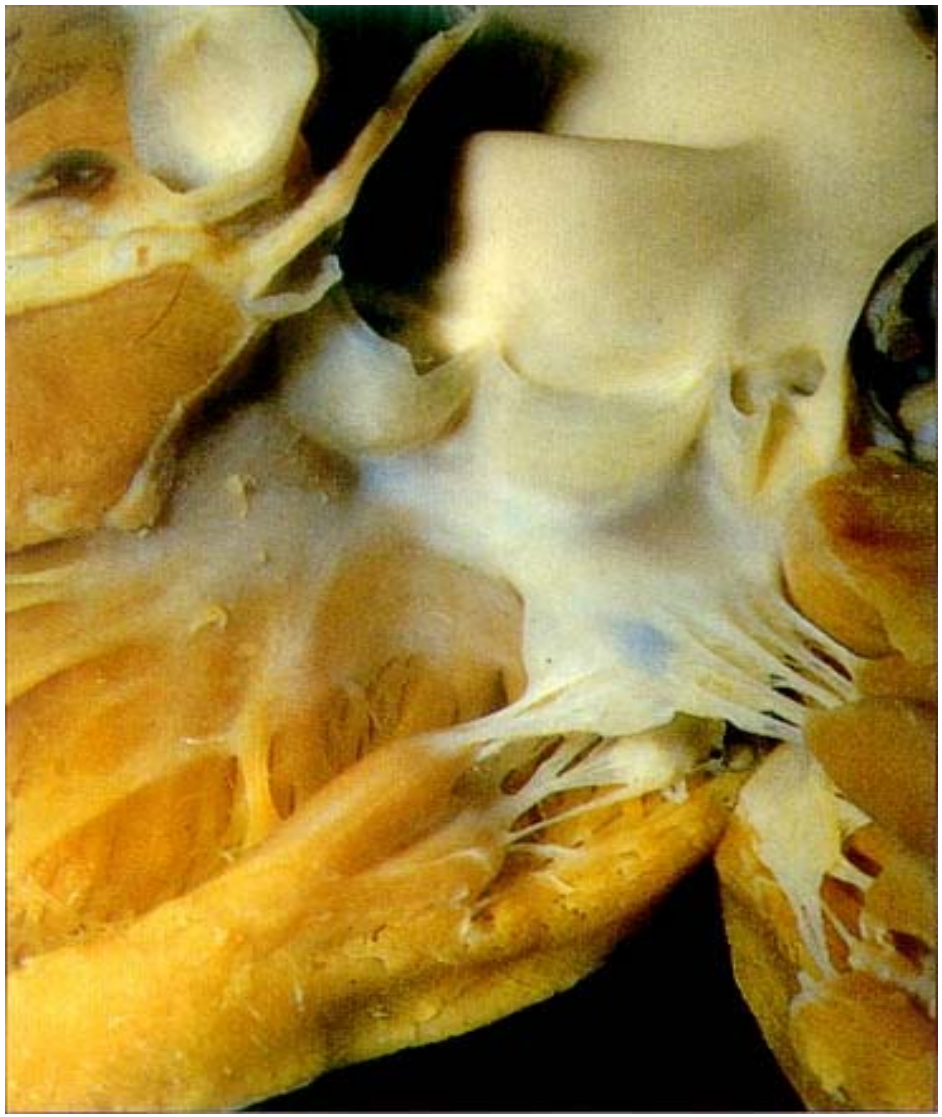
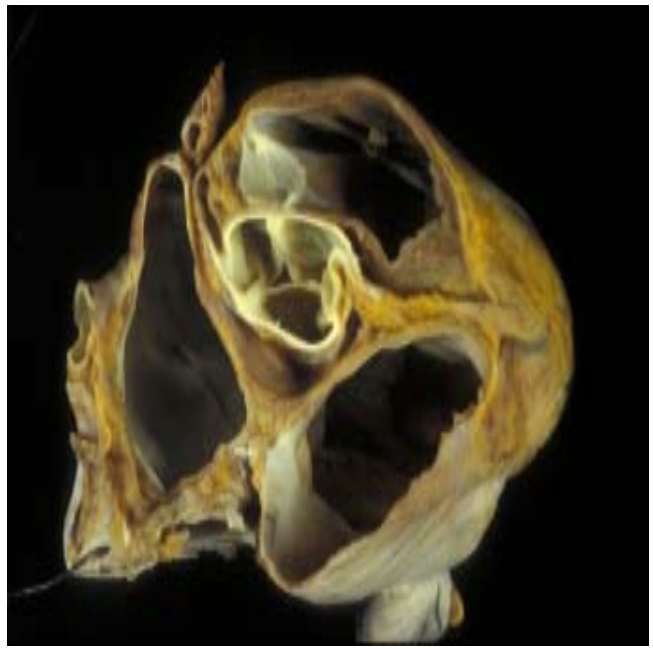
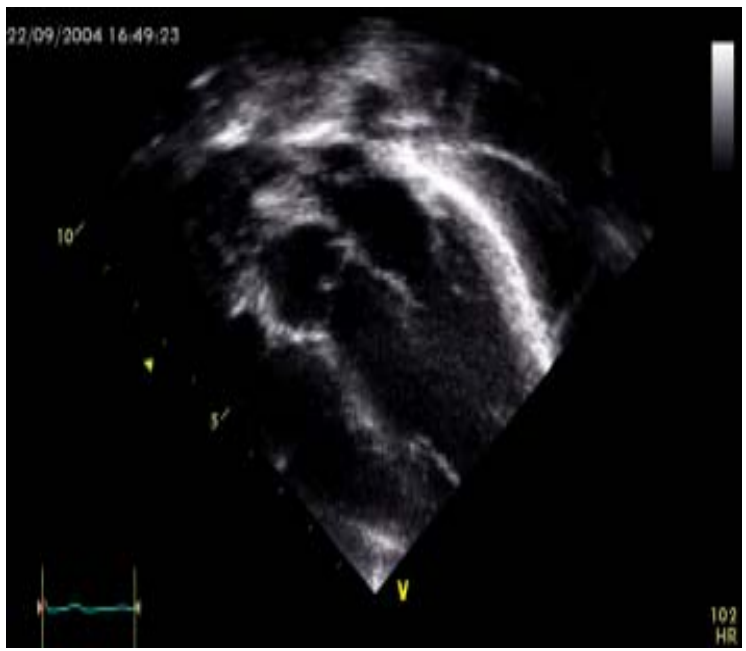
The left heart valves; normal anatomy and physiology echo-correlation

