Aortic Stenosis

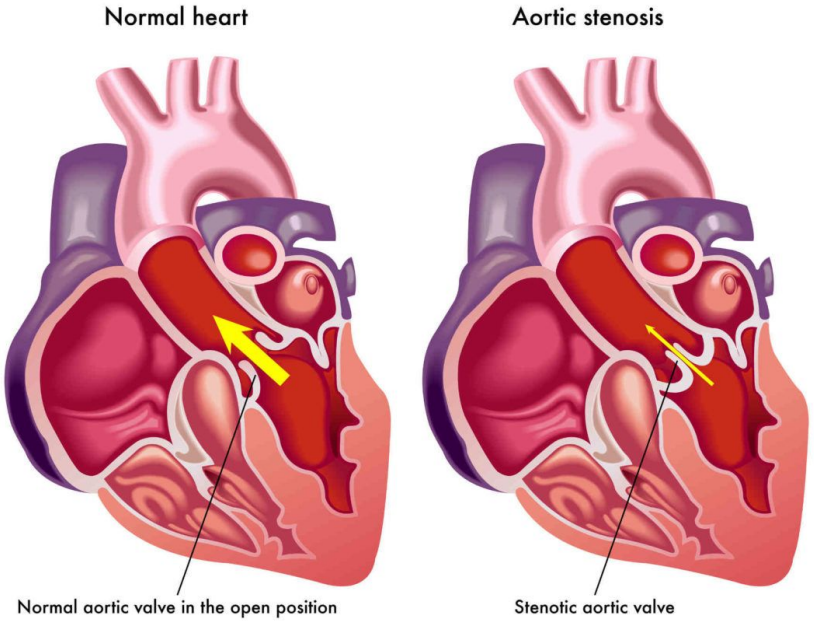
And Its Surgical Management

Objectives

- Define aortic stenosis.
- Understand the causes, risk factors, pathology, and staging of aortic stenosis.
- Describe the natural history, symptoms, and physical exam findings of patients with aortic stenosis.
- Describe findings of aortic stenosis on TTE, ECG, chest X-ray and cardiac catheterization.
- Understand the indications for TAVR and SAVR.
- Compare and contrast bioprosthetic and mechanical aortic valves.

Aortic Stenosis: Definition and Epidemiology

- Narrowing of the aortic valve opening
- Causes left ventricular outflow obstruction
- Prevalence increases with age
  - 50-59 years: 0.2%
  - 60-69 years: 1.3%
  - 70-79 years: 3.9%
  - 80-90 years: 9.8%



- Worldwide, the most common cause is rheumatic valve disease
- In North America and Europe, the most common causes are degenerative calcific disease and congenital bicuspid aortic valve

Causes

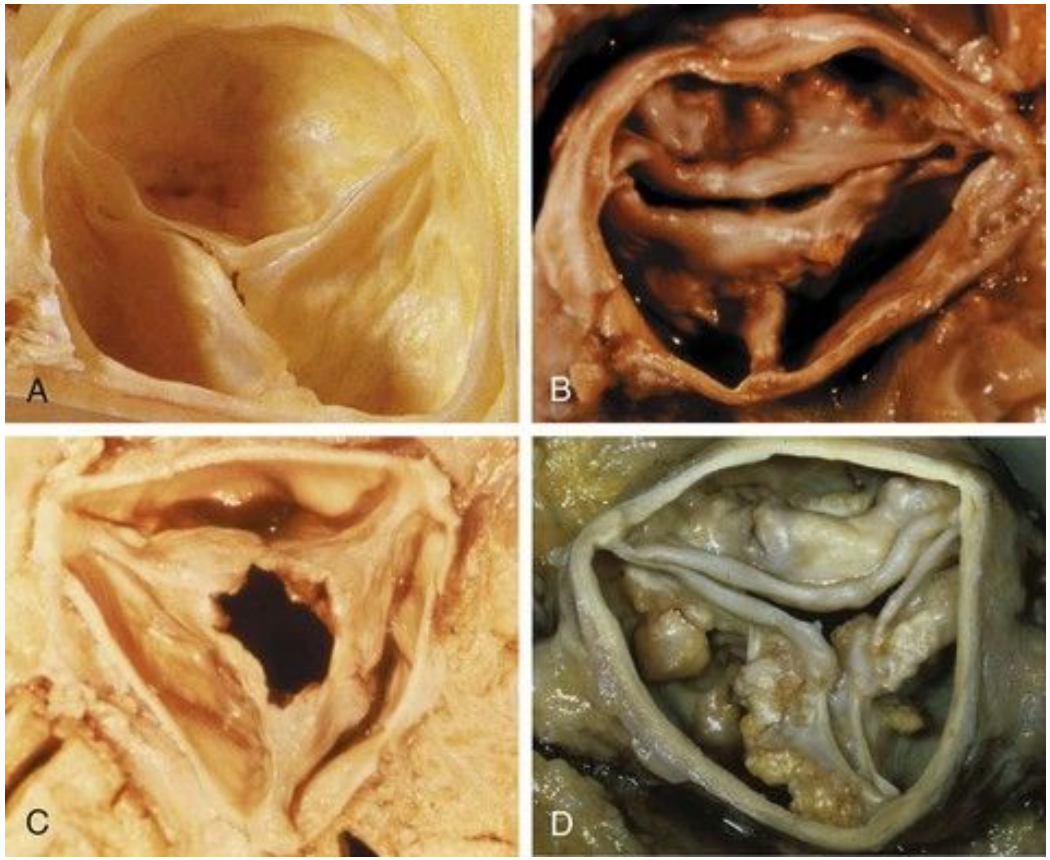
1. **Degenerative calcification** of previously normal trileaflet aortic valve
2. **Congenital bicuspid valve** calcification
3. **Rheumatic** aortic valve disease

