Demonstration of **Functional Classification of Aortic Regurgitation and Aortic Leaflet Repair** using Computed Tomography

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1. Introduction
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   • Aortic valve repair

2. Functional Classification of Aortic regurgitation
   • Type I, II and III

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   • Surgical options according to the type of functional classification

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   • Transaortic valve implantation
Introduction

- Etiology of aortic regurgitation
- Aortic valve repair
Aortic Regurgitation

Introduction

**Etiology**
- Congenital: bicuspid aortic valve, ventricular septal defect
- Degenerative valve
- Rheumatic valve disease
- Endocarditis with aortic valve involvement
- Aortic aneurysm (Marfan syndrome)
- Trauma
- Syphilis
- Ankylosing spondylitis

Commonly combined aortic disease
Indications for aortic valve replacement

- Symptomatic patients
- LV systolic dysfunction
- Patients undergoing CABG
- Severe LV dilatation
- Progressive LV dilatation, low risk for surgery

LVSD >50mm
LVDD >65mm
LVSD >25mm/m²
Factors associated with clinical outcome
Introduction

Aortic Valve Surgery

Severe AR with LV systolic dysfunction

Factors predictive of postoperative survival and functional recovery:
- Preoperative symptoms
- Severity of preop. LV dysfunction
- Duration of preop. LV dysfunction

Asymptomatic AR with Normal LV function

Factors predictive of symptoms and/or LV dysfunction:
- LV end-systolic dimension/volume
- LV end-diastolic dimension/volume
- LV ejection fraction with exercise

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Aortic valve repair has received less attention than repair of mitral or tricuspid valve because

- Stenosis is much more than regurgitation.
- Mostly degenerative process
- Variable valve substitutes with lower thromboembolic potential and greater longevity already had been developed.

But in younger adult patients,

- Anticoagulation and prosthesis durability can be a problem

→ Repair can be a good solution in these patients

For better long-term outcome, patient should be carefully selected
• Transesophageal echocardiography (TEE)
  - High diagnostic performance
  - Limitation (e.g. invasiveness, operator dependency)

• Cardiac CT
  - Emerging modality for valvular heart disease
  - More detailed valve morphology
Functional Classification of AR

• Type I, II and III
Functional classification of AR

Classification of AR

- Repair-oriented functional classification of AR
  - Type I  Dilated aortic root with cusp tethering (normal cusp)
    Perforated cusp of any cause, no other abnormality
  - Type II  Prolapse of one or two cusps (partial or whole)
  - Type III  Cusp retraction
  - Type IV  Rheumatic or degenerative valves,
    Infective endocarditis or aortic dissection

Modified from The J of Thoracic and Cardiovasc Surg 2009
Type I (normal cusp)

- **Type Ia** Sinotubular junction (STJ) enlargement and dilatation of the ascending aorta
- **Type Ib** Dilatation of the sinuses of Valsalva and the STJ
- **Type Ic** Dilatation of the ventriculoaortic junction
- **Type Id** Cusp perforation
Functional classification of AR

Type Ia (normal cusp)

STJ enlargement and dilatation of the ascending aorta

- Typically by progressive atherosclerotic degeneration of ascending aorta and STJ
- Failure of coaptation in central area, leading to central jet AR

Case 1 74/M

Aortic sinus and ascending aorta dilatation causing central AR
Type Ib (normal cusp)

Dilatation of the sinuses of Valsalva and the STJ

- When degenerative disease of media such as the Marfan syndrome
- Failure of coaptation in central area, leading to central jet AR

Case 2 34/M
Aortic sinus dilatation and central AR in Marfan syndrome patient
Functional classification of AR

**Type Ic (normal cusp)**

Dilatation of the ventriculoaortic junction

- Present whenever chronic AR is present.
- Frequently associated with type Ib or more complex pathogenesis such as bicuspid valve.
- Failure of coaptation in central area, leading to central jet AR.

**Case 3 55/F**

Aortic sinus and ventriculoaortic junction dilatation and central AR → S/P David operation with ascending aorta replacement.