배 은정
서울대 병원 소아과



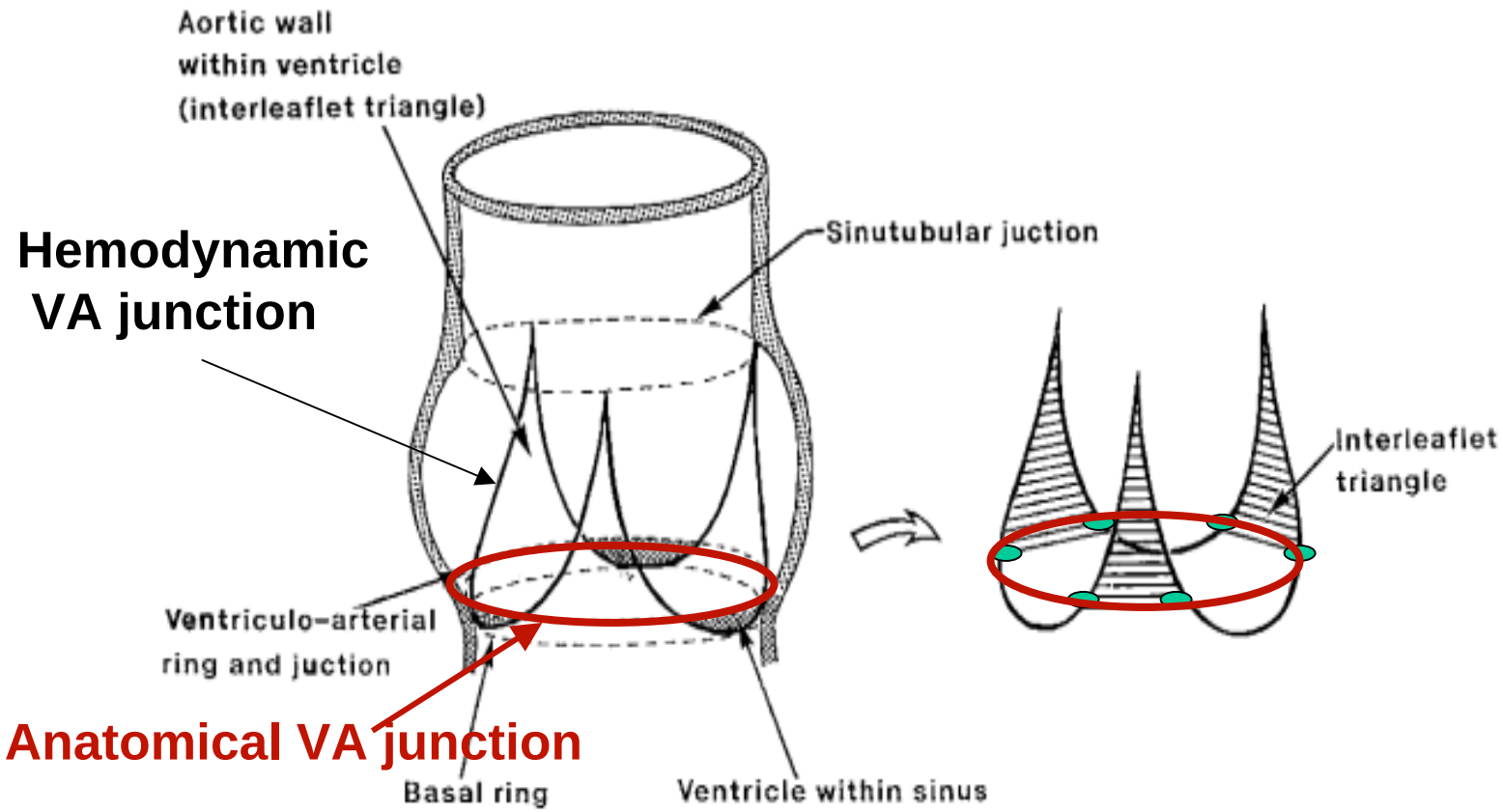



22/09/2004 16:49:23
10
5
102
HR

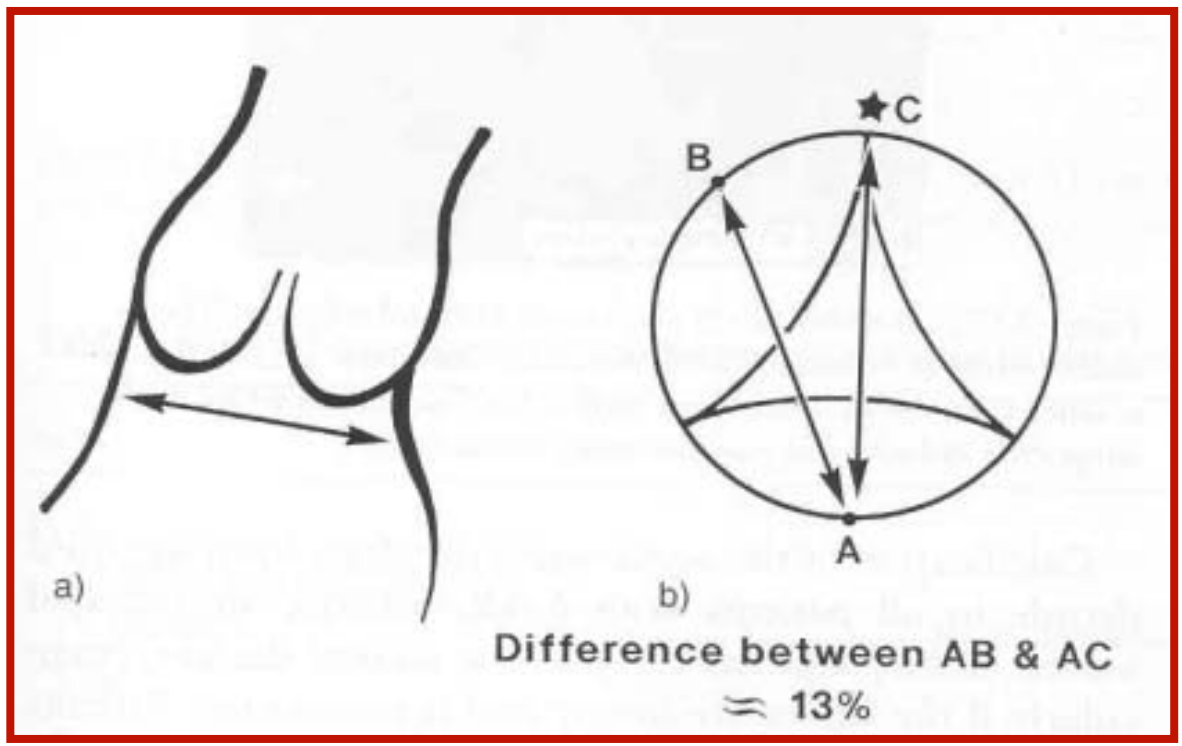
Structure of aortic root and aortic valve