Cardiac Risk Factors

- Coronary artery disease
- Dyslipidemia
- Smoking
- Hypertension

Normal aortic valve

Congenital bicuspid valve



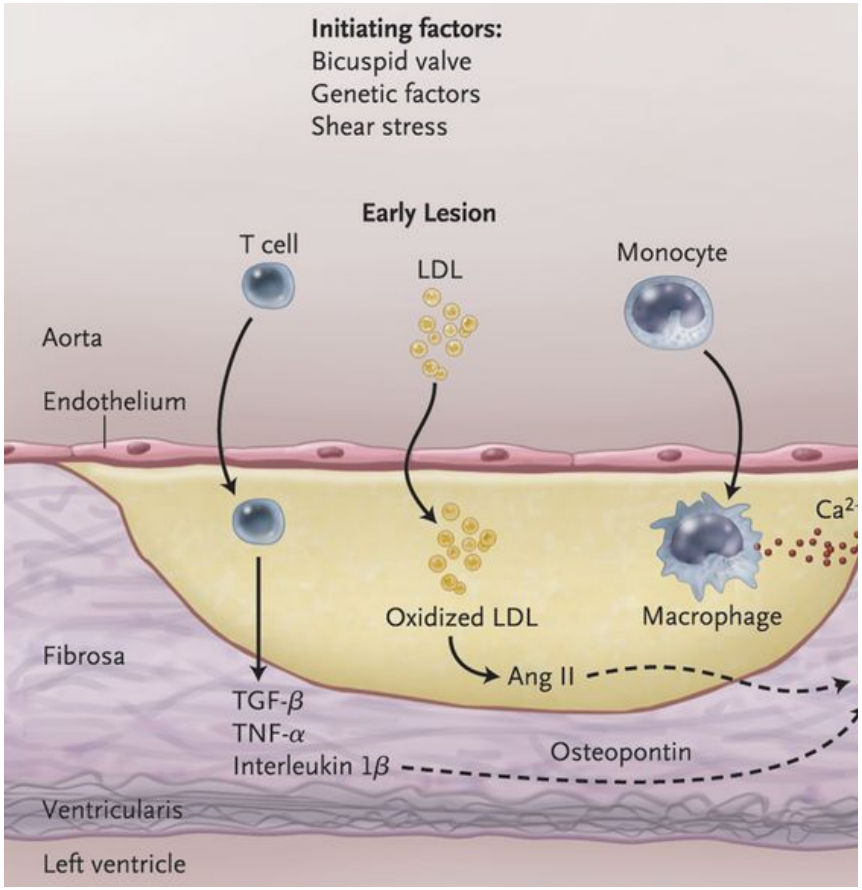
Rheumatic aortic stenosis

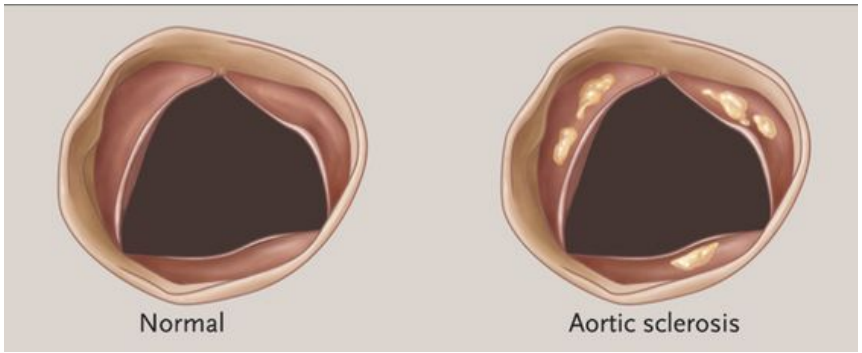
Degenerative calcification

Pathology

Initiating factors:

- Endothelial dysfunction
- Lipid accumulation
- Inflammation





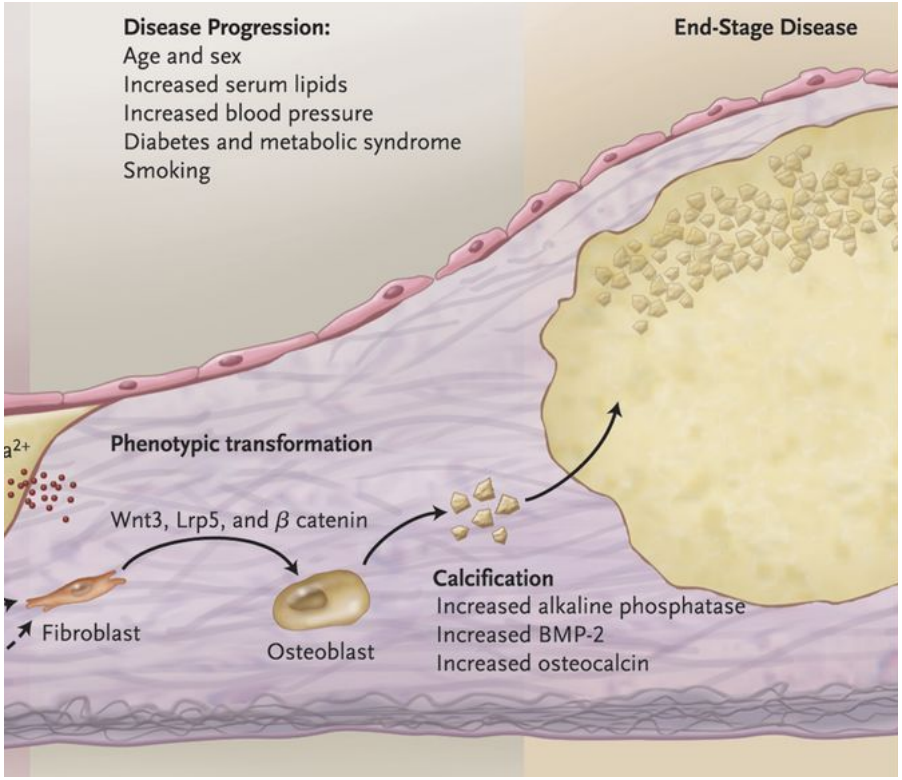
Pathology

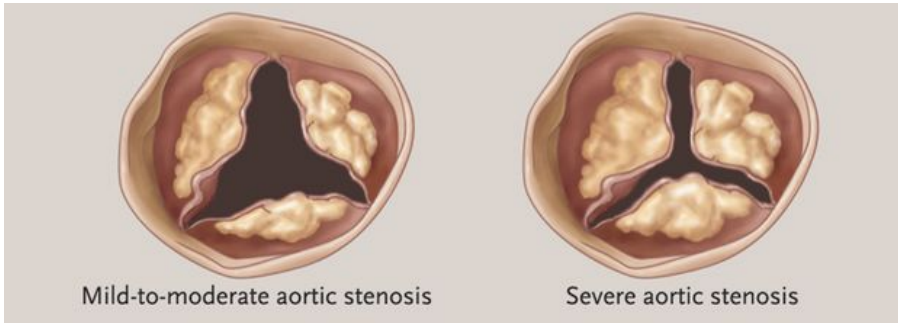
Disease progression:

