Adult Cardiac Surgery: Past, Present and Future

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9th Annual Meeting of the Euro-Asian Bridge
Sofia, Bulgaria, 2012
No Conflicts of Interest to Declare
MISSION IMPOSSIBLE
The Past: Surgical Milestones

– Surgery of the Pericardium
– Stab wounds of the Heart
– Pulmonary Embolectomy
– Pre CPB heart valve surgery
Timeline – Surgery of Pericardium

**Morgani, 1761**
7 cases of constrictive pericarditis
“heart was so constricted and confined that it could not receive a proper quantity of blood to pass through it”

**Weill, 1895**
excision of thickened fibrous pericardium in constrictive pericarditis

**Pick, 1896**
course of chronic pericarditis
The Past Era of Surgery
A Brief History…Major Milestones

• Delayed development of major surgery due to lack of knowledge and technology
• General anesthetics, ether and chloroform were developed in the mid-1800s
• Surgery of pericardium opened up new questions
• Surgical approach to pulmonary embolectomy
• Heart surgery before the era of CPB
Timeline – Heart Wounds

Dr. Daniel Hale Williams (1856-1931): July 10, 1893
-24y/o with stab wound to heart
-Hole in Pericardium

Dr. Rehn, 1896:
-First successful RV stab repair, 22y/o male

Dr. Rehn, 1906:
-Accumulates 124 cases with 60% mortality
Timeline – Pulmonary Embolectomy

Trendelenburg:
Evaluated sudden death in 9 patients with P.E.
Performed pulmonary embolectomy in 2 pts, none survived

Kirschner: Student of Trendelenburg - First successful pulmonary embolectomy.
(Reported at German Surgical Conference in Berlin)
Timeline – Heart Valve Surgery before CPB

Theodore Tuffier, 1912: First clinical attempt to open a stenotic valve

Souttar, 1925: Successful Mitral finger commissurotomy

Charles Bailey, 1948: 2 cases of mitral commissurotomy

Thomas Holmes, Sellers, 1947: Pulmonary valvotomy
Timeline – Heart Valve Surgery before CPB

**Early 1952**
Charles Hufnagel – implanted valve in the descending thoracic aorta in 30 y/o patient, who would live normal life
Current Cardiac Surgery Milestones

- Development of Cardiopulmonary Bypass
- Pacemaker
- Myocardial Protection
- Valve Prostheses/Repair
- Coronary Artery Surgery
- Surgery for Heart Failure/Artificial Heart/Assist Device
Development of CPB

• Alexis Carrel, French surgeon and biologist, awarded Nobel Prize in Physiology/Medicine in 1912; pioneering vascular suturing techniques. He invented the first perfusion pump with Charles A. Lindbergh
Development of CPB
Dr. C. Walton Lillehei (1918 – 1999)
Natural Heart/Lung Machine (the parent)

- Cross Circulation 1954-1955
- Controversy - 200% Mortality
  - (parent and child)
Imagine such a procedure in 2012!

FDA would never approve it

Potential for serious consequences…
Pacemakers

- John Hopps:
  - Canadian electrical engineer, (University of Manitoba NRC): Heart stopped beating due to cooling. Could be started by artificial stimulation (mechanical or electric means)

- World’s first external cardiac pacemaker in 1950 - Too large to be implanted into humans
Early Pacemakers
Lillehei was looking for a better pacemaking system. One day when Bakken was visiting the hospital, a storm knocked out power, and a patient hooked up to an external pacemaker died. Bakken was asked if he could build a better and more reliable pacemaker.
• William Chardack and Dr. Andrew Gage, 1959, Buffalo, N.Y. working with electrical engineer William Greatbatch, developed a viable implantable pacemaker using primary cells as a power source.
Heart/Lung Machine

• First Heart/Lung Machine
  1953 – 5 out 6 Patients died

• Mayo Clinic launches own Heart Program in March of 1955
  – Using heart/lung machine based on Gibbon IBM Machine
Development of CPB