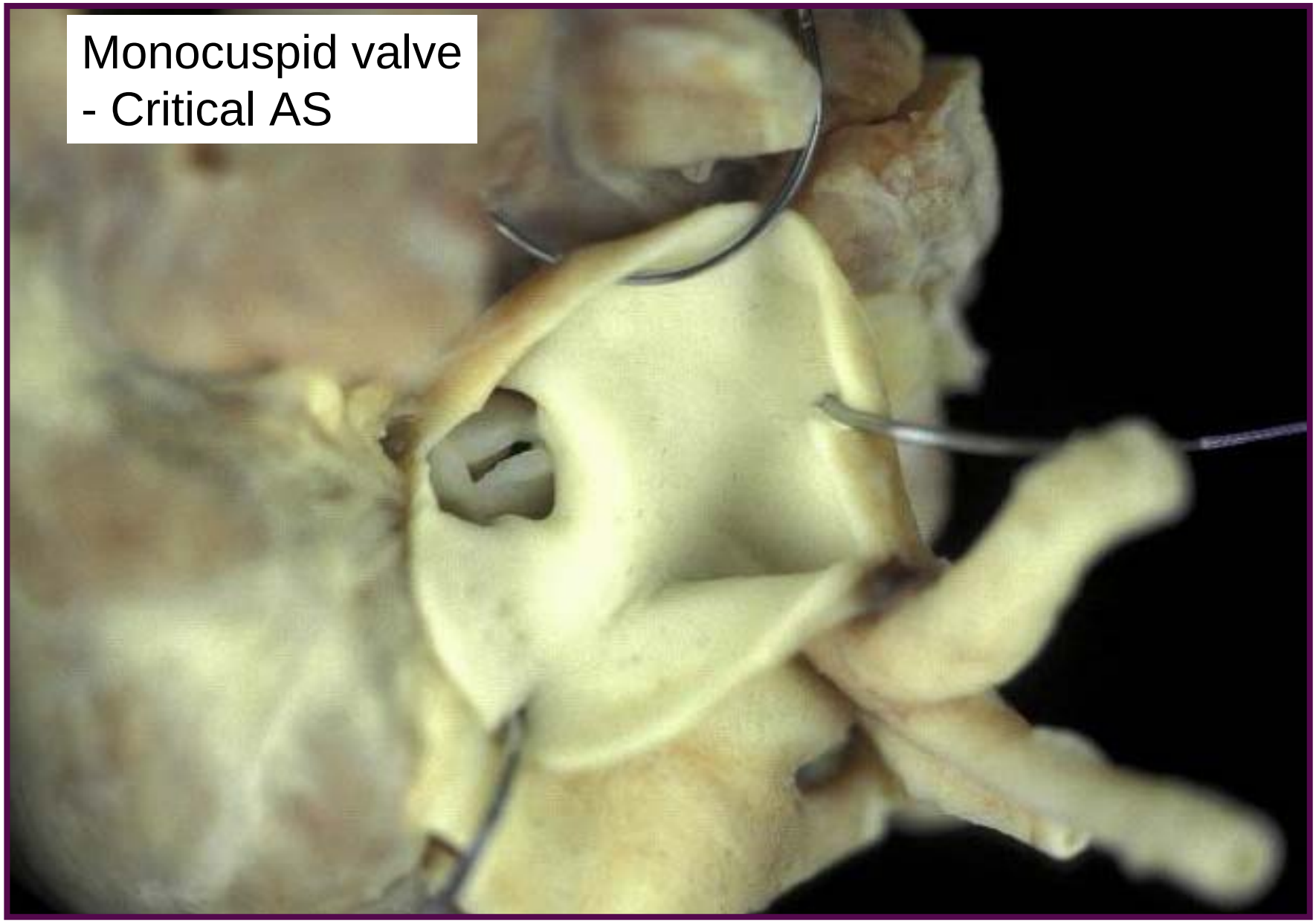
Aortc valve; 3 semilunar valves

Valve attachment site; looks like crown, not circular

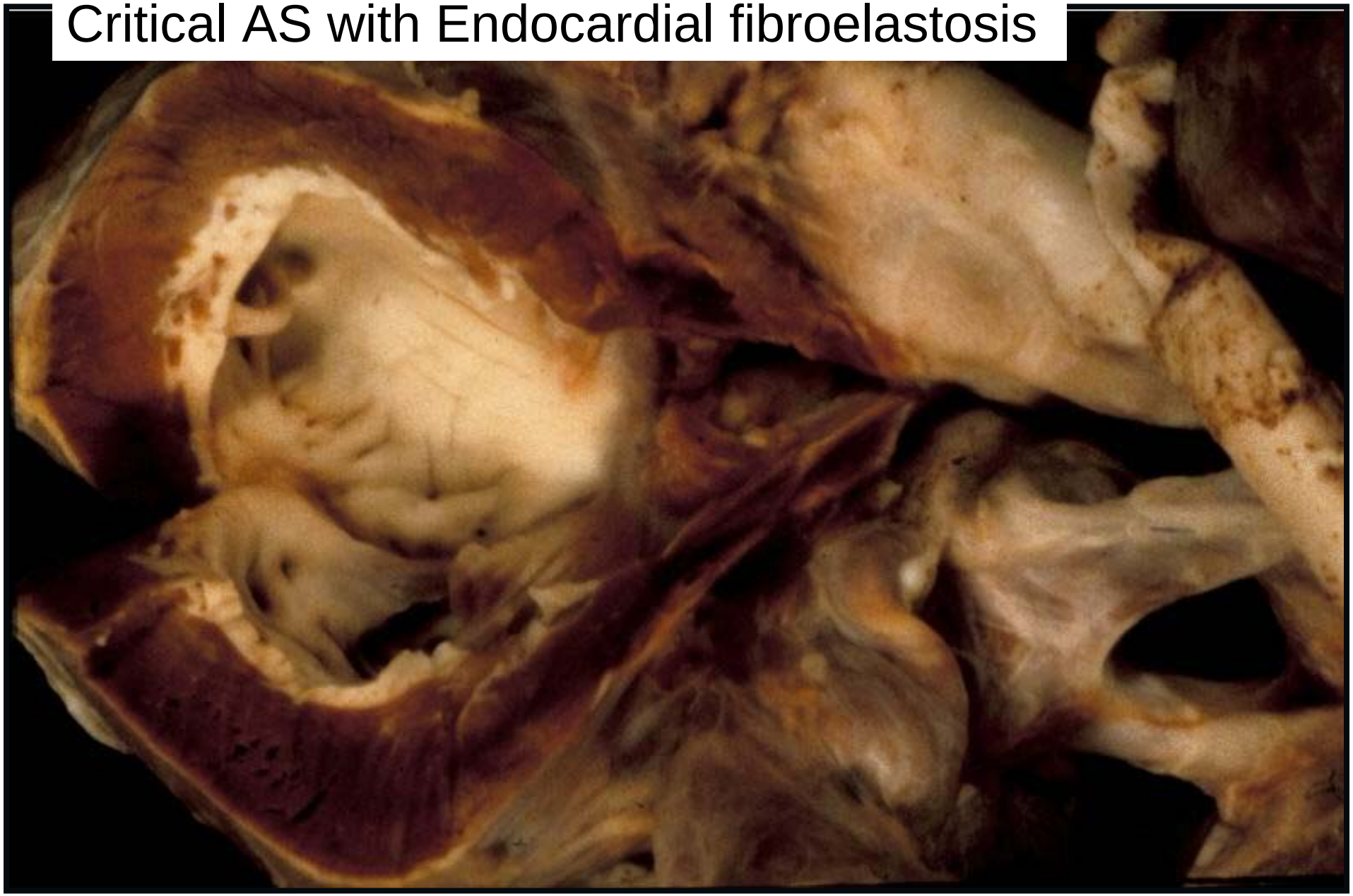


Inaccurate measurement of aortic annulus



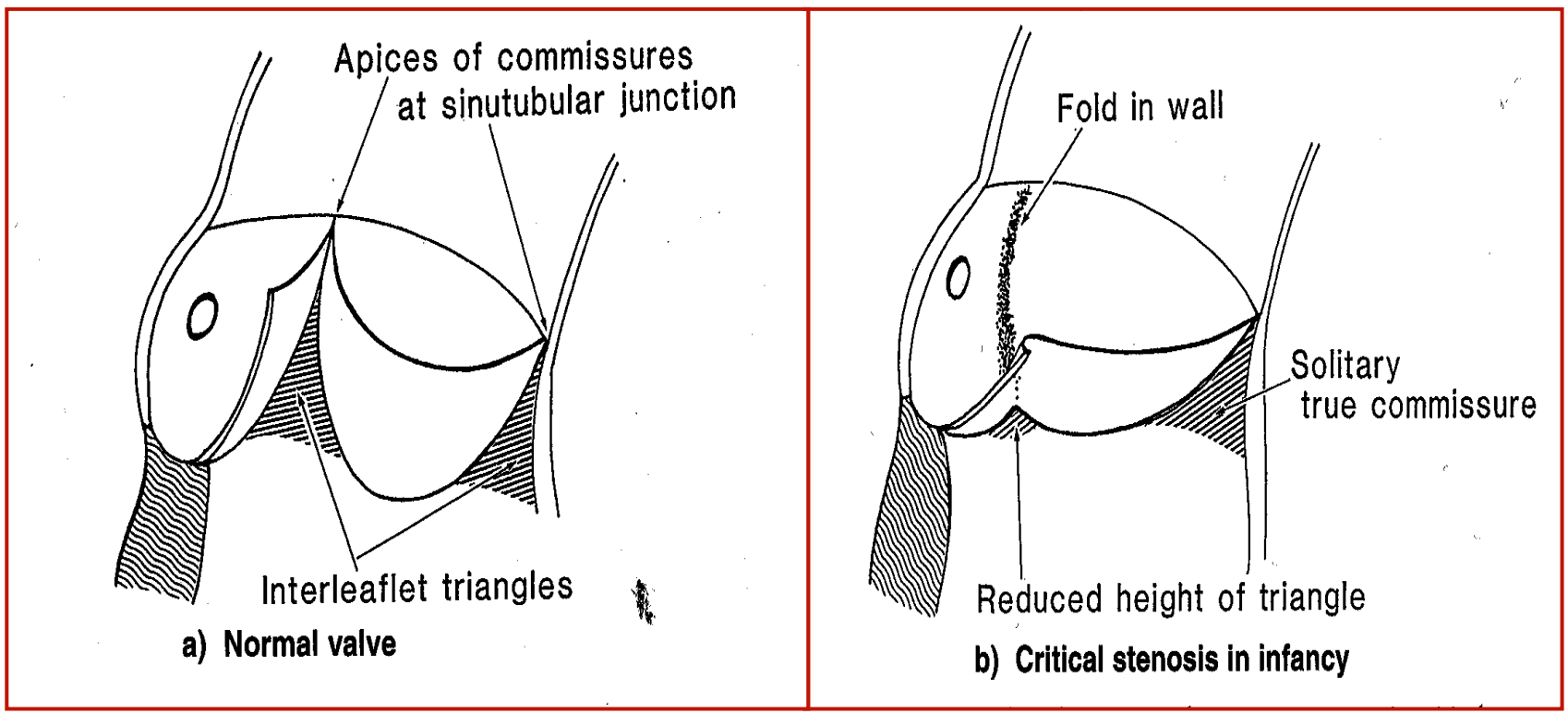

Monocuspid valve
- Critical AS

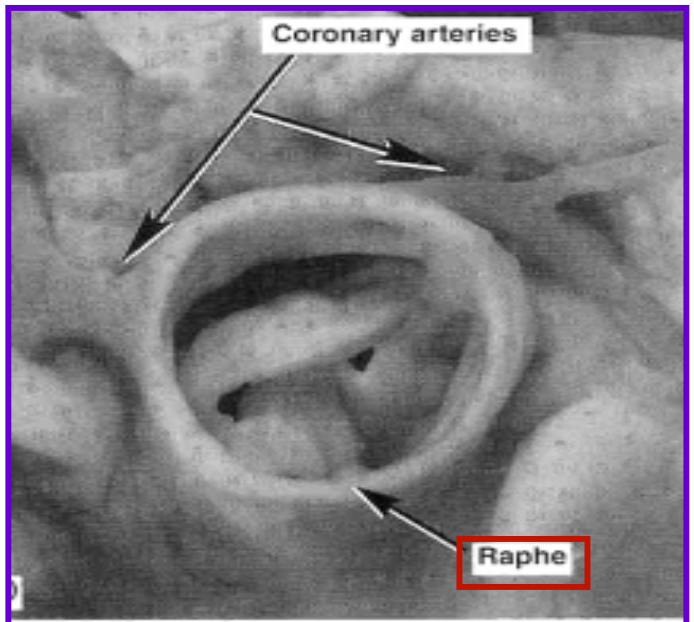
Critical AS with Endocardial fibroelastosis

