>
<tr>
<td>2005/6</td>
<td>2.5 ± 4.4%</td>
<td>16/979 (1.6%)</td>
</tr>
<tr>
<td>p value</td>
<td>0.08</td>
<td>0.86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of Major Complications</td>
<td>14.7 ± 8.4%</td>
<td>127/967 (13.1%)</td>
</tr>
<tr>
<td>2005/6</td>
<td>15.3 ± 8.2%</td>
<td>96/979 (9.8%)</td>
</tr>
<tr>
<td>p value</td>
<td>0.22</td>
<td>0.003</td>
</tr>
</tbody>
</table>


**VOLATILE ANESTHETICS: PRECONDITIONING**

**ANESTHETIC AGENTS: MOA**

- GABA receptor
  - Propofol, thiopental, inhalational agents
- NMDA receptor
  - Nitrous oxide, ketamine, xenon
- Receptor-synapse based/kinetics of cellular events

**CARDIAC SURGICAL RECOVERY MODELS**

- Fast Track Cardiac Anesthesia
  - Conventional Model
  - Parallel Model
  - Integrated Model


**PUBLIC VS PRIVATE INSTITUTIONAL PERFORMANCE REPORTING**

- 30-day mortality rate decreased by 29% between no reporting (1991-1993) and confidential reporting (1994-1998)
- No further decrease with public reporting (1999-2001)
- Confidential disclosure of outcomes is sufficient to accelerate Quality Improvement in a public health care system

Guru, Fremes, Naylor. Am Heart J 2006;152:573-8
PARADIGM SHIFT IN MANAGEMENT OF CARDIAC SURGERY PATIENTS

Past
- Risks
- Assessment and Stratifications

Present
- Risks/Costs
- Reduction and Outcome Improvement

Future
- Genomics
- CV Technology
- Safety & EB practice

CARDIAC ANESTHESIOLOGIST (PERIOPERATIVE MEDICINE)
- Cardiac Surgeon - Interventionist
- Imaging & Nuclear Medicine
- Cardiac Patients
- Perfusionist - Nurse
- Point of Care Lab

CARDIAC PHARMACOLOGY & TECHNIQUE
- Future Projections
  - Genomic and Risk Stratification
  - ‘Personalized’ ‘Perioperative’ Medicine
  - MOA Anesthetics
  - Safety, Cost-Effectiveness and Evidence-Based Practice

TODAY TO TOMORROW
- Cardiac Pharmacology & Technique
- Organs Monitoring & Protection
- CPB & Coagulation Management
- Minimally Invasive Cardiac Surgery

FTCA: INTRAOPERATIVE AWARENESS
- Last memory before surgery:
  - Holding Area / OR: (n = 608) 100%
- Next memory:
  - ICU: (n = 606) 99.7%
  - Intraop: (n = 2) 0.3%

Dowd N, Cheng D, et al.
Anesthesiology 1998;89:1068

Depth of Anesthesia - CATEEM, BIS, SFI
In 58.5% of the unstable patients, clinical management was changed by TEE result.
In surgical intervention, mortality is improved.
NON-INVASIVE FUNCTIONAL AND MORPHOLOGICAL IMAGING

Function
Normal (EF = 58%)
Mild LVH

Perfusion
Global
Ischemia

Viability
Small Anterobasal
Infarct

TwinSpeed Excite II
MYOCARDIAL PRODUCTION
THE PRESENT

- Temperature: Tepid
- Direction: Combined, continuous when possible
- Composition: Arrest-Perfuse-Protect
  K+ lowest to induce arrest
  Mg++ to facilitate arrest and protect
- Additives: Insulin, adenosine, L-Arginine, Beta-adrenergic blocker

NOVEL DEVICES TO REDUCE INFARCT SIZE

ORGANS MONITORING & PROTECTION

Future Projections

- Specific target organs monitoring and protection (brain, heart)
- Decrease utilization of PAC and increasing TEE
- Multi-functional IVUS (+ enhancements) achieves widespread acceptance and use
- MRI and CT techniques evolve further as versatile non-invasive high resolution diagnostic modalities
- Gene induced Angiogenesis
- Stem Cell therapy to restore heart function

DIRECT INTRA-MYOCARDIAL INJECTIONS: STILETTO™
TODAY AND TOMORROW

Cardiac Pharmacology & Technique
↓
Organs Monitoring & Protection
↓
CPB & Coagulation Management
↓
Minimally Invasive Cardiac Surgery

EMERSON MOFFITT, M.D.