John W. Kirklin (1917-2004) and colleagues at the Mayo Clinic launched their open heart program on March 5, 1955. They used a heart-lung machine based on the Gibbon-IBM machine.
Catheterization of Right side of the Heart

- Werner Theodor Forsmann (1904-1979)

- 1956:
  - Nobel Prize in Physiology or Medicine
  - (Andre Cournand and Dickenson Richards)
Werner Forssmann

• “I kept looking for different, safer access to the cardiac chambers: the catheterization of the right heart via the venous system”…

• “…After these successful preliminary studies, I attempted the first experiment on a living human, performing the experiment on myself”…
…I checked the position of the catheter radiographically, a nurse was holding a mirror in front of the x-ray screen for me to observe the catheter in advance position…”
Prosthetic Heart Valve Development

- Albert Starr, 1960
- First successful orthotopic mitral valve replacement (Starr Edwards Ball Valve);
- Followed by Harken’s implantation of a prosthesis in the aortic position
Myocardial Protection

Cold Blood cardioplegia (Gerald Buckberg)

Milestone in myocardial protective strategies


Myocardial Protection

Crystalloid → Cold Blood Cardioplegia → Warm Blood Cardioplegia → Tepid

Intermittent → Continuous delivery → Antegrade, Retrograde and simultaneous delivery

Cardioplegia → Beating Heart
“Tom” Tomas Salerno

“Geri” Gerald Buckberg
Beating Heart Valve Surgery
Borut Gersak (Retrograde perfusion) and
Tomas Salerno (Simultaneous perfusion)
Beating Heart Valve Surgery with Lung Perfusion/ventilation


Coronary Artery Surgery – Founding Fathers

- 1876: Adam Hammer establishes that heart attacks occur when at least one coronary artery is blocked
- 1910: Alexis Carrell presents paper describing coronary artery bypass
- 1950: Arthur Vineberg reroutes the internal mammary artery into heart muscle
- 1953: D.W. Gordon uses sections of mammary, axillary or carotid arteries to replace diseased left anterior descending artery sections
- 1953: William Mustard does first direct suture of carotid to coronary artery – patient does not survive
- 1955: Sidney Smith harvests saphenous vein from leg and uses it as a graft from aorta to direct blood flow into the myocardium
- 1960: Robert Goetz and Michael Rohman performed a single mammary artery bypass to anterior descending coronary artery and implanted tantalum stent
- 1962: Sones and Shirey at Cleveland Clinic use angiography to visualize blockages in coronary arteries
Arthur Vineberg (1903-1988)
Coronary Artery Surgery – From Vineberg Procedure to CABG

• Rene G. Favaloro (1923 – 2000)

• Large experience with Vineberg Procedure

• 1968 – Cleveland Clinic – 171 Patients with saphenous vein with multiple grafts
Conventional CABG

- Gained popularity and became the most common operation performed
- The most investigated procedure, with excellent results
- Majority of the surgery performed by Cardiac Surgeons
Pioneers in Off Pump Coronary Surgery: Federico Benetti and Enio Bufolo
CABG SURGERY – TRANSITION PHASE AND EVOLUTION

- On Pump with Sternotomy
- Off Pump with Sternotomy
- Small Incisions On Pump
- Small Incisions OFF Pump
- Hybrid
- Robotic
Integrated left small thoracotomy and angioplasty for multivessel coronary artery revascularisation

Angelini GD, Wilde P, Salerno TA, Bosco G, Calafiore AM.

Lancet 1996;347:757-758
LIMA Extension

KW - LIMA Extension

Expiration

Inspiration

Peter Wilde
University of Bristol - Academic Department of Clinical Radiology

LAST operation
LIMA-LAD
Beginning of a new era
(Calafiore et al)
MIDCAB Procedure

- No CPB
- Small incision
- Replaces conventional CABG
- Starts in 1990’s and gained popularity
- LIMA-LAD and other grafts
- Calafiore (LAST operation)
Robotic Surgery (TECAB)
Coronary Artery Balloon Angioplasty

- Andreas Gruntzig – German cardiologist; first to use coronary artery balloon angioplasty

AHA Scientific Sessions Miami FL, 1975
Severe Stenosis

Successful Angioplasty with Stent

Three months later
Easter Island – Rapa Nui 1975 – Discovery of new antibiotic
CABG vs. Stents: Know Your Options: David Taggart
Current Changes in Coronary Surgery

Types of Patients

- Severe diffuse disease
- Extreme tortuosity
- Dangerous/difficult anatomy
- LM
- Unstable patients
- Chronic total occlusion
- Combined cardiac disorders
- Valvular
- LV remodeling
- Emergency bail out

Effects on Practice

- More complex cases
- Higher morbidity and mortality
- Longer hospital stays
- Need for LVAD or transplant support
- Training implications
- Case numbers
What is left for Cardiac Surgeons at the Present Time?
CARDIAC SURGERY
PREDICTING THE FUTURE
A Realistic View of the Cardiothoracic Surgery Specialty

Salerno TA

(CTSnet, In My Opinion, March 18, 2002)

• Surgeons need to learn from the past

• Explosion of new developments: robotic, minimally invasive, dilated cardiomyopathy surgery, assist devices/artificial heart, percutaneous valve

• These procedures are being done mostly by radiologists, cardiologists, neurosurgeons
Cardiac Surgeons should move from the operating room...

To the Catheterization Laboratory
Future of Coronary Artery Disease: Cardiologist’s Role

- Imaging techniques to complement/replace catheterization
- Angioplasty/stent for selective cases
- Medical treatment of coronary disease (prevention): Beta Blockers, ACE inhibitors, Statins, Gene Therapy
- What if a drug is developed that eliminates atherosclerosis?
• Surgery for Tuberculosis: Isoniazid

• Ulcer Surgery: Tagamet, H. pylori

• Coronary surgery: Rapamycin (stent)=====dinosaur!
Surgeon’s Role: Mainly complex coronary cases

- Complications of acute MI
- Other procedures (surgery for heart failure, assist devices, transplantation) related to ischemic heart disease
Congestive Heart Failure

Annual In-patient Volume

CHF is America’s Highest Volume DRG
Mortality Rates in Heart Failure

Smith WM. Am J Cardio 1985
Cost of Heart Failure

- $14.7 billion outpatient care
- $23.1 billion in-patient care
- $270 million 1800 heart transplants
- Total $38.1 billion - 5.4% of estimated $700 billion total healthcare expenditure 1991 (federal hospitals excluded)

  – J Heart Lung Transpl 1993:13(4);S107-112
Heart Transplantation

- Norman Shumway – Father of Tx
- Christian Barnard – 1967, first human heart transplant
Listed/Transplanted/Died on List 1988-1997
Molecular Engineering and Gene Therapy: - Xenotransplantation?
Building Hearts

Left Ventricular
Reconstructive
Surgery in 1985
Approaching CHF Surgically

- Transplantation
- Dilated Cardiomyopathy
  - Partial left ventriculectomy (Batista)
  - Jatene Procedure, Dor Operation
  - Acorn
  - Myosplint
- Ischemic Cardiomyopathy
  - Remodelling procedures
- High-risk reparative surgery
  - Bolling mitral valve repair
  - High risk coronary bypass
- Mechanical circulatory assist
- (Stem cells and others)
Surgery for Heart Failure:
The Dor Procedure

Left Ventricular Reconstructive Surgery in 1985
The Batista Operation:

- Partial Left Venticulectomy for Dilated Cardiomyopathy (1994)
Gerald Buckberg: Ventricular Restoration
Controversy of SVR - Con


- Summary:
  - The efficacy of CABG alone versus CABG + SVR in pts with coronary artery disease and LV systolic dysfunction
  - No significant difference between the two study groups in the degree of symptom improvement or in the rate of death or hospitalization for cardiac causes.
Controversy of SVR - Pro

• The STICH trial: Misguided conclusions
• Gerald D. Buckberg, MD et al
  • (J Thorac Cardiovasc Surg 2009;138:1060-1064, 2009)

• Summary: The STICH trial must address each of these questions because misguided STICH conclusions contradict the role of augmented ventricular volume as the surrogate for the natural history of increasing morbidity and mortality in dilated hearts.\textsuperscript{2,18} Without this action, the STICH trial conclusions simply show that statisticians can defy nature from a flawed database.
Ventricular Assist Devices

- **Bridge to recovery**
  - Abiomed, Thoratec

- **Bridge to Transplant**
  - HeartMate, Novacor, CardioWest, Abiomed, Thoratec, MicroMed (DeBakey), Lion Heart

- **Alternative to Transplant (Destination Therapy)** — must be portable, but not necessarily totally implantable-
  - HeartMate, Novacor, Micromed, Lion Heart, Abiomed TAH, Thoratec, CardioWest
Future VAD Products
Thoratec Implantable VAD
Mechanical Assist Devices

• Univentricular Assist
  – Micromed DeBakey VAD
  • Axial flow Pump
Mitral Valve Surgery - Milestone
Legendary Contributions:
Alain Carpentier/David Adams
Mitral Valve Surgery – The Future

• From Replacement to Repair

• From Conventional surgery to minimally invasive, robotic surgery and others
Mitral Valve Surgery – The Future

• Switching from formal open-heart surgery to percutaneous intraluminal procedures
• Done mostly by Cardiologists
Percutaneous Mitral Clip (contribution of Alfieri)

- Everest II Trial:
  - 3+ or grade 4+ mitral regurgitation:
    Clip: 19.8%  Surgery: 21.7%  (0.84)

- Freedom from death:
  Clip: 11.0%  surgery: 10.8%  (>0.999)

- Freedom from death, mitral valve surgery, and grade 3+ or grade 4+ mitral regurgitation:
  Clip: 51.7%  surgery: 66.3%  (<0.001)
Percutaneous Aortic Valve Replacement

- Feasibility
  - Is this procedure possible?
  - Can the device be delivered successfully?
  - Can the patient survive the procedure?

- The patients treated were desperately ill and had no alternative, many were at imminent risk of death

1st Successful Transcatheter Aortic Valve
April 16, 2002
7 Terminally ill patients
Expected Survival < 6 Months
Symptomatic calcific AS
Inoperable by a cardiac surgeon
Percutaneous Valves Cont.

• Approaches
  – Transfemoral/Iliac
  – Transapical
  – Trans-Subclavian
  – Direct Aortic

• Expansions
  – Mitral Valve Disease
  – Tricuspid
  – Pulmonic
  – Valve in Valve
Thoracic Aortic Surgery: Aortic Stenting
Figure 4: Fenestrated Zenith® device with Palmaz stents designed for the treatment of juxtarenal abdominal aortic aneurysms.

Permission obtained from the International Society of Endovascular Specialists © Anderson JL et al. (2001) J Endovasc Ther 8: 3-15
The Future of Cardiologists and Cardiac Surgeons

• Formation of one specialty combining cardiology/Cardiac Surgeons with skills in both specialties

• The training of future generation of heart surgeons with skills in cardiology

• Training of cardiologists with training in Cardiac surgery
Cardiovascular Team

The Chimera on a red-figure Apulian plate, ca 350-340 BC (Museo du Louvre)
Requirements for the Future

• Leadership of Societies to change paradigm

• Cardiologists and Cardiac Surgeons desire to amalgamate the specialties

• Program directors to the change attitude

• Common clinical decisions
Thank You for Your Attention