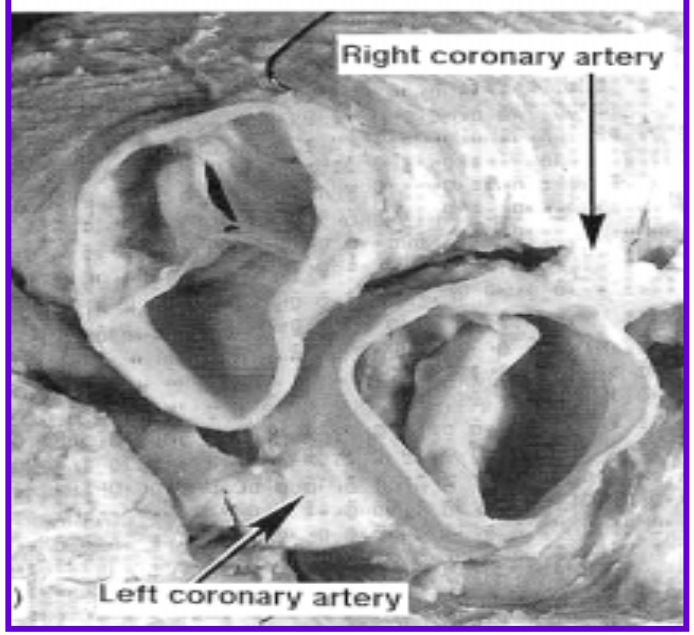


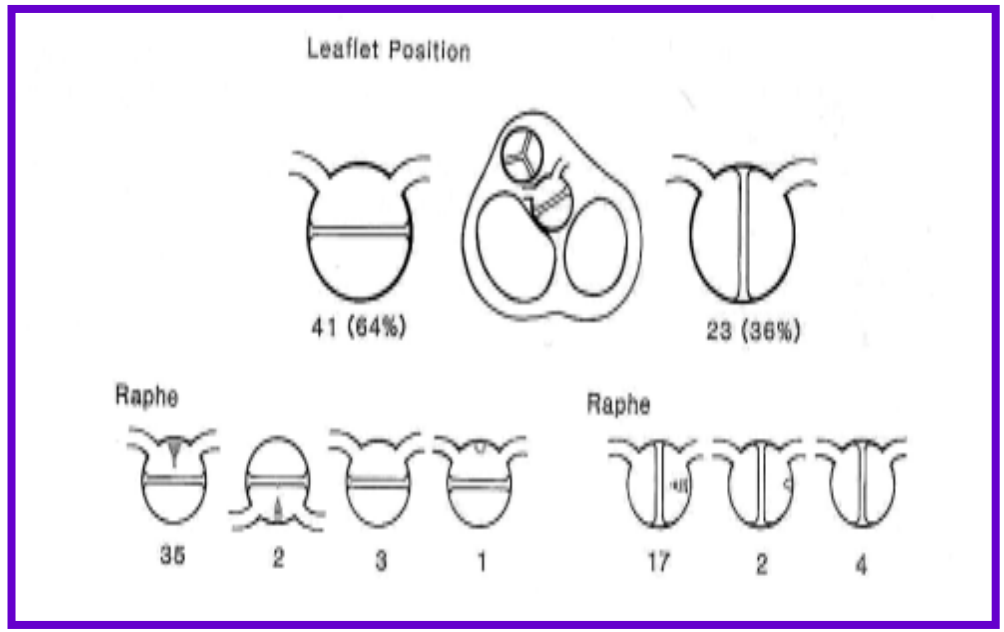
Aortic valvular stenosis

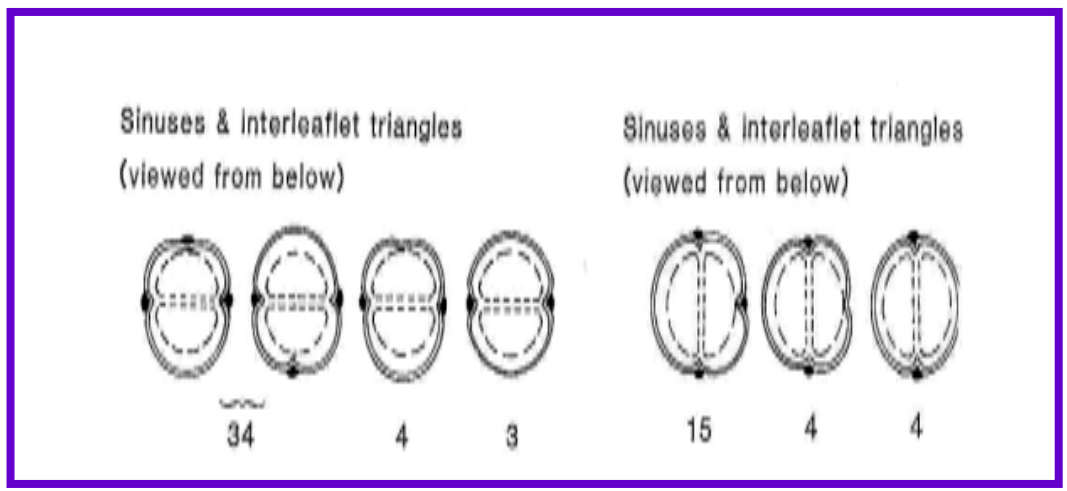
- Bicuspid




Coronary arteries
Raphe


Right coronary artery
Left coronary artery

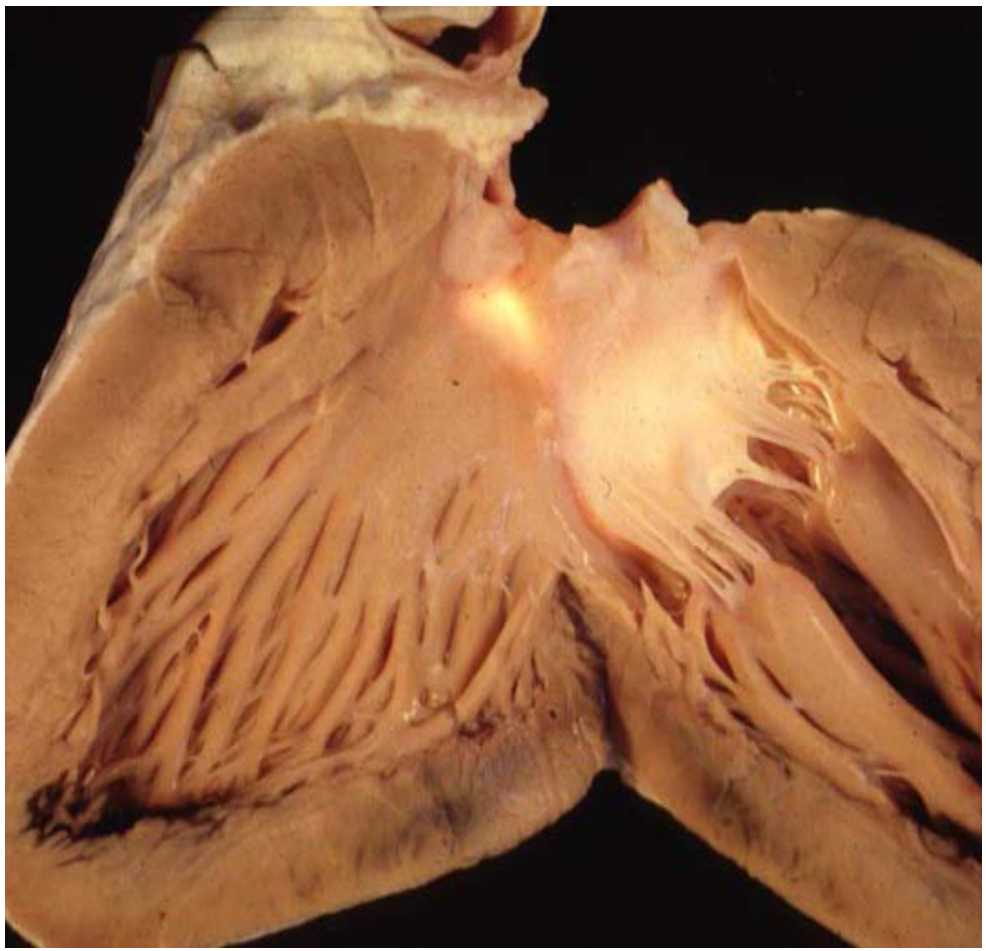

Leaflet Position
41 (64%)
23 (36%)
Raphe
35
2
3
1
Raphe
17
2
4


Sinuses & interleaflet triangles
(viewed from below)
34
4
3
Sinuses & interleaflet triangles
(viewed from below)
15
4
4

