Percutaneous MV Repair

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DISCLOSURE

I have NO relevant financial relationships.
3D-TEE in Mitral Interventions

- Surgical mitral valve repair (Operating Rm)
- Edge-to-edge repair of mitral regurgitation
- Transcatheter MV insertion (TMVI) → (e.g., Tendyne)
- Closure of paravalvular mitral regurgitation
- Valve-in-valve implantation
- Balloon mitral valvuloplasty (mitral stenosis)
Echo for MV Disease

- Mitral valve anatomy/pathology
  [Mechanism(s) of MV disease]

- Quantitation of MR

- Procedural guidance
Unlike AS $\rightarrow$ singular pathology

MR $\rightarrow$ highly variable etiologies
MV anatomy/pathology
Mitral Valve Apparatus

- Left atrium
- Annulus
- Leaflets
- Chordae tendinae
- Papillary muscles
- LV free wall
- Dilatation
- Calcification
- Prolapse
- Redundancy
- Thickening
- Perforation
- Cleft
- Commissural fusion
- Abnormal insertion
- Elongation
- Rupture
- Thickening/fusion
- Ischemia
- Fibrosis
- Rupture
- Lateral displacement (ischemia, fibrosis, dilatation)
Tenting area

Coaptation depth

Leaflet overlap
Mechanisms of Mitral Regurgitation

- Normal
- Apical Tethering
- Dilated anulus
- Restricted PML
- Prolapse
- Ruptured pap muscle
Ruptured cords
Case 1

Ruptured cords P2
Case 2

Ruptured cord P2
MVP
Mechanisms of Mitral Regurgitation

- Normal
- Apical Tethering
- Dilated anulus
- Restricted PML
- Prolapse
- Ruptured pap muscle
Case 4
Mitral Valve Prolapse
Functional MR
Functional Mitral Regurgitation

Normal

Restricted PML

Apical Tethering

Dilated anulus

Prolapse

Ruptured pap muscle
Morphologic Changes in Heart Failure

Papillary muscles displaced apically and laterally

Bolling  J Heart Valve Dis  11:S28(2002)
Functional Mitral Regurgitation - Mechanisms

- Global LV dysfunction
- Regional LV dysfunction
- Increased sphericity of LV
- Excessive pap muscle displacement
- Decreased overlap of leaflets
- LA enlargement
- Loss of systolic mitral annular contraction
- Increased “tenting” area
- Delayed activation of P-M pap muscle (dyssynchrony)
Ischemic Mitral Regurgitation

Mitral leaflets are tented apically
Mitral annulus is enlarged  \((A-B = 45\text{mm})\)
Mitral coaptation depth is increased  \((C-D = 13\text{ mm})\)
Procedural Guidance
Wánghòu
Queen of Structural Heart Disease
Essentials for Echo-Guidance

- Pre-procedure strategy b/w echocardiographer and interventionalist
- Common understanding of appropriate and necessary echo views
- Presentation of echo images on main monitor

NOTE: Fluoro limited b/c MV has no calcium
Percutaneous MV Repair
Patient Selection

- Planimetered MV area $\geq 4.0 \text{ cm}^2$
- Minimal leaflet calcium in grasping area
- Width of flail segment $< 15 \text{ mm}$
- Flail gap $< 10 \text{ mm}$
Eligibility Criteria for MitraClip

Functional MR

- Coaptation Length $\geq 2$ mm
- Coaptation Depth $< 11$ mm

Degenerative MR

- Flail Gap $< 10$ mm
- Flail Width $< 15$ mm

adapted from Cavalcante  JACC CV Imaging 2012;5:733-746
MitraClip Procedure

Ideal MV Morphology

- MR originating from mid-portion of MV (degenerative or functional etiology)
- Lack of calcification in the grasping area
- MV area > 4 cm²
- Length of posterior leaflet ≥10 mm
- Non-rheumatic or non-endocarditic MVD
- Flail width < 15 mm; flail gap < 10 mm
- Sufficient leaflet tissue for coaptation (coaptation depth < 11 mm; coaptation length > 2 mm)
The Mitral Valve and Subvalve Apparatus

Note lack of chordae in mid-portion of anterior leaflet
MitraClip Procedure
Less-than-Ideal MV Morphology