- Differentiation of myofibroblasts to osteoblasts
- Osteoblasts deposit calcium hydroxyapatite crystals

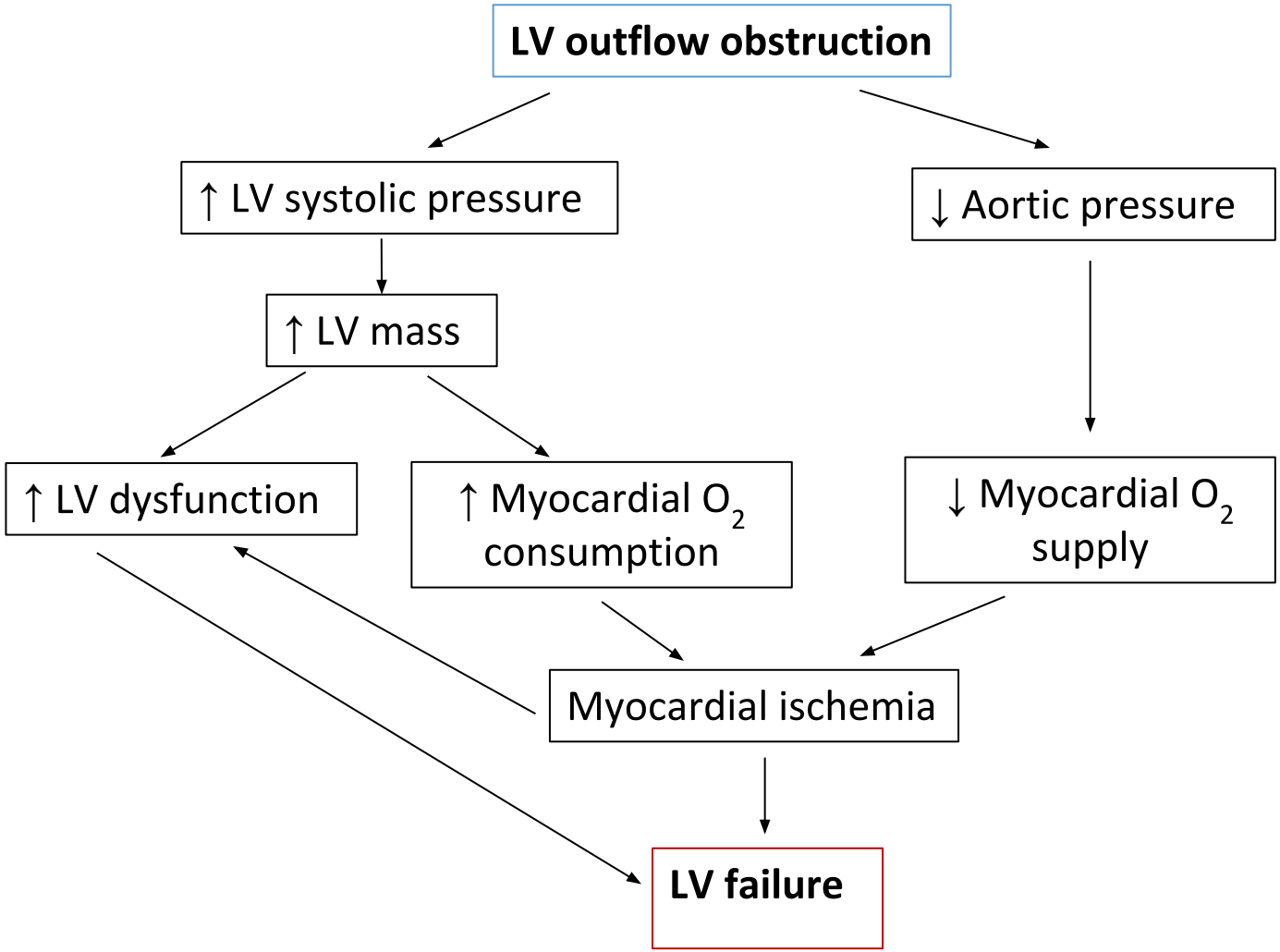
End stage disease:

- Formation of large calcific lesions
- Severe aortic stenosis





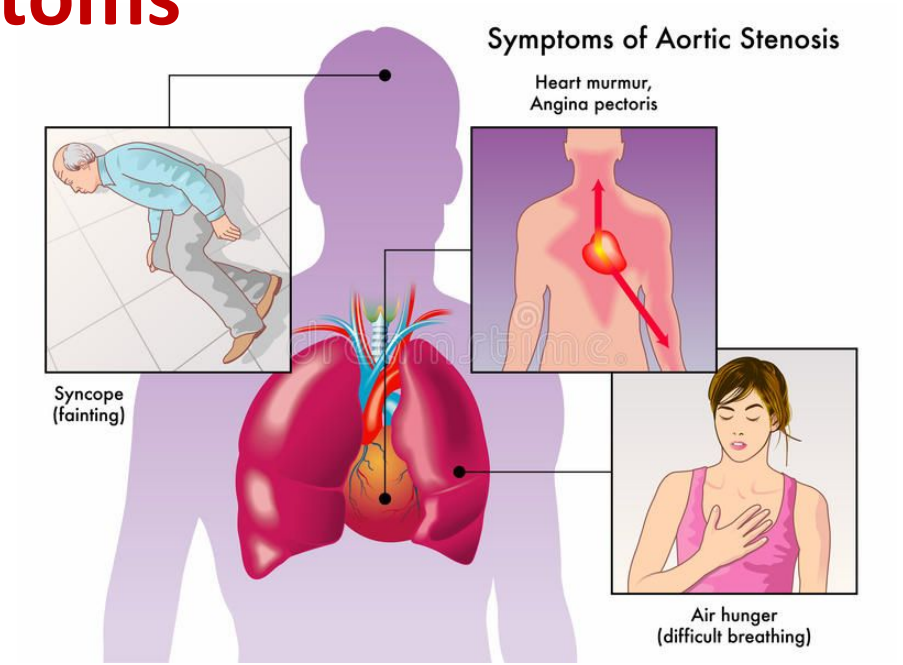
Natural history of untreated aortic stenosis