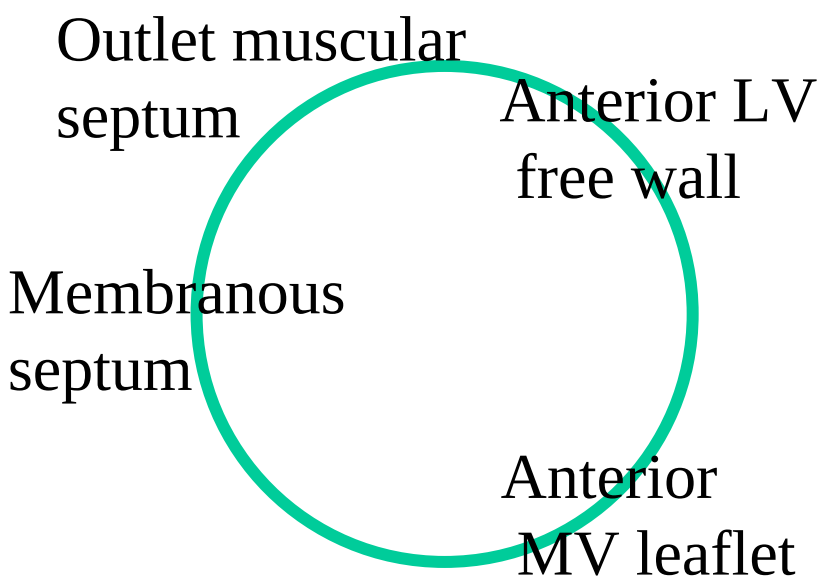
Subvalvar structure

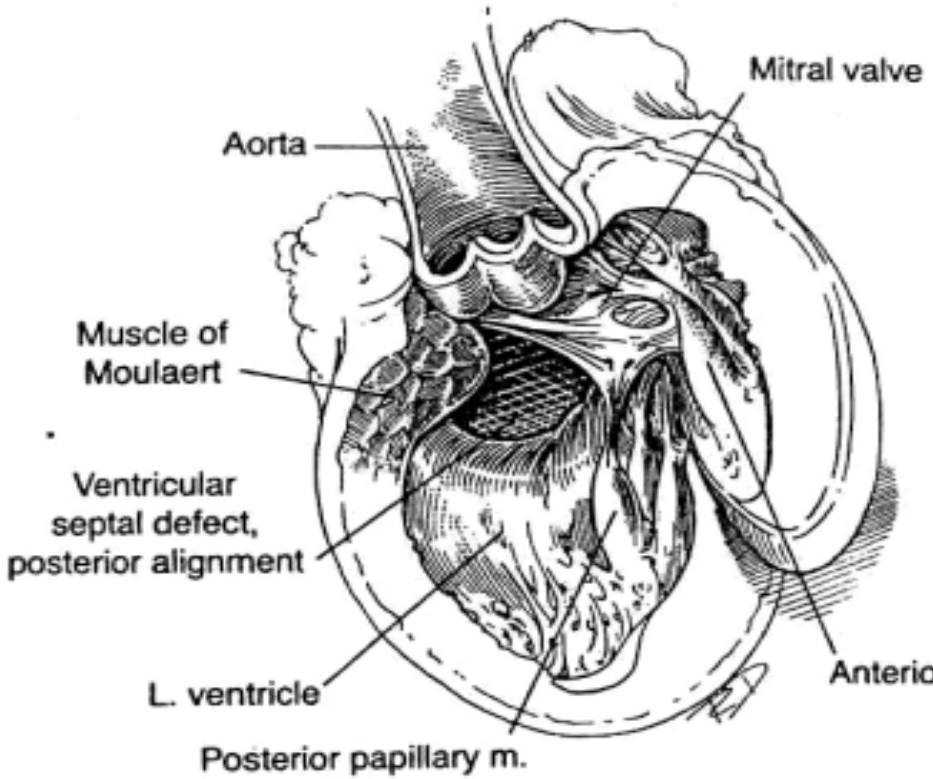
Anterior; muscular support

Below NCC, LCC; fibrous continuity to AMV



Subvalvar LVOT ring

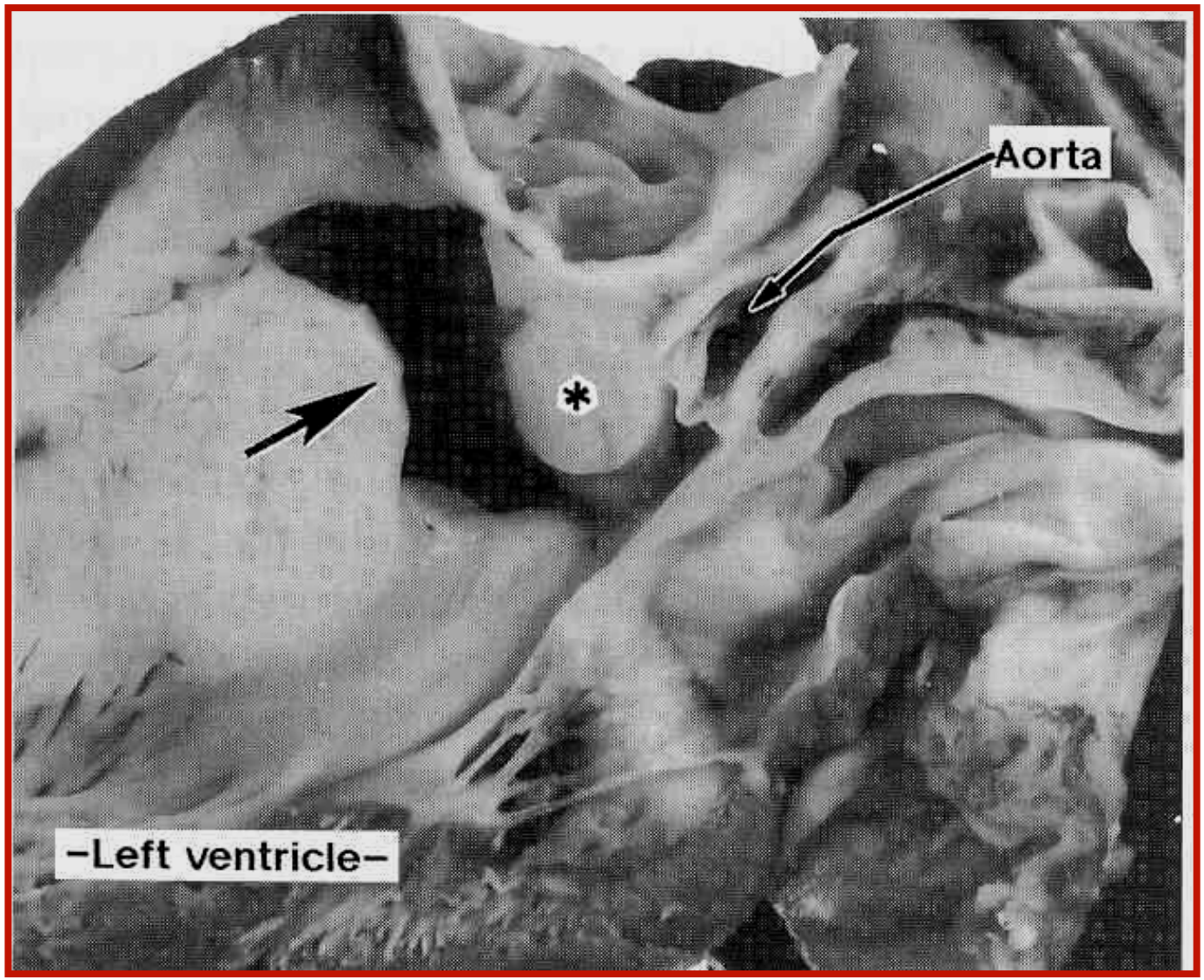




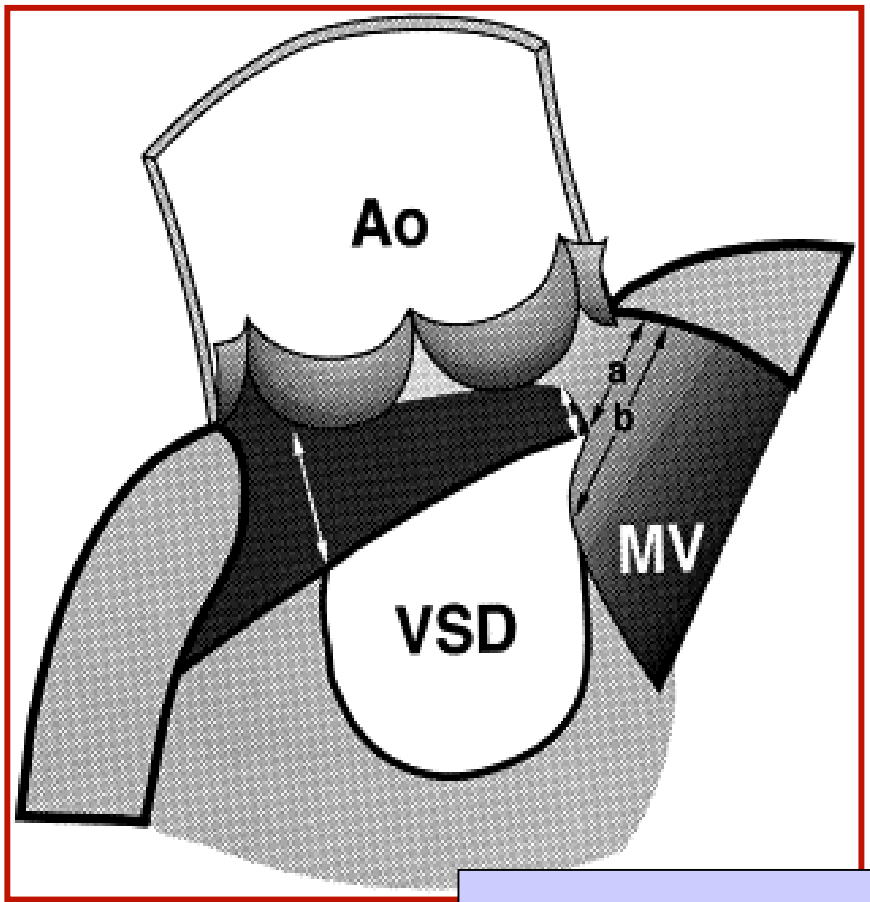
Subaortic stenosis

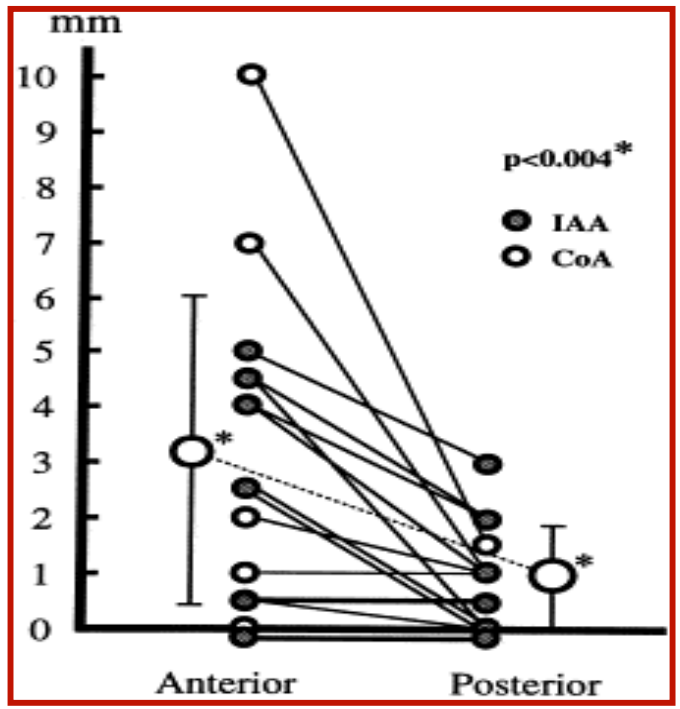
- **Subvalvar ridge;**
  endothelial fold ~ fibromuscular ridge
- **Deviated muscular outlet septum**
- **Hypertrophied ALM of Moulaert**
- **Anomalous tissue tag**
  from membraous septum or AV valve
- **Hypertrophied IV septum**

- Terminology
  - **Outlet septum; muscular shelf separates the subaotic outflow tract from RV**
  - **Ventriculoinfundibular fold (VIF);**
    muscle separating AV valve from arterial valves, inner curvature of the heart
  - **Anterolateral muscle;**
    muscular trabeculation extending along anterolateral wall of LVOT


Aorta
*
-Left ventricle-

Superoinferior length of outlet septum

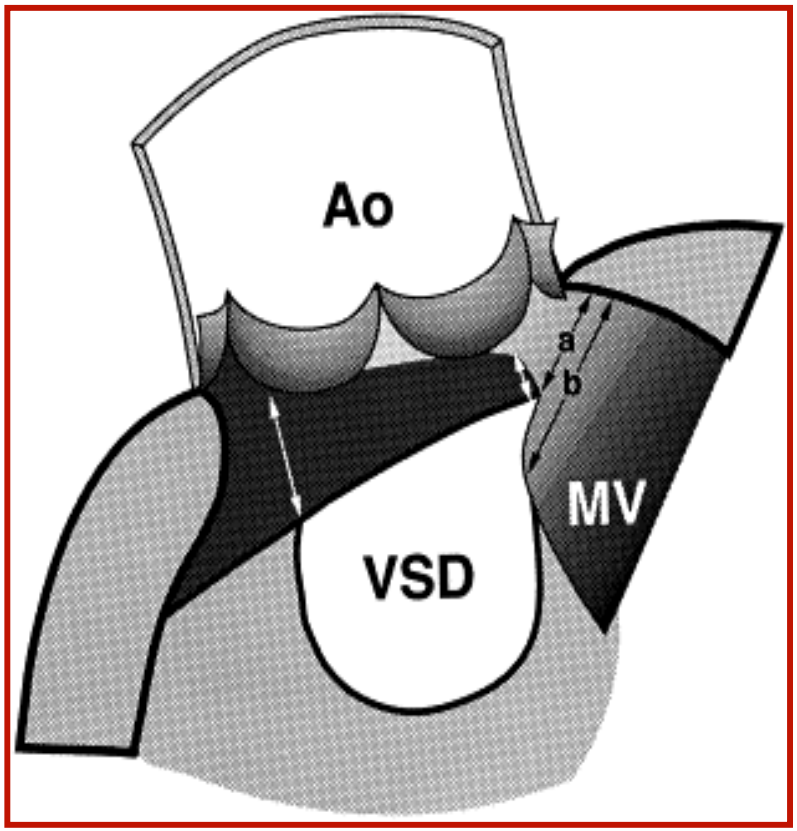


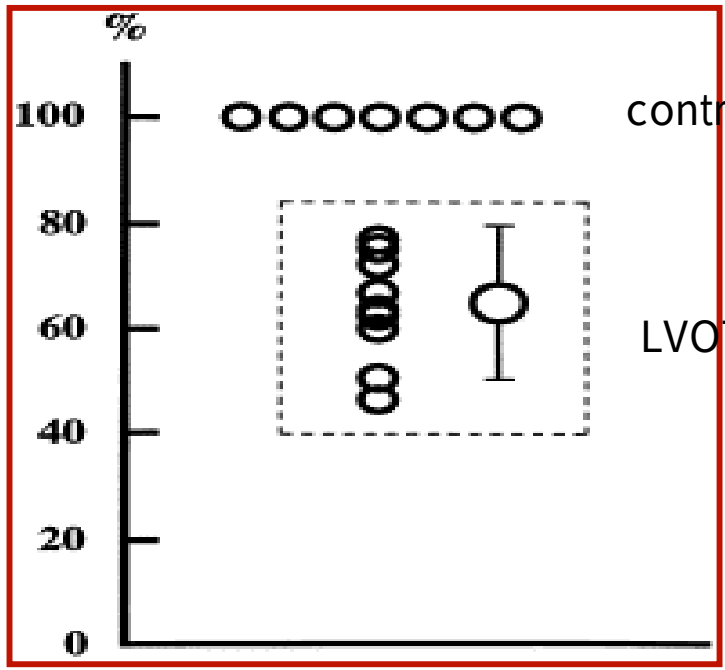


Length of outlet septum
Anterior > posterior

(ATS 1998)