Postoperative CT images.
Functional classification of AR

Type Id (perforation of cusp)

- Related to a traumatic injury or infective endocarditis, whether active or healed

Case 4 56 M

Right coronary and non-coronary cusp perforation causing eccentric AR

→ S/P AVR with Hancock 25mm
Type II (cusp prolapse)

Whole vs. partial prolapse

- Related to a degenerative process such as aging or hypertension
- Often present when longstanding AR has progressively damaged the cusps
- In acute aortic dissection, detachment of the commissures results in leaflet prolapse
- May cause eccentric AR jet
Functional classification of AR

Type II (cusp prolapse)

Whole vs. partial prolapse

Case 5 70 M
Whole prolapse of right coronary cusp and partial prolapse of left coronary cusp
Functional classification of AR

Type II (cusp prolapse)

Whole prolapse

Case 6 56/M

Prolapse of the non coronary cusp with eccentric AR
Functional classification of AR

Type II (cusp prolapse)

Partial prolapse

Case 7 62/M
Partial prolapse of the right coronary cusp with eccentric AR → S/P David operation
Type III (cusp retraction)

Possibly due to bicuspid, degenerative, or rheumatic valvular disease

- Cusp shortening and motion restriction by fibrotic change
- Hypertrophied nodes of Arantii

Case 8 44/M
Central coaptation defect due to retraction of the three cusps
Which Aortic Valve Shape is Prefer to Aortic Valve Repair?

- Surgical options according to the type of functional classification
Aortic valve repair

Type Ia (normal cusp)

STJ enlargement and dilatation of the ascending aorta

- Reduction of the circumference of the STJ
  → Replacing the ascending aorta with graft
- Type I lesions may cause central AR, but when combined cusp pathology such as prolapse or retraction, AR may be eccentric
  → both aortic root and AV surgeries are required

Case 9 73/F

S/P Replacement of ascending aorta and arch
Aortic valve repair

Type Ib (normal cusp)

Dilatation of the sinuses of Valsalva and the STJ

- Valve sparing aortic root operation:
  - Remodeling (Yacoub) and Reimplantation (David operation)

- Remodeling
  - Replacement of aortic sinus and ascending aorta
  - When normal aorta-ventricular junction (AVJ)

- Reimplantation
  - When AVJ dilatation
  - When impaired aortic root integrity: Marfan syndrome, acute type A dissection and excessive annular dilatation
Aortic valve repair

Type Ib (normal cusp)

Dilatation of the sinuses of Valsalva and the STJ

Reimplantation (David)
Entire aortic valve is preserved and sewn within a graft

Remodeling (Yacoub)
Replace all three sinuses by triple-tongue-shaped graft
Type Ib (normal cusp)

Dilatation of the sinuses of Valsalva and the STJ

Case 10 37/M
S/P David operation for annuloectasia
Aortic valve repair

Type Ic (normal cusp)

Dilatation of the ventriculoaortic junction

- When isolated functional aortic annulus dilatation (>25-28 mm)
- If left untreated, could be a major risk factor for failure of valve sparing operation
  → **Ring annuloplasty** (external or internal) or **suture annuloplasty** (commissural or circular)
  - In recent report, use of these sutures was associated with increased risk of reoperation
Aortic valve repair

Type Id (perforation of cusp)

- Repair the perforation (patch closure) and sometimes require the stabilizing the root (subcommissural annuloplasty)
Aortic valve repair

Type II (cusp prolapse)

- Redundancy in the valve should be corrected
  - Leaflet plication or triangular resection
    - Continuous suture is recommended rather than interrupted suture, because it decrease change of leakage and lessens the thrombogenic “knot-burden”
Aortic valve repair

Type III (cusp retraction)

- Shortening of cusps → Extension with bovine or autologous pericardium
- Commissural fusion → Blade commissurotomy
- Hypertrophied node of Arantius → Shaving
- Nodular calcification → Enucleation
Other Surgical Options