- Perforated MV leaflets; cleft MV leaflets
- Severe calcification in the grasping area
- Hemodynamically relevant mitral stenosis
- Length of posterior leaflet < 7 mm
- Rheumatic valve disease
- Gap between leaflets > 10 mm
Suitability for MitraClip Therapy

Classical EVEREST Criteria

- Location/extent of flail/prolapsing segment
- Determine flail gap (<10 mm) (distance from tip of flail segment to opposing leaflet)
- Width of the flail segment (<15 mm)
- Coaptation depth (≤ 11 mm)
- Coaptation length (≥ 2 mm)
Suitability for MitraClip Therapy

Unsuitable Valve Morphology

- Signif. Leaflet calcification in grasping area
- Very short posterior leaflet
- Rigidity of leaflets
- Extensive thickening of leaflets (Barlow’s)
- Significant cleft
- Perforation of leaflet
Suitability for MitraClip Therapy

“Conditionally” Suitable Valve Morphology

- Pathology in segments 1 or 3 of either leaflet
- Mild calcification outside the grasping area
- MV area between 3 cm$^2$ and 4 cm$^2$
- Flail width > 15 mm – amenable to multiple clips
- Coaptation depth ≥ 11 mm
- Mobile post. leaflet length b/w 6-7 and 10 mm
MitraClip Procedure
Echo Guidance
Guidance of the Procedure

1. Transseptal puncture
2. Steerable guide catheter (SGC) insertion into LA
3. Advancement of Clip Delivery System through the SGC into the LA
4. Steering/positioning MitraClip in the LA above MV
5. Advancing MitraClip into the LV
6. Grasping the leaflets/verifying proper insertion
7. Assessment of result before clip detachment
8. Clip detachment
1. Transseptal Puncture

- Optimal puncture site important for MitraClip
- Facilitates steering maneuvers
- Minimizes complexity and duration of procedure
- Preferred site → superior-posterior portion of fossa ovalis

continued . . .
1. Transseptal Puncture

- Short-axis view at base (~30-50°) (anterior-posterior orientation)
- Long-axis view (bicaval) - (~90-120°) (superior-inferior orientation)
- Four-chamber view (~0°) (correct height above mitral valve)

3D X-plane can present SAX and long-axis simultaneously
1. Transseptal Puncture

Echo Guidance

superior and posterior

- Too low $\rightarrow$ too close to MV
- High preferred $\rightarrow$ want the approach to be perpendicular to the MV
Direction of Transseptal

Standard → from IVC through center of fossa ovalis → too anterior
Preferred for MitraClip → posterior (over the coaptation line)
1. Transseptal Puncture

Tip of transseptal needle creates “tenting” of the atrial septum toward LA
1. Transseptal Puncture

Optimal site above MV differs for primary (degenerative) vs secondary (functional) MR

- Primary MV disease $\rightarrow$ 4-5 cm above annulus
  Provides space to maneuver the MitraClip delivery system within the LA

- Secondary MR $\rightarrow$ $\sim$ 3.5 cm
  Tenting results in a shift in position of closure line to below the mitral annulus
2. Steerable Guide Catheter (SGC) Insertion into the LA

- Exchange guidewire placed in LUPV
- SGC gently advanced over the guidewire
- Done with fluoro and TEE guidance (to avoid injury to free LA wall)
- SGC catheter has echo-bright double ring that can be seen by TEE → needs to be in LA
- SGC securely placed ~ 2-3cm within LA
Guiding catheter “on-end”
3. Advancement of Clip Delivery System (CDS) through the SGC into LA

- CDS advanced thru the Steerable Guide Catheter (SGC)
- Tip of clip reaches tip of SGC (fluoro)
- CDS then further advanced into LA
- Clip should be free from LA wall and MV
4. **Steering/Positioning MitraClip in the LA above the MV**

- Align clip perpendicular to mitral valve coaptation line ($\approx 1$ cm above valve)
- Move in small iterations
- Center over origin of MR jet
  (direct tip of clip towards largest PISA)
- **X-Plane images:**
  - Intercommissural view
  - LVOT view
- If only 2D-TEE available $\Rightarrow$ transgastric SAX
4. Steering Clip Perpendicular to Coaptation Line - Echo Guidance

- Align clip arms perpendicular to the line of coaptation
- Maintain clip open to at 180° to help visualize the clip arms
- Advance clip into LV just below the leaflet edges prior to grasping
Steering and Positioning the MitraClip above the MV

- Align clip perpendicular to plane of mitral annulus
- Align clip arms perpendicular to coaptation line
- Align clip parallel to antegrade flow
- Move in small iterations
- Center over origin of MR jet

Wunderlich and Siegel  Eur Heart J: CV Imaging 2013;;14:935-949
5. Advancing MitraClip into the LV

- System advanced across MV into LV
  \( \approx 2 \text{ cm below the MV} \)

- Usually clip is fully opened

- Reassess orientation of the clip
  (Clip may rotate during “dive” into LV)

- X-plane imaging is best:
  - Intercommissural view
  - LVOT view

- Correct positioning:
  - Perpendicular to line of MV coaptation
  - Both leaflets move freely above the clip
  - Clip splits the MR jet
6. Grasping of Leaflets

Verification of Adequate Leaflet Insertion

- Grip arms placed in grasping position ($\approx 120^\circ$)
- Pull back during systole to capture leaflets
- Verify both leaflets inserted into the clip
- Limited leaflet mobility relative to tips of clip arms
- Adequate degree of MR reduction
  (if not adequate move clip or place 2nd clip)
- Creation of a double MV orifice
- Degree of MS

Midesophageal long-axis view
Leaflets need to move freely above the arms
6. Grasping of the Leaflets

[Image: Diagram showing grasping of leaflets with labels PML and AML.]
6. Assessment of Leaflet Capture
Echo Guidance

- Clip partially closed to secure insertion of leaflets into the clip

- Carefully assess the grasp of leaflets: - Adequacy of leaflet insertion - Resultant degree of MR

Then, close the clip incrementally under echo-guidance
7. Assess Results before Clip Release

- Adequate leaflet insertion
- Degree of MR (Currently no consensus guidelines or validated studies on how to best evaluate residual MR)
- Degree of MS: - MV area > 1.5 cm²
  - Mean gradient ≤ 5 mm Hg
- Achievement of double orifice
8. Clip Release

- Reconfirm stable clip position
- Reassess grade of residual MR
- Achievement of double orifice
- Check for pericardial effusion
- Degree of shunting through the transseptal puncture site (iatrogenic ASD)
Detection of Complications

- Pericardial effusion/tamponade
- Sudden or worsening of MR
- Partial clip detachment
- Device embolization (rare)
- Leaflet tear
- Injury to subvalve apparatus (chordal entrapment)
- Mitral stenosis
- Persistent iatrogenic ASD (seldom hemodynamically signif)
- Thrombus formation on catheters
Case 26

TTE 1 day post MitraClip insertion
The End
Transcatheter MV Insertion (TMVI)
Transcatheter Mitral Valves Currently in Human Trials

A  Tiara
B  FORTIS
C  Tendyne
D  CardiAQ
Various TMVI Anchoring Mechanisms

A: Native Anatomy
B: Tabs to Anchor at Basal Myocardial Shelf and Fibrous Trigones
C: Paddles for Attachment to Native Leaflets
D: Opposing Barbs for Anchoring at Annulus and Native Leaflets
E: Apical Tether (Neochord)

Tabs | Paddles | Barbs | Tether (Neocord)
Percutaneous MV Replacement (TMVR)

- In a phase of product development
- Limited clinical experience
- Greater obstacles/challenges than TAVI
Challenges to Percutaneous TMVR Devices

- Asymmetrical saddle-shaped annulus
- Large annulus size → large devices
- Dynamic changes in annulus size during cardiac cycle
- No stable calcified structure for anchoring (most cases)
- Irregular geometry of mitral leaflets
- Obstruction of LV outflow tract
- Preservation of subvalve apparatus mandatory to preserve LV geometry
- Thrombogenicity of a bulky device
- Perforation of adjacent structures
- Potential for:
  - occlusion of left circumflex artery
  - compression of coronary sinus
  - conduction system disruption
- Even mild paravalve leak may result in hemolysis