Presentation: Symptoms

Cardinal symptoms:

- **S**yncope
- **A**ngina pectoris
- **D**yspnea



Other signs and symptoms

- Fatigue
- Heart palpitations (arrhythmias)
- Heart murmur
- Pedal edema
- Increased bleeding (Heyde syndrome)

Severe aortic stenosis:

- Valve area <1.0 cm^2
- Jet velocity >4.0 m/s
- Mean transvalvular gradient ≥40 mmHg

Clinical History

- Asymptomatic latent period of 10-20 years

Dyspnea: NYHA classification

I - No limitation of physical activity

II - Ordinary physical activity results in fatigue, palpitation, dyspnea (shortness of breath).

III - Less than ordinary activity results in fatigue, palpitation, dyspnea (shortness of breath)

IV - Unable to carry on any physical activity without discomfort. Symptoms of heart failure at rest.

Angina: CCS classification

I - No angina with ordinary physical activity.

II - Slight limitation of ordinary activity (able to walk >2 blocks, climb >1 flight of stairs).

III - Marked limitation of ordinary activity (able to walk 1-2 blocks, climb 1 flight of stairs).

IV - Discomfort on any physical activity. Angina at rest.

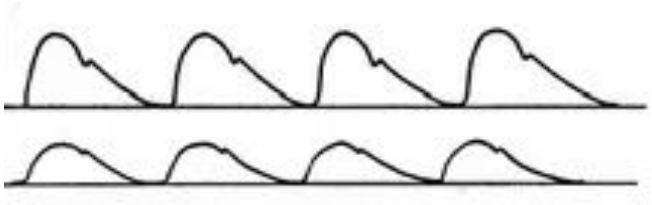
- Syncope: dizziness, lightheadedness
- Progressive inability to exercise
- Paroxysmal nocturnal dyspnea, orthopnea (heart failure)

Physical Exam

Carotid pulse: pulsus *parvus et tardus*

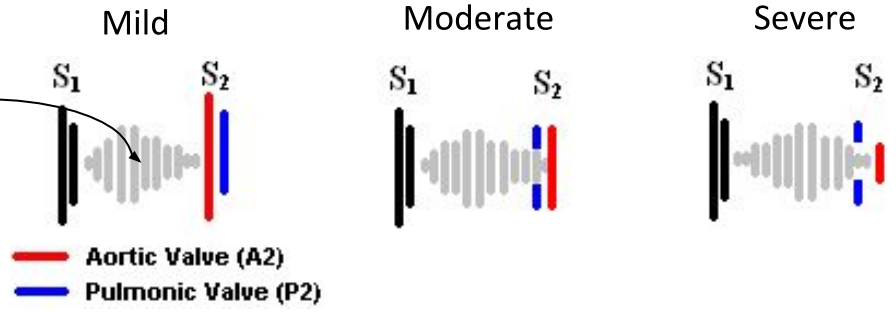
Normal pulse

Pulsus parvus et tardus



Auscultation of the heart:

- Murmur: crescendo-decrescendo
- Single S2 sound → paradoxical splitting (when severe)
- S4 (stiff ventricle)



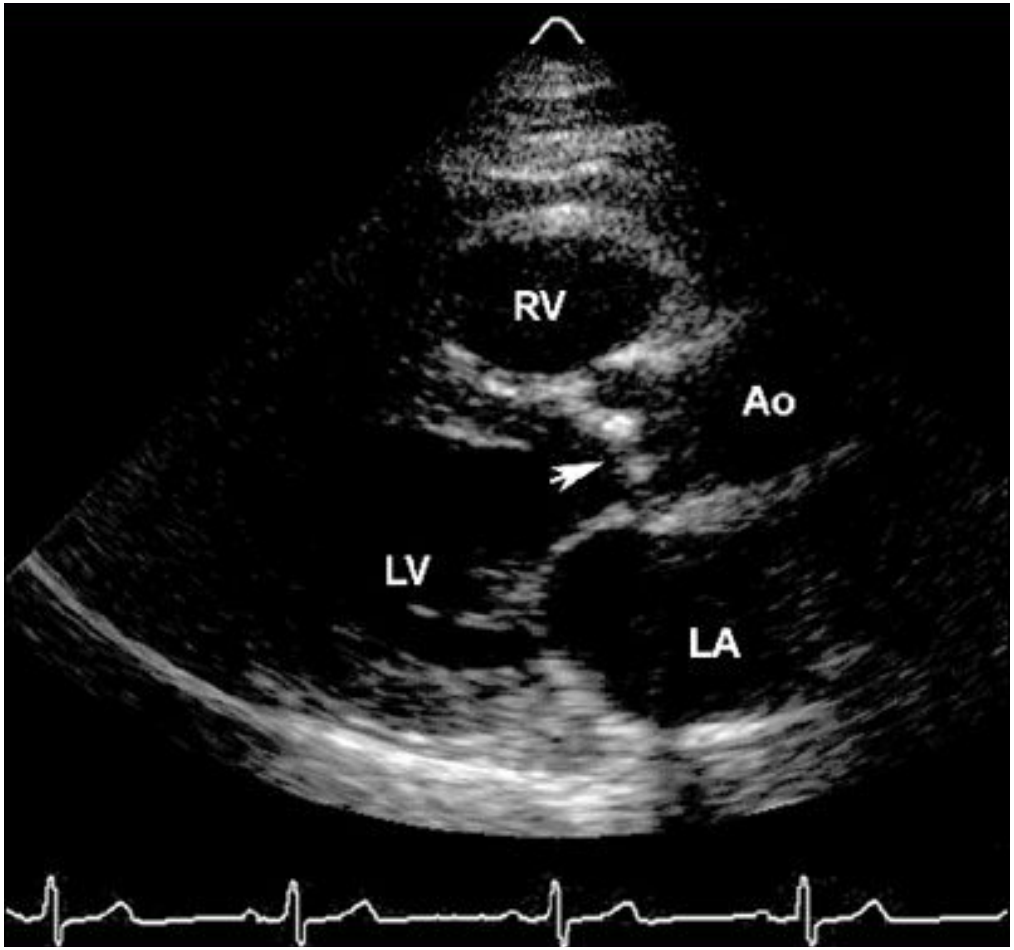
Signs of heart failure:

- Pedal edema
- Lung crackles (pulmonary edema)

Investigations: Transthoracic echocardiogram

Gold Standard

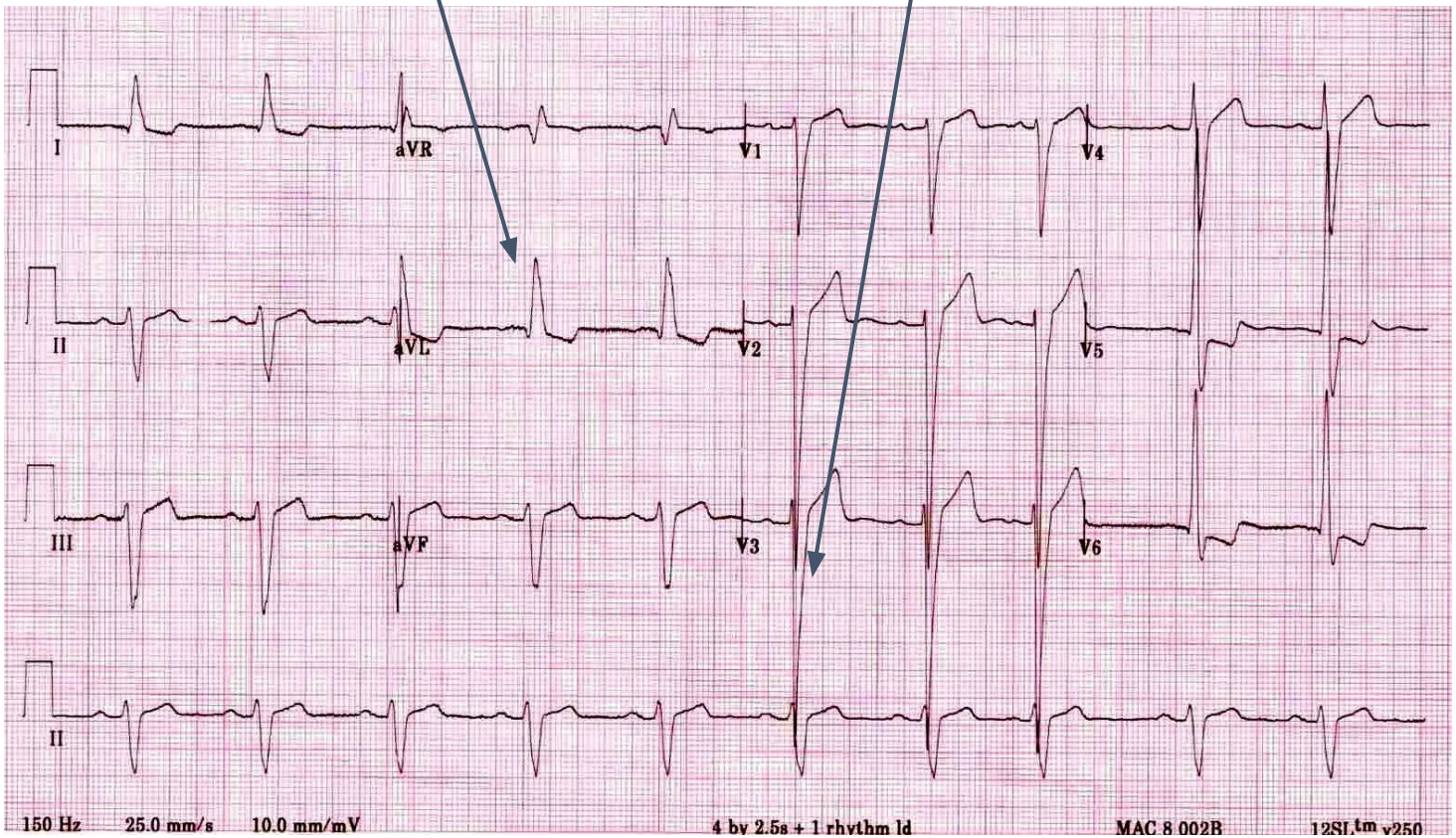
Valve anatomy, hemodynamics, and other valve diseases



Investigations: ECG

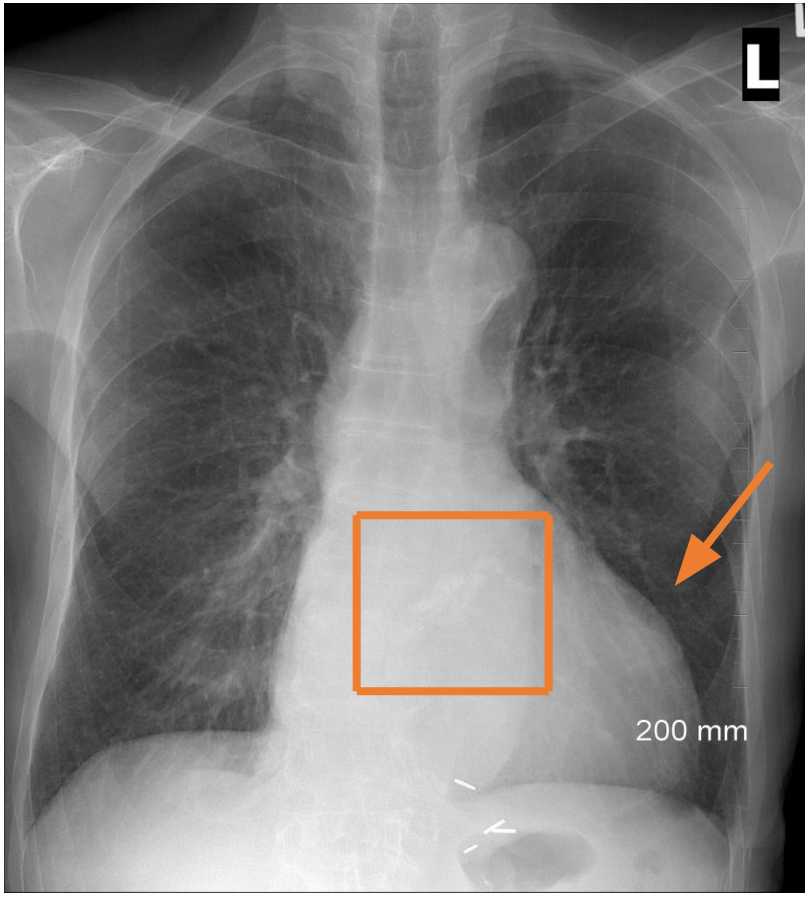
Left ventricular hypertrophy: large QRS complex voltages

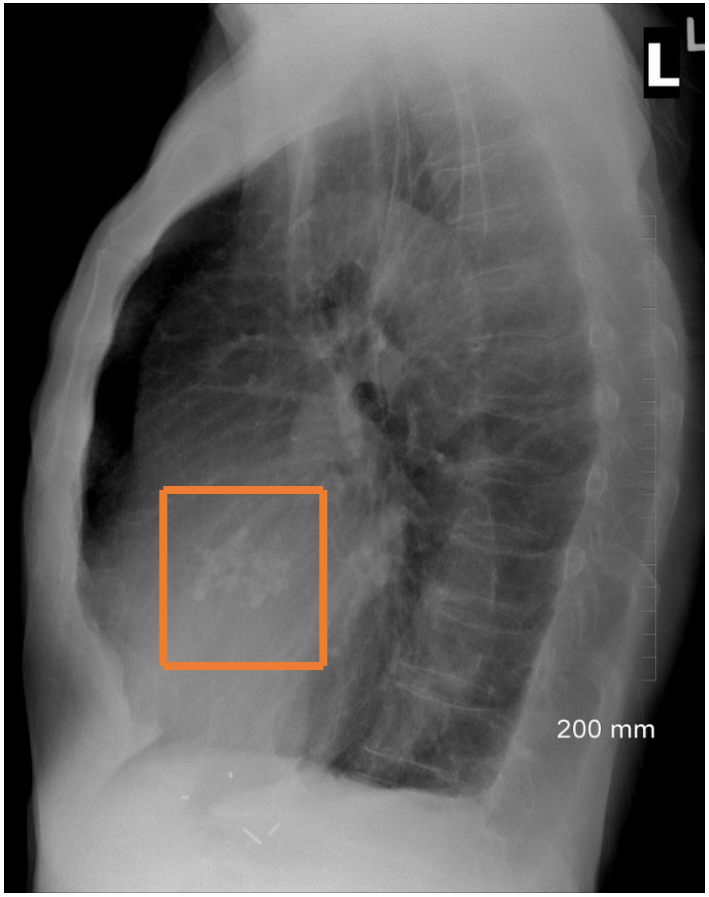
Cornell Criteria for LVH: R wave in aVL + S wave in V3 > 28mm (M) or >20mm (F)



Investigations: Chest X-ray

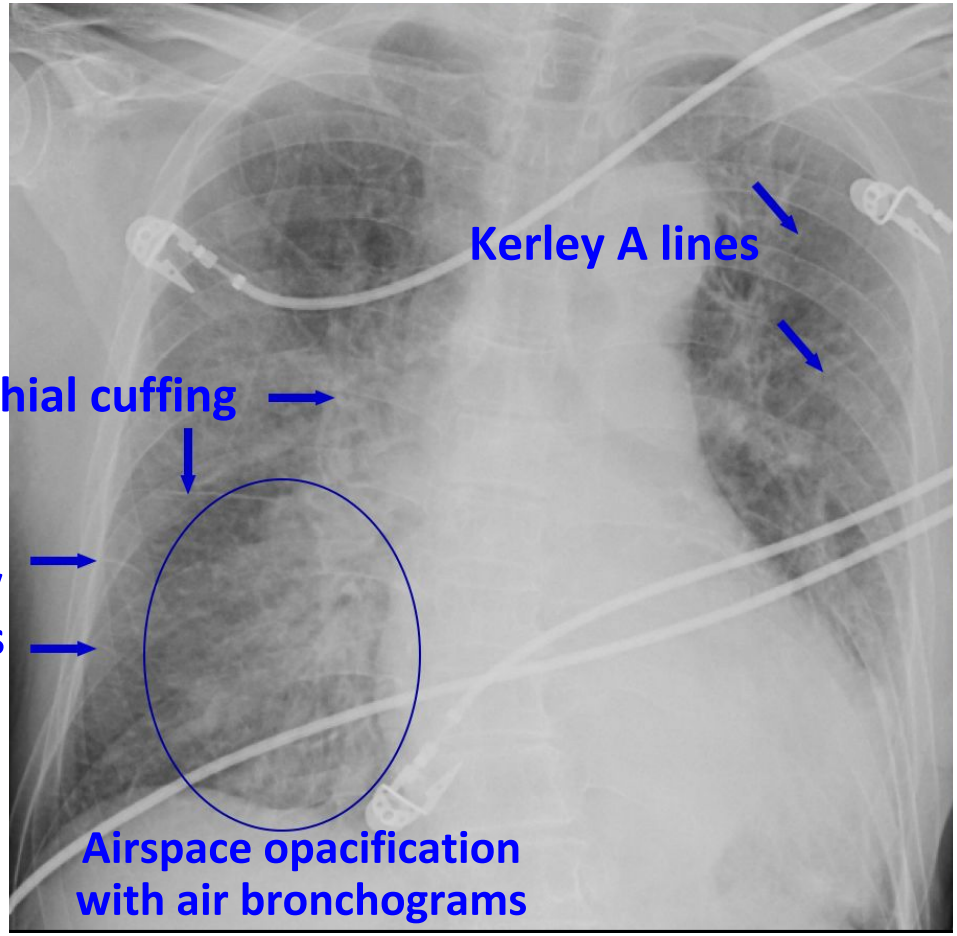
Calcification of aortic leaflets (box), left ventricular enlargement (arrow)





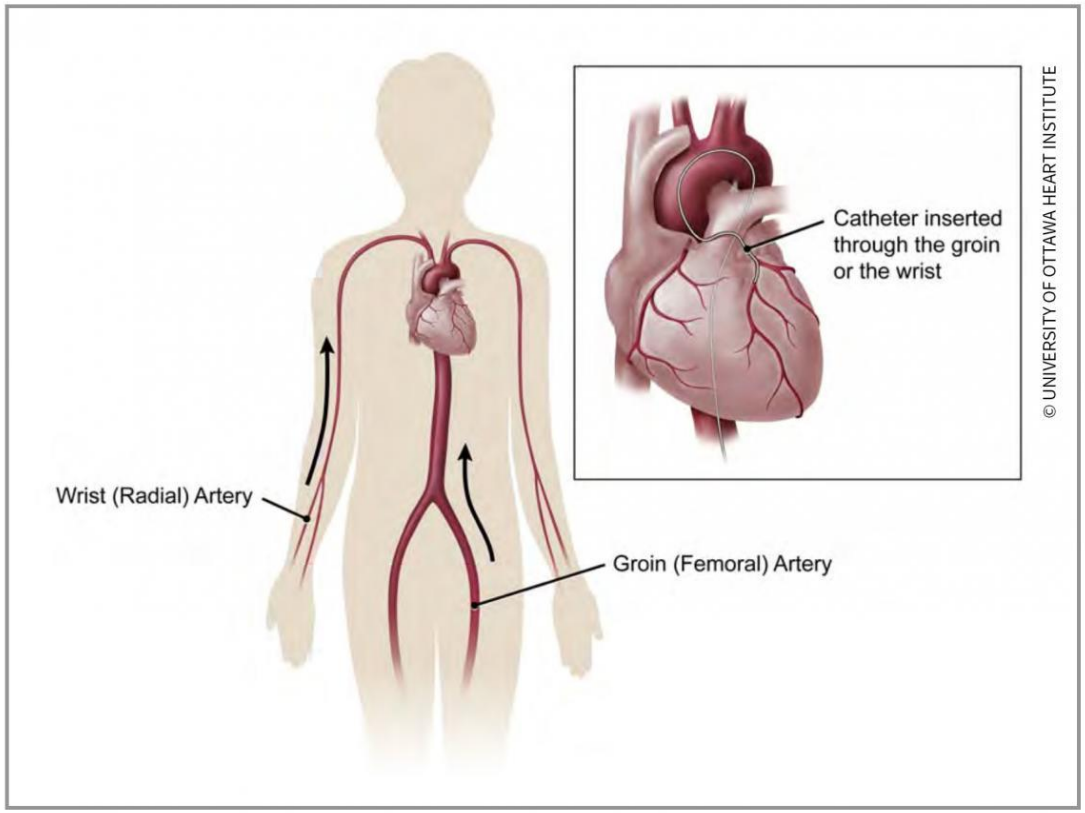
Investigations: Chest X-ray

Pulmonary Edema



Investigations: Cardiac catheterization

- Measures pressure gradient across aortic valve
- Useful in patients with:
  - Concurrent coronary artery disease
  - Discrepancy between clinical evaluation and echocardiogram



Staging of Aortic Stenosis Severity

Stage A	Stage B	Stage C	Stage D
• Asymptomatic • Bicuspid aortic valve • Aortic sclerosis • V_{max} <2m/s	• Asymptomatic • Calcified valve leaflets • V_{max} 2.0–2.9m/s • P < 20 mmHg	• Asymptomatic • Severe stenosis • V_{max} ≥4m/s • P ≥40 mmHg • Aortic valve area ≤1.0 cm^2	• Symptomatic • Severe stenosis • V_{max} ≥4m/s • P ≥40 mmHg • Aortic valve area ≤1.0 cm^2

V_{max} – maximum transvalvular aortic velocity
P – mean transvalvular pressure gradient

Indication for intervention

Surgical aortic valve replacement is indicated (Class I) in patients with:

Severe aortic stenosis

- Valve area <1.0 cm^2
- Jet velocity >4.0 m/s
- Mean transvalvular gradient ≥40 mmHg

+

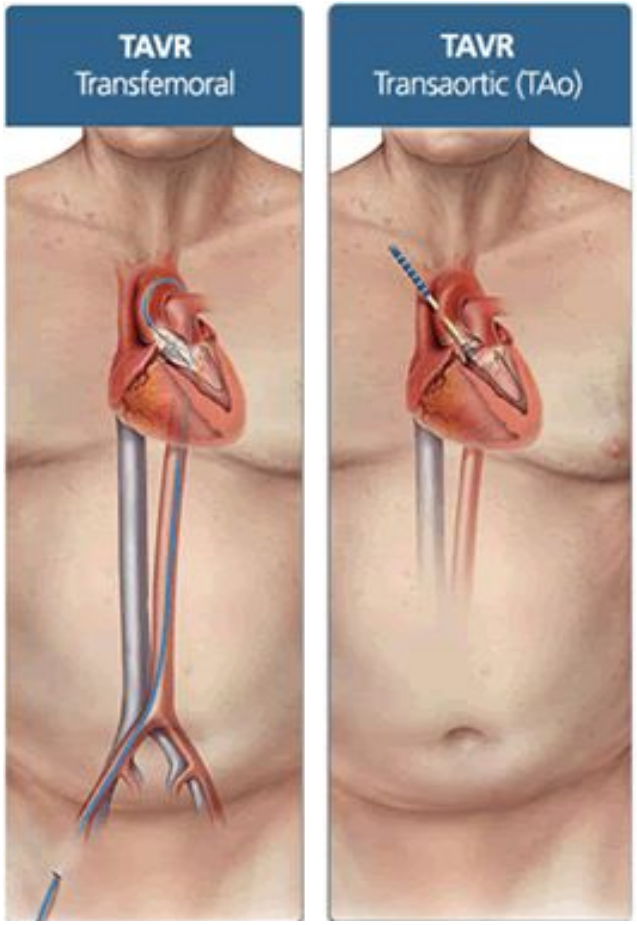
A) Develops **symptoms**
(Syncope, angina, dyspnea)

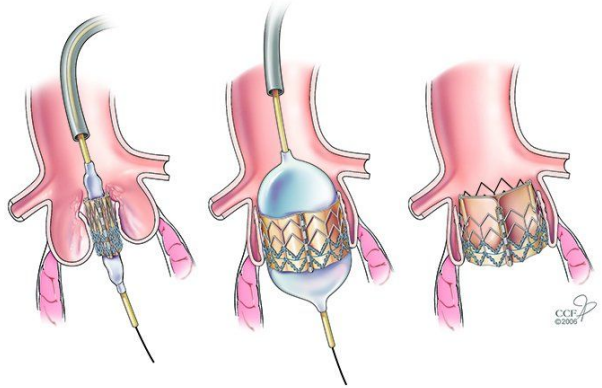
OR

B) Evidence of **progressive left ventricular dysfunction** (LVEF < 50%)

Treatment: Transcatheter aortic valve replacement

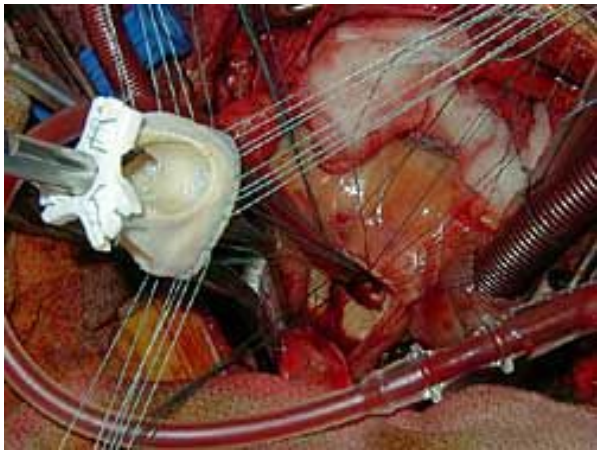
- A replacement valve delivered through a blood vessel (eg. transfemoral, transaortic, subclavian)
- Minimally invasive
- Indication: intermediate to high risk of complication from surgery, frail patients
- Higher risk of post-operative perivalvular regurgitation and permanent pacemaker implantation; unknown long-term durability

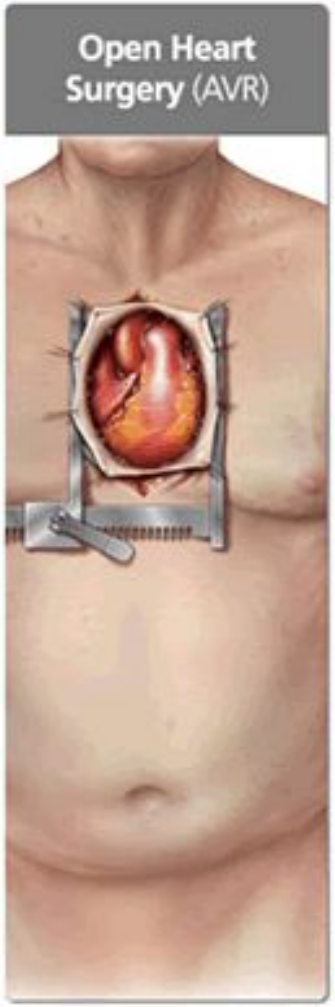




Treatment: Surgical aortic valve replacement

- Open-heart surgery with sternotomy
- Invasive and requires cardiopulmonary bypass
- <u>Indications:</u>
  - Low to medium surgical risk based on Society of Thoracic Surgeons risk score
  - Severe aortic stenosis
  - Undergoing other cardiac surgery with concomitant severe aortic stenosis





Bioprosthetic vs. mechanical valves

	Bioprosthetic Valve	Mechanical Valve
Material	Pig or cow heart-sac tissue	Carbon or titanium
Durability	Limited (10-15 years)	Life long
Risk of blood clots	Lower	Higher
Anti-coagulation medication	Not required	Needed for rest of life (Warfarin)
Age of patients	Older (>65 years old)	Younger (<65 years old)

Aortic Valve Replacement Surgery

In summary…

- Caused by degenerative calcification, congenital bicuspid valve, or rheumatic disease
- Syncope, angina, dyspnea are the three common symptoms
- P/E: crescendo-decrescendo systolic ejection murmur, pulsus parvus et tardus
- If left untreated, can lead to left heart failure
- Transthoracic echocardiogram = modality of choice for imaging
- Treatment:
  - Transcatheter aortic valve replacement
  - Surgical aortic valve replacement
  - Bioprosthetic vs. mechanical valves

Credits

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Sources:

- Brecker, S. J., & Aldea, G. S. Choice of therapy for symptomatic severe aortic stenosis. *UpToDate2017*.
- Lilly, L. S. (2012). *Pathophysiology of heart disease: a collaborative project of medical students and faculty*. Lippincott Williams & Wilkins.
- Otto, C. M. (2016). Clinical manifestations and diagnosis of aortic stenosis in adults. *U: UpToDate, Yeon SB ur. UpToDate [Internet]. Waltham, MA: UpToDate*.
- Video: Dr. Arie Blitz, MD
  http://www.surgerytheater.com/video/1963/Aortic-Valve-Replacement-Operative-Technique

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