- Prosthetic valve replacement
- Transaortic valve implantation
Aortic valve replacement

Types of aortic valve replacement

- **Mechanical heart valve**
  - Implanted via surgically
  - Long lifespan but lifelong anticoagulation

- **Bioprosthetic heart valve**
  - Implanted via surgically or transcatheter
  - Less thrombogeneity
  - Bovine, xenograft, homograft, allograft

- Selection of artificial valve: depends on multifactorial factors (age, involvement site, LV cavity size, ready to anticoagulation)
Aortic valve replacement

Mechanical valve

- **Type 4** Rheumatic or degenerative valves, Infective endocarditis or aortic dissection

**Case 11** 49/F
S/P AVR using OnX 23mm
Aortic valve replacement
Mechanical valve

Case 12 63/M
S/P AVR and replacement of ascending aorta and hemiarch for bicuspid AV and ascending aorta dilatation
**Aortic valve replacement**

**Bioprosthetic/biological valve**

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**Case 13 74/M**

S/P AVR and ascending aorta replacement for bicuspid AV with ASR and ascending aorta dilatation
Sutureless AVR

- Reducing aortic cross-clamp and cardiopulmonary bypass duration
- Less invasive procedure so could diminish the operative risk in elderly patients

Case 14 71/M
S/P Sutureless AVR for ASR
Aortic valve replacement

Bioprosthetic/biological valve

Transcatheter aortic valve implantation (TAVI)

- Treatment option in high-operation risk or inoperative patients

Case 15 83/F
S/P TAVI for severe AS and mild AR
Aortic valve replacement

Bioprosthetic/biological valve

Transcatheter aortic valve implantation (TAVI)

Acceptable safety and efficacy in high-risk patients with AR

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**Transcatheter Aortic Valve Implantation (TAVI) for Native Aortic Valve Regurgitation — A Systematic Review —**

Altayyeb Yousef, MD; Zachary MacDonald, BSc; Trevor Simard, MD; Juan J. Russo, MD; Joshua Feder, BSc; Michael V. Froeschl, MD; Alexander Dick, MD; Christopher Glover, MD; Ian G. Burwash, MD; Azeem Latib, MD; Josep Rodés-Cabau, MD; Marino Labianca, MD; Benjamin Hibbert, MD, PhD

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**Table 5. Comparison of 1st- and 2nd-Generation Valves for TAVI in NAVR**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>1st-generation valves, n (%)</th>
<th>2nd-generation valves, n (%)</th>
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<tbody>
<tr>
<td><strong>Primary outcome</strong></td>
<td></td>
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<tr>
<td>Device success</td>
<td>76/97 (78.4)</td>
<td>75/78 (96.2)</td>
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<tr>
<td>AR ≥3+</td>
<td>8/97 (8.3)</td>
<td>9/78 (0.0)</td>
</tr>
<tr>
<td>Conversion to SAVR</td>
<td>2/97 (2.1)</td>
<td>2/78 (2.6)</td>
</tr>
<tr>
<td><strong>Secondary outcomes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate procedural outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post TAVI AR ≥2+</td>
<td>31/97 (32.0)</td>
<td>0/78 (0.0)</td>
</tr>
<tr>
<td>30-day cardiovascular death</td>
<td>5/82 (6.1)</td>
<td>1/74 (1.4)</td>
</tr>
<tr>
<td>NYHA III/IV at 30day</td>
<td>12/50 (24.0)</td>
<td>7/65 (12.7)</td>
</tr>
<tr>
<td>1-year death</td>
<td>16/72 (22.2)</td>
<td>0/8 (0.0)</td>
</tr>
<tr>
<td>1-year cardiovascular death</td>
<td>8/71 (11.3)</td>
<td>0/8 (0.0)</td>
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Conclusion

- Distinguish functional classification of aortic regurgitation makes surgical repair techniques to be applied in a logical fashion with good short-term results.

- By showing the detailed valve morphology, CT may help in decision making for predicting the aortic valve repairability.
References

Thank you for your attention.