- Extracorporeal Circulation: Relationship of Blood Flow and Volume
  - Surgical Forum, 1957

- Cardiac Support with the Gibbon Oxygenator
  - Anesthesiology, 1957

RELATION OF VENOUS OXYGEN SATURATION TO BLOOD FLOW DURING TOTAL PERFUSION

COAGULATION MONITORING

- TEG whole blood test of viscoelastic blood clot formation
- Ultegra platelet response to a thrombin receptor agonist peptide (TRAP)
- Clot Signature Analyzer (CSA) measure platelet reactivity
- Plateletworks platelet count ratio to assess platelet reactivity

BLOODLESS SURGERY


Jehovah’s Witnesses who require operation represent a challenge to the physician because of the patients’ refusal to accept blood transfusion. We report a 20-year experience with a consecutive series of 542 Jehovah’s Witness patients ranging in age from 1 day to 89 years who underwent operation. Early mortality (within 30 days after operation) was 9.4%. In 362 patients requiring temporary cardiopulmonary bypass, early mortality was 10.7%. Mortality was 13.5% among 126 patients who had single- or double-valve replacement. The only deaths among patients who had aortic valve replacement or repair of a ventricular septal defect occurred in those who had some serious complication before operation. Preoperative or postoperative anemia was a contributing factor in 12 deaths, and loss of blood was the...
RFVIIa MECHANISM OF ACTION: BOOSTS THROMBIN GENERATION ON ACTIVATED PLATELETS

TODAY TO TOMORROW
Cardiac Pharmacology & Technique
Organs Monitoring & Protection
CPB & Coagulation Management
Minimally Invasive Cardiac Surgery
END STAGE CHF: TREATMENT OPTIONS

Medical Management

Cardiomyoplasty Artificial Heart Mechanical Assist Device Partial Left Ventriculectomy

Heart Transplantation

VENTRICULAR ASSIST DEVICES

- Extracorporeal pulsatile pump: ABIOMED BVS 5000, Thoratec Assist
- Intracorporeal implantable: HeartMate, Novacor – LVAD
  ABIOCOR, TAH

THORATEC VENTRICULAR ASSIST DEVICE

Left Support

Biventricular Support

Naughton P and Bashour CA.

TCI-HEARTMATE LVAD
Cheng CHD. Cardiac Anesthesia & Surgery

TMR: MECHANISM OF ACTION?

- Channel Patency
- Angiogenesis
- Neurogenic
- Placebo

HYBRID OR: LHSC

TRANSMYOCARDIAL REVASCULARIZATION

SURGICAL TECHNIQUE: ENDOSCOPIC VEIN HARVESTING

wound drainage, necrosis, infection, and leg edema

PERCUTANEOUS INTERVENTION FOR STRUCTURAL HEART DISEASE

THE LOTUS™ VALVE BY SADRA MEDICAL

NEW PFO CLOSURE DEVICES

THE LOTUS™ VALVE BY SADRA MEDICAL

PRESENT / FUTURE – THE BIO-TECHNOLOGY AGE

ENDOVASCULAR MITRAL REPAIR SYSTEM (EVALVE)

• Interventional Cardiology
• Hybrid procedure
• Angiogenesis
• Tissue Engineering
• Xenotransplant
• Stem cell therapy

Robotics Operating Suite Floor Plan - Level 2
MINIMALLY INVASIVE CARDIAC SURGERY

Future Projections

- Minimally invasive coronary and valve surgery
- Robotic hybrid procedure
- Interventional cardiovascular procedures
- Anesthesia imperative to complement the advancement in Biotechnology