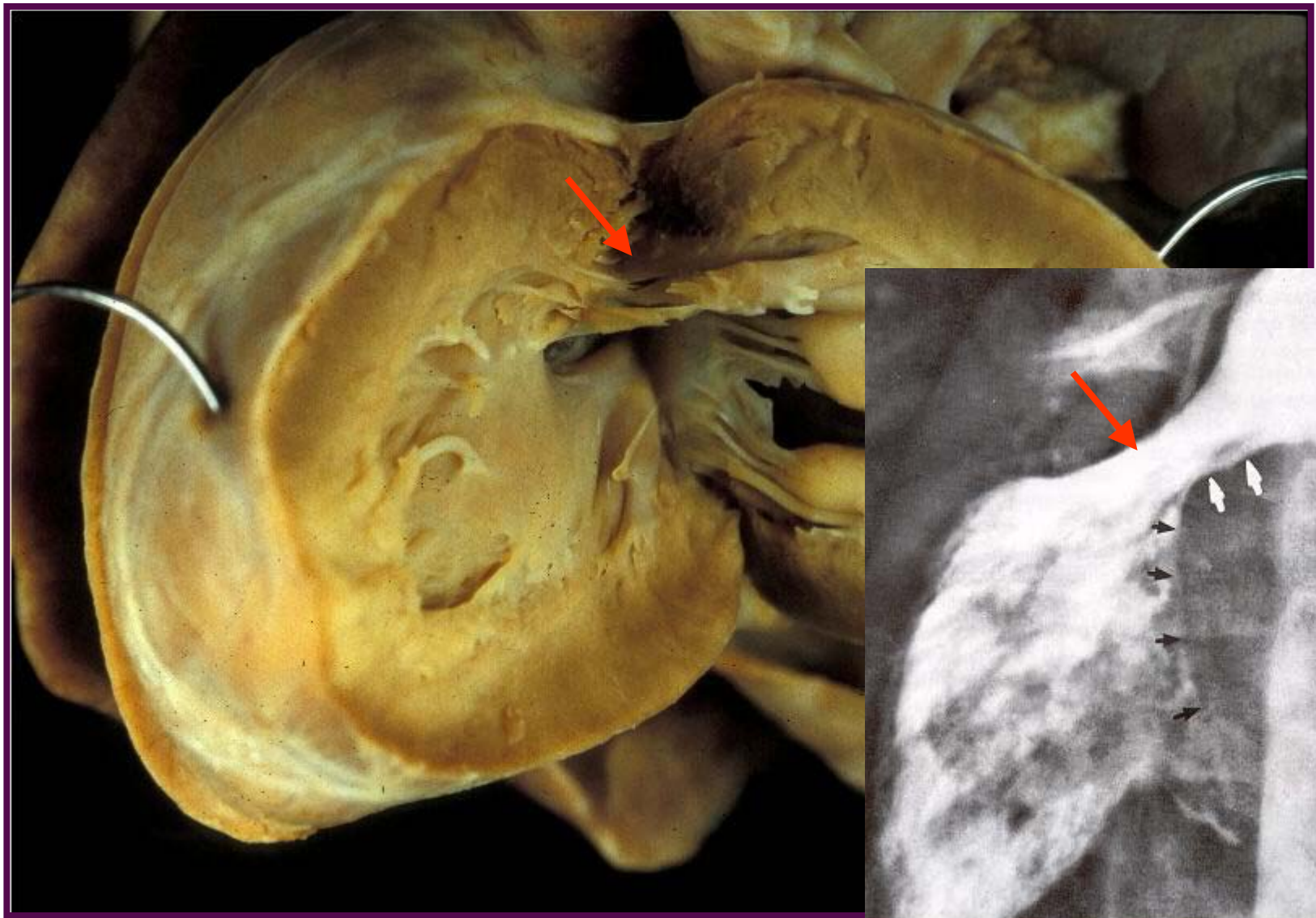
Percent width of Ao- mitral fibrous continuity





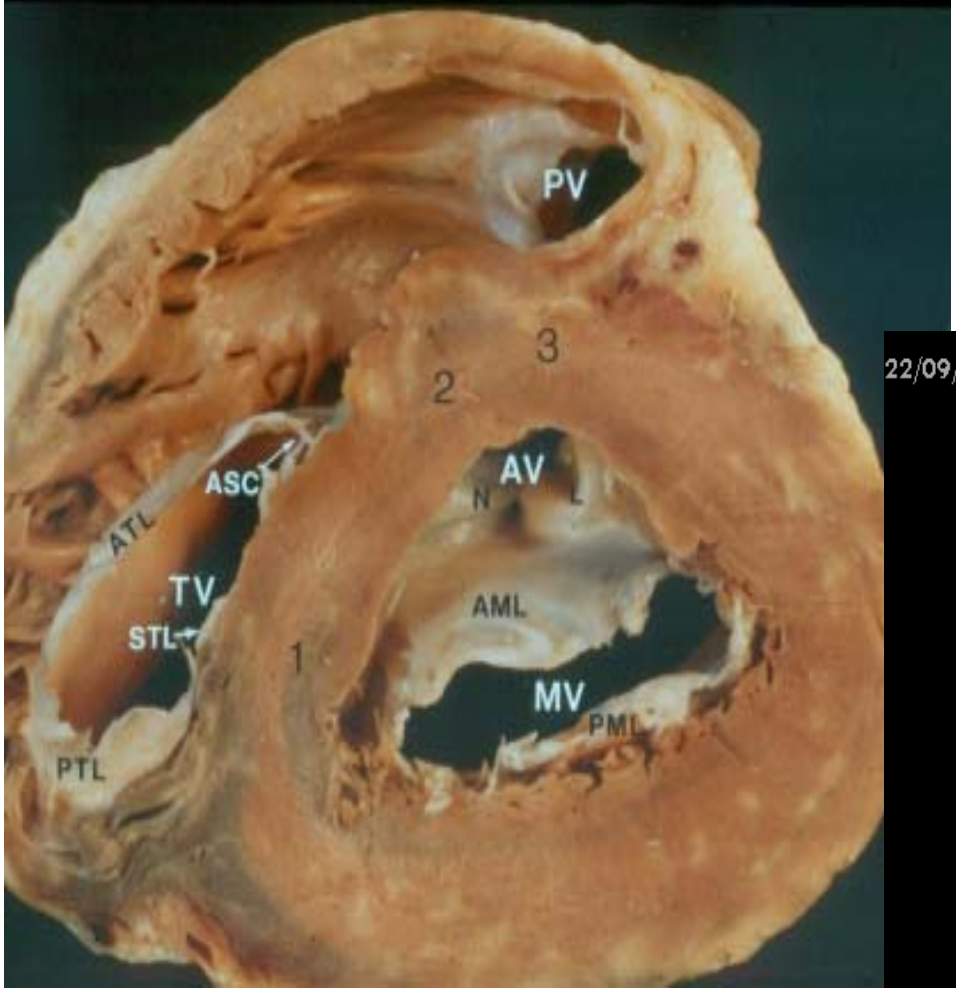
Marked reduction of MV component of LVOT
Abnormal insertion of AMV into outlet septum
(ATS 1998)

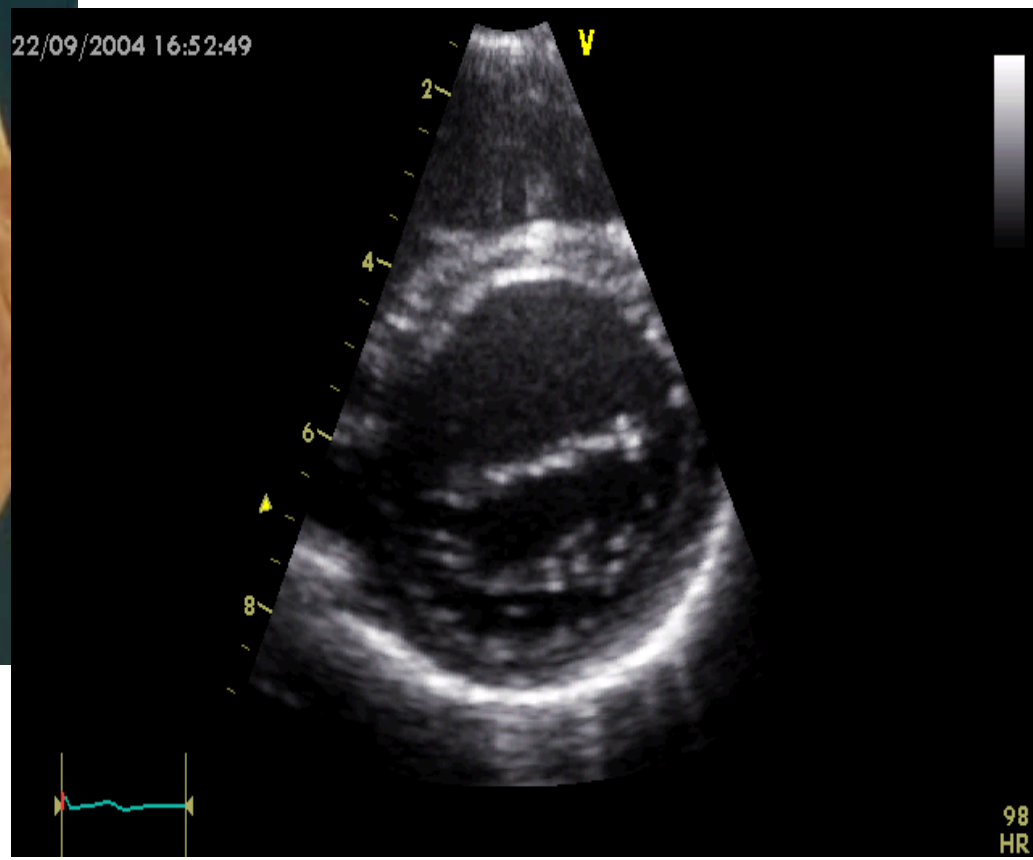
Subaortic stenosis by abnormal MV leaflet; AVSD

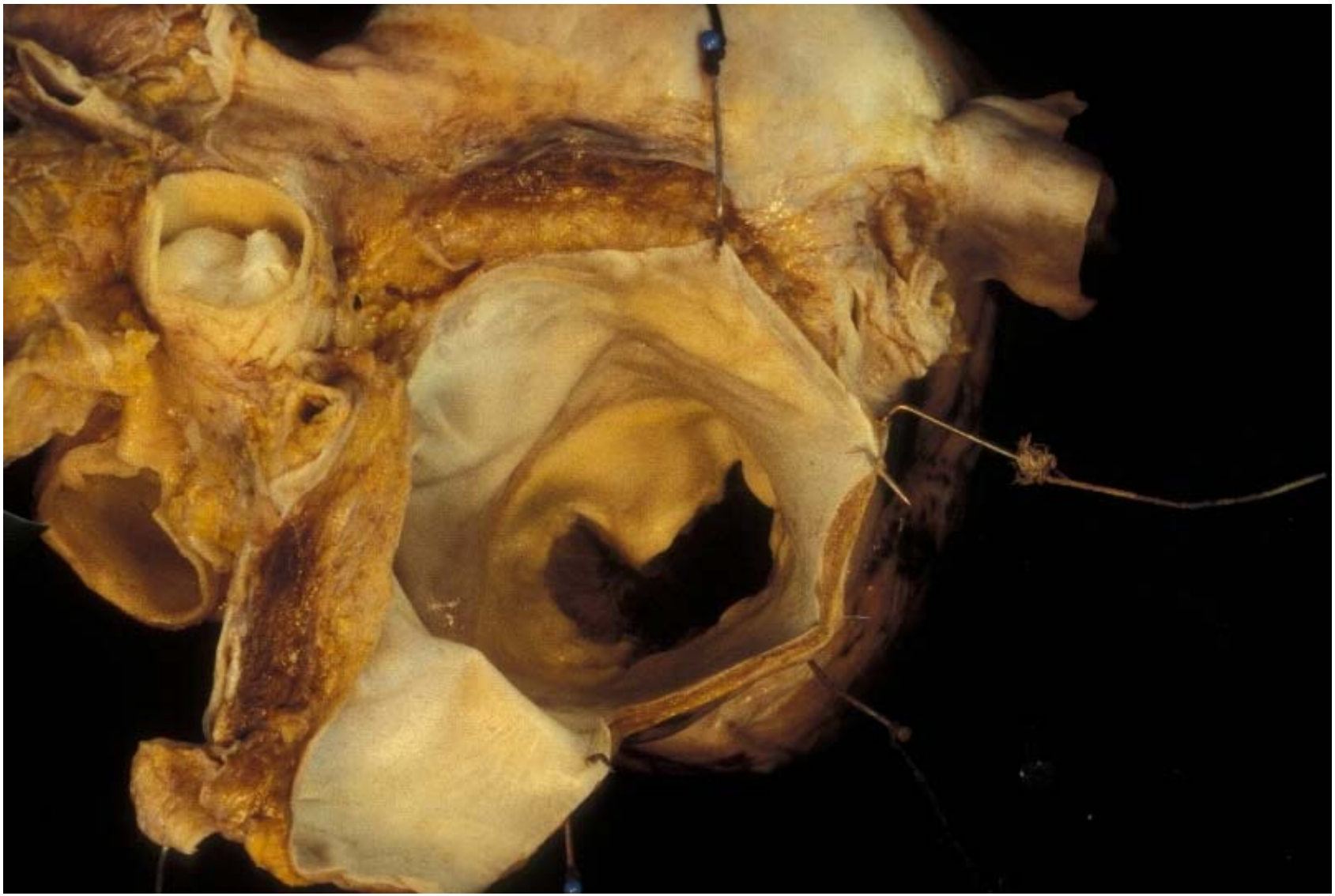


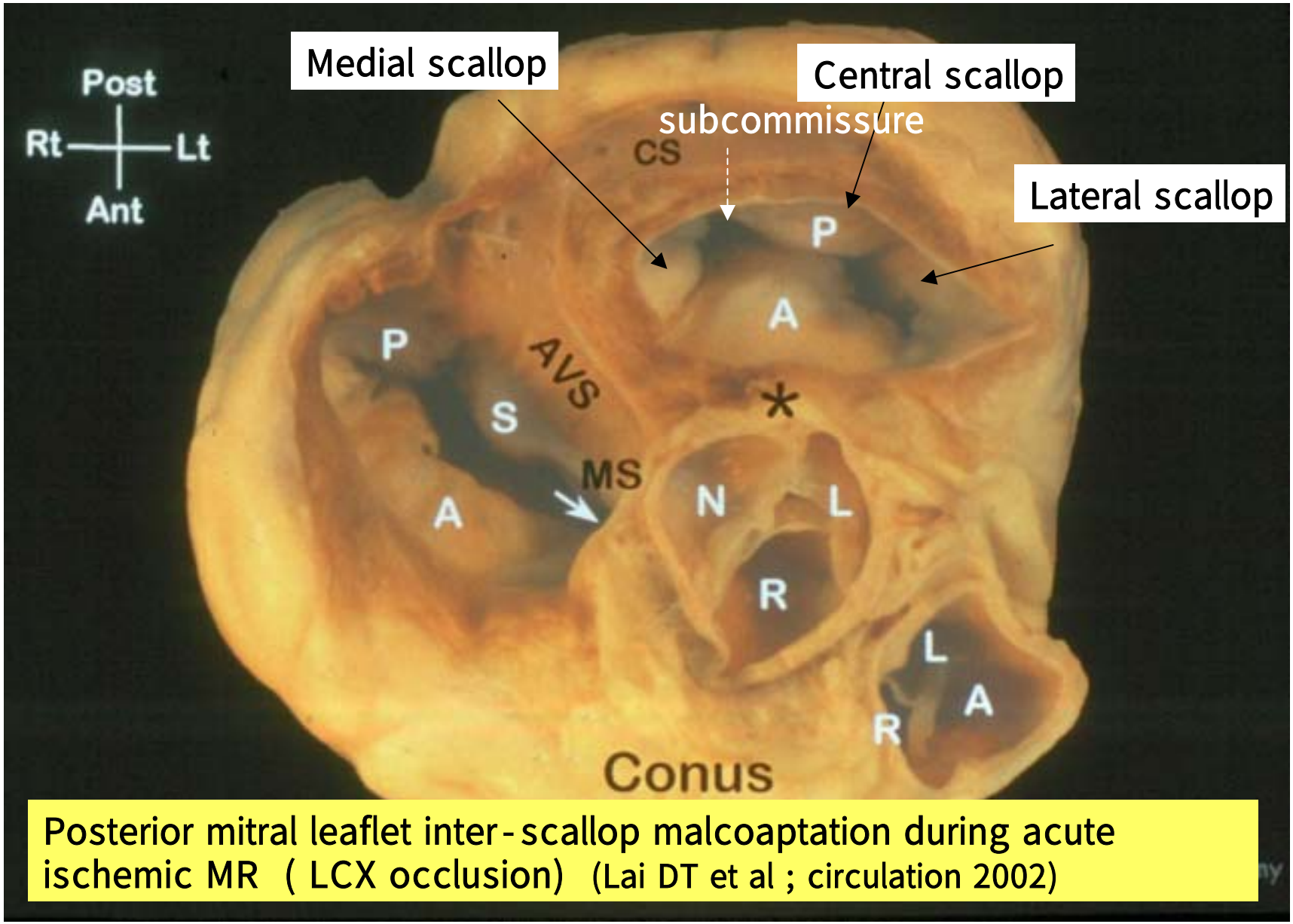
Mitral valve

- Annulus
- Two leaflets
  - Anterior leaflets; aortic leaflets **(tall, 1/3)**
  - Posterior leaflets; mural leaflets **(lengthy, 2/3)**
    - 3 Scallops or commissural leaflets
  - Commissures
    - Anterolateral
    - Posteromedial
- Chordae tendinea
- Two papillary muscles


PV
3
2
AV
N
L
ASC
ATL
TV
STL
AML
1
MV
PML
PTL


22/09/2004 16:52:49
V
2
4
6
8
98
HR

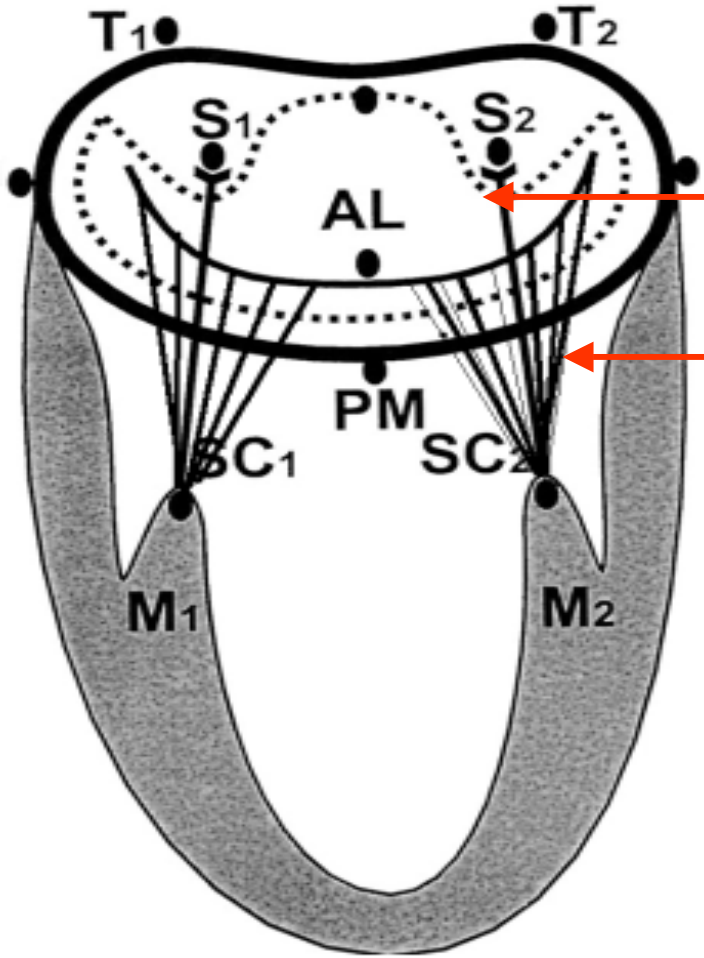




Posterior mitral leaflet inter-scallop malcoaptation during acute ischemic MR (LCX occlusion) (Lai DT et al ; circulation 2002)

Mitral Subvalvar Apparatus

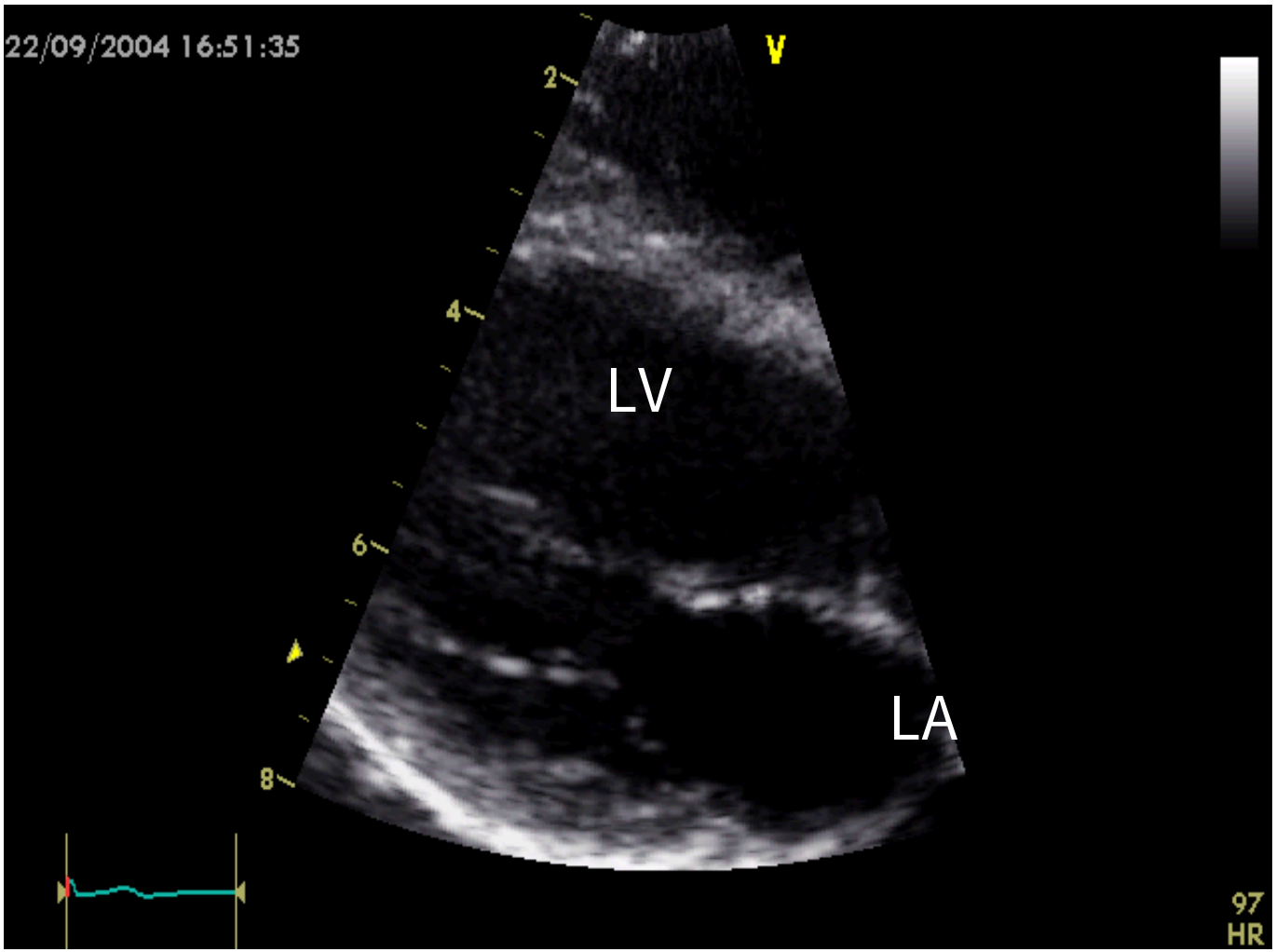
- Two papillary muscles; attached to free wall
  - Anterolateral
  - Posteromedial
- Chordae teninea (tendinous chords)
  - Primary chords
  - Secondary chords;
    - Strut chords (anterior MV); basal stay chords
    - Basal chords (posterior MV)



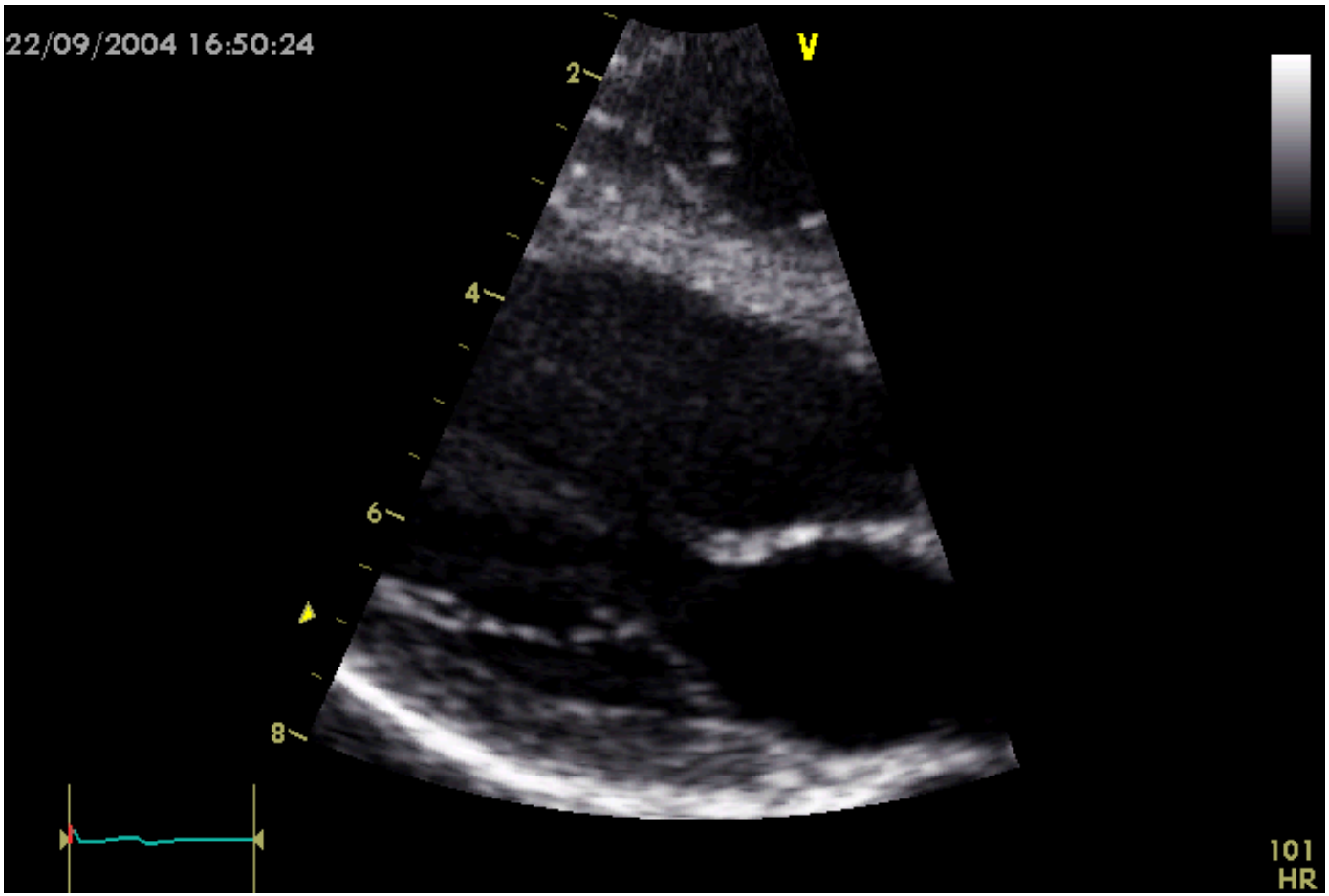
Strut chords

Primary chords

Primary chords

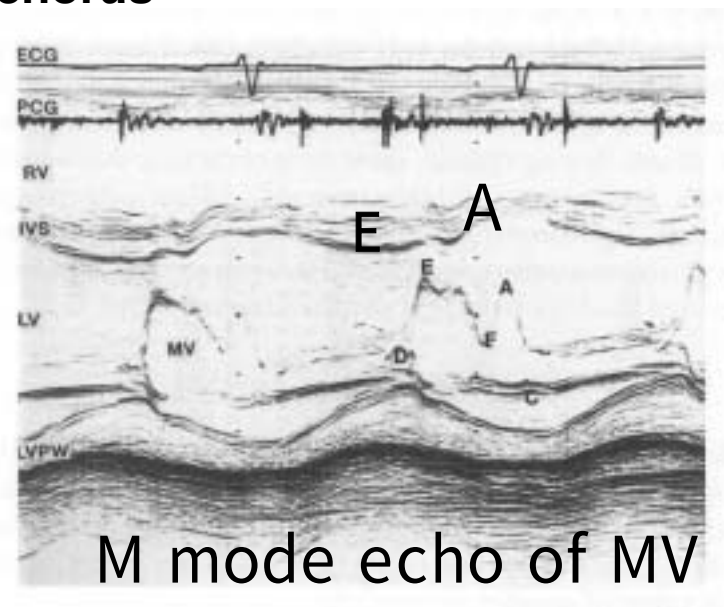


Secondary Chords; Strut chords

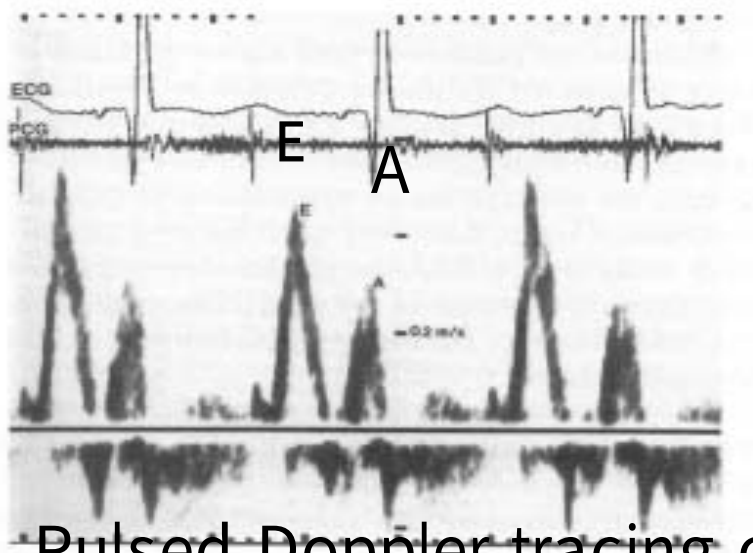


Dynamics of mitral valve

- **Isovolemic relaxation of LV**
- **Mitral valve opening**
  - **Reversal of diastolic pressure of LV and LA**
- **Mitral inflow; E wave**
- **Passive closure**
- **Reopening by atrial contraction; A wave; 15-20% of C.O.**
- **Mitral valve closