Echo Evaluation of a Mitral Valve Prostheses
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Disclosures

Speakers Bureau
Philips, Medtronic
Prosthetic valves have been in clinical use for about 50 years.

Until recently, cross-sectional 2D imaging was practically the only way to visualize them.

With 3D echocardiography images start to match the appearance of actual valves.

St. Jude mitral valve in ‘anti-anatomic’ position.
HISTORICAL DEVELOPMENT OF PROSTHETIC VALVES

- Mechanical Valves
- Bioprosthetic Valves

1960’s | 1970’s | 1980’s | 1990’s | 2000’s
Valve Prostheses

Mechanical

First implantation 1960

Starr-Edwards mechanical valve

Albert Starr
(b. 1926 in New York)

Bioprosthetic

First implantation 1965

Carpentier-Edwards bioprosthetic valve

Miles Lowell Edwards
(1898-1982)

Alain Carpentier
(b. 1933 in Toulouse)
Mechanical Valves

(Year of First Introduction)

Starr-Edwards (1960)

Björk-Shiley (1969)
>> Discontinued 1986

Hall-Kaster (1977)
>> Medtronic Hall

Omniscience (1978)

Nicoloff-Posis (1977)
>> St Jude

Omnicarbon (1984)

Carbomedics (1980's)

Ball-in-Cage

Single Leaflet

Bileaflet
Mechanical Mitral Valve Prostheses

1. Ball-in-Cage
2. Single Tilting Disc
3. Double Tilting Disc


Increase in Valve Orifice Area

Metal cage + silastic ball

Partly or fully made of **pyrolytic carbon**
(originally used in nuclear reactors)

Jack Bokros
(b. 1935)
Inventor of pyrolytic carbon
**Question #1:** How many prosthetic valves are implanted in the United States annually?

A. 1,000
B. 10,000
C. 100,000
D. 1,000,000

**Question #2:** What percentage of implanted valves are mechanical?

A. 10%
B. 30%
C. 50%
D. 70%

Annually, approximately 100,000 prosthetic valves are implanted in the United States, approximately 50% of which are mechanical.

United States represents approximately 1/3 of the world valve prosthesis market.
Mechanical Prostheses

BALL-IN-CAGE
Starr-Edwards
Ball-in-Cage Valve

Albert Starr
(b. 1926 in New York)
American Surgeon
Trained at Bellevue Hospital,
now part of NYU

Miles Lowell Edwards
(1898-1982)
American Engineer

Bottle Stopper
1858 patent to JB Williams from New York
77-year-old woman; s/p Starr-Edwards MVR (Model 6120; size 2M = 28 mm) 35 years earlier in Rochester, NY
Starr-Edwards Mechanical Valve
(Model 6120)
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Used since 1960’s

Still in production and implanted mostly in developing countries due to its reasonable cost.
3D TEE: Starr-Edwards Valve

LA Side

AV
Atrial Septum
LAA
Coronary Sinus

LA
LV
Starr-Edwards Valve on Fluoroscopy

Fluoroscopy
Starr-Edwards Mitral Valve

Video 1

Mechanical Prostheses

SINGLE TILTING DISC
SUMMARY: SINGLE TILTING DISC MECHANICAL PROSTHESES

Björk-Shiley
------------------------
2 central struts

Medtronic Hall
------------------------
1 central strut

Omniscience
------------------------
No central struts
Björk-Shiley Single Tilting Disc Valve

Viking Björk (1918-2009) Swedish Cardiac Surgeon

Donald Shiley (1920-2010) American Engineer
**Björk-Shiley Single Tilting Disc Valve**

Fluoroscopy: Björk-Shiley MVR
Figure
40-year-old woman; s/p Björk-Shiley MVR in 1980’s
Now presents with progressive dyspnea
2D TEE: Björk-Shiley MVR

**NORMAL**
Mild Mitral Regurgitation
(Washing Jets)

**ABNORMAL**
Paravalvular Mitral Regurgitation
3D TEE: Björk-Shiley Mitral Prosthesis

**DiaSTOLE:** Valve Open

**SYSTOLE:** Valve Closed

**SYSTOLE:** Paravalvular Leak
3D TEE: Björk-Shiley Mitral Prosthesis

Severe paravalvular mitral regurgitation
77-year-old woman; s/p Björk-Shiley MVR in 1980’s
Now presents with hemolytic anemia
Hall-Kaster (Medtronic Hall) Singe Tilting Disc Valve

Karl Victor Hall  
(b. 1917)  
Norwegian Surgeon

Robert Kaster  
(b. 1933)  
American Engineer
Medtronic Hall (Hall-Kaster) Singe Tilting Disc Valve

Karl Victor Hall (1917-2001)
Norwegian Surgeon

Robert Kaster (b. 1933)
American Engineer
Medtronic Hall Single Tilting Disc Valve

Used since 1977; still in production
Fluoroscopy: Medtronic Hall MVR + AVR

Fluoroscopy
Hall-Medtronic Mechanical
Mitral & Aortic Prostheses
Single-disc mechanical prosthesis with a centrally protruding shaft

Physiologic central mitral regurgitation (‘donut hole regurgitation’)
Medtronic Hall Valve

Single-disc mechanical prosthesis with a centrally protruding shaft

Physiologic central mitral regurgitation ('donut hole regurgitation')
Omniscience Single Tilting Disc
(Derived from Lillehei-Kaster Valve)

C. Walton Lillehei
(1918-1999)
American Surgeon

Robert Kaster
(b. 1933)
American Engineer
Fluoroscopy: Omniscience MVR
Single-disc mechanical prosthesis with no protruding shaft

Minimal physiologic regurgitation
OMNISCIENCE
Single Tilting Disc
Mechanical Valve

Used since 1978;
still in production.

OMNICARBON
Variant of
Omniscience, made
purely of pyrolytic
carbon; in production
since 1984
3D TEE: Omniscience Valve

- Ligated LAA
- Atrial Septum
- Coronary Sinus

[Images showing anatomical structures]
**SUMMARY: SINGLE TILTING DISC MECHANICAL PROSTHESSES**

Björk-Shiley

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2 central struts

Medtronic Hall

---

1 central strut

Omniscience

---

0 central struts
Mechanical Prostheses

Double Tilting Disc
St. Jude Bileaflet Tilting Disc Valve  
(Nicoloff-Posis-Villafaña Valve)

Named after St. Jude Thaddeus, patron saint of difficult cases by Manuel Villafaña whose son was recovering from serious disease at the time.

Demetre Nicoloff  
(1934-2003)  
American Surgeon

Manuel Villafaña  
(b. 1940 in New York)  
American Entrepreneur

Apostle Jude Thaddeus  
by Anthony van Dyck  
c. 1619
Fluoroscopy: St. Jude MVR

Fluoroscopy
St. Jude Mitral Valve
Double-disc mechanical prosthesis

2 out of 6 jets of physiologic regurgitation seen
ST. JUDE Bileaflet Tilting Disc Mechanical Valve

Used since 1977; still in production

CARBOMEDICS

Very similar to St. Jude valve
St. Jude mitral valve in ‘anti-anatomic’ position.

Multiple jets of physiologic regurgitation + Paravalvular leak At 7 o’clock
St. Jude mitral valve in ‘anatomic’ position.

Paravalvular Leak (PVL)
At 10 o’clock
3D TEE: St Jude MVR with Multiple Paravalvular Leaks
3D TEE: St Jude MVR – Closure of PVLs
Bioprostheses
Bioprostheses

He developed the concept and coined the term bioprosthesis.

Alain Carpentier
(b. 1933 in Toulouse)
French Surgeon
Bio-prostheses

- Autograft
  - Ross procedure

- Homograft
  - Cadaveric aortic valve

- Xenograft (Heterograft)
  - Porcine
  - Bovine

The only type used in mitral position

Alain Carpentier
(b. 1933 in Toulouse)

Carpentier’s contributions

- Glutaraldehyde preservation
- Use of pig aortic valve in human mitral position
- Prosthetic stent
- Coined the term ‘bioprosthesis’ (‘bioprothèse’ in French)
Bioprosthetic Valves

- **Bovine pericardium**
- **Porcine aortic valve**
- **Stentless**

Source: *J Am Coll Cardiol Intv* 2011;4:721–32
BIOPROSTHETIC VALVES: X-RAY IMAGING

HANCOCK
standard

MEDTRONIC
Hancock II

CARPENTIER-EDWARDS (CE)
CE, pericardial

Hancock modified

Medtronic Mosaic

CE, supra-annular

CE, Perimount (Magna)

Source: J Am Coll Cardiol Intv 2011;4:721–32
Carpentier-Edwards PERIMOUNT Stented Bovine Pericardial Valve

One of many types of bioprosthetic valve.
3D TEE: Normal Carpentier-Edwards MVR

LA Side

LV Side
3D TEE: Edward Magna Bio-MVR

LV Side

LV Side
3D TEE: Stenosed Mitral Bioprosthesis

Stenosed mitral bioprosthesis (LA side)

Stenosed mitral bioprosthesis (LV side)
Fluoroscopic Guidance of Balloon Valvuloplasty
Bioprosthetic Mitral Balloon Valvuloplasty
Mitral Valve Repairs
MV Repairs

- Ringless
- Ring (Full circle)
- Band (Partial circle)

Alain Carpentier
(b. 1933 in Toulouse)
‘Father of MV repair’

Carpentier’s Contributions

- Use of prosthetic ring
- Techniques of mitral repair
Mitral Valve Repairs

RINGLESS REPAIR
‘Ringless’ Mitral Valve Annuloplasty

Not commonly performed.

LA Side  LV Side
Ringless Mitral Valve Repair

3D TEE
Ringless MV Repair
Annuloplasty Rings & Bands

Full annuloplasty ring

Partial annuloplasty ring (band)
Mitral Valve Repair With Annuloplasty Band

Figure 67

Stephen Colvin
(1943-2008)

Aubrey Galloway
Head, NYU CT Surgery

Colvin-Galloway Future Band,
a semi-rigid annuloplasty band (2001)
Colvin-Galloway Future Band Mitral Valve Repair

One of several types of annuloplasty bands

LA Side

LV Side
Mitral Band Annuloplasty

3D TEE
Mitral Annuloplasty Band
Mitral Annuloplasty: Partial Ring (Band)

Normal Annuloplasty Band
Mitral Annuloplasty: Partial Ring (Band)

Dehisced Annuloplasty Band
85-year-old man; s/p mitral band annuloplasty a year earlier
Now presents with *Staph aureus* bacteremia

3D TEE: Mitral Annuloplasty Band

NYU Leon H. Charney Division of Cardiology 2/11/2016
85-year-old man; s/p mitral band annuloplasty a year earlier
Now presents with *Staph aureus* bacteremia
Mitral Valve Repair With Annuloplasty Ring
Carpentier
Physio
Mitral Valve
Ring
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One of many types of annuloplasty rings
Mitral Ring Annuloplasty
Mitral Annuloplasty: Full Ring

AV

Atrial Septum

LAA

Coronary Sinus
Percutaneous MV Repair (Mitral Valve Clipping)

**MitraClip**
4-mm wide Cobalt Chromium V-shaped clip covered with polyester cloth

Figure 78
History of Mitral Valve Repair

1970’s
MV Repair with Annuloplasty Ring

June 1991
Surgical Edge-to-Edge Repair (Alfieri stitch)

2000’s
Percutaneous Edge-to-Edge Repair (Evalve; MitraClip)
Mitral Valve Repairs

SURGICAL EDGE-TO-EDGE REPAIR (ALFIERI STITCH)
83-year-old man; s/p surgical Alfieri stitch 9 years earlier
Surgical Alfieri Stitch: 3D TEE

83-year-old man; s/p surgical Alfieri stitch 9 years earlier

LA Side

LV Side
Mitral Valve Repairs

PERCUTANEOUS EDGE-TO-EDGE REPAIR (MITRAL CLIP)
Percutaneous mitral clipping is approved in the United States for the following indication:

Significant symptomatic degenerative mitral valve disease with mitral regurgitation ≥ 3+ who have too high a risk for surgery.
Mitral Clipping: Clip Deployed

Left atrial side

Left ventricular side
Percutaneous Mitral Clipping: Clip Being Deployed
Percutaneous Mitral Clipping: Clip Positioning

**Improper**
Clip Orientation

**Proper**
Clip Orientation
Percutaneous Mitral Clipping: Clip Deployed
Percutaneous Mitral Valve Clipping

Single Clip

Two Clips
Post clipping: Only mild mitral regurgitation
Valve-in-Valve App
Available for iOS; android version pending
Thank You!

New York University Medical Center
This presentation is a result of a collaborative effort of many members of the NYU medical community including Echo Lab, Cath Lab, EP Lab, Clinical Cardiology, Cardiac Surgery & Pediatrics.
Christian Hall

The son of Karl Victor Hall, the inventor of the Medtronic Hall valve

American Heart Association (AHA) Meeting, Los Angeles
November 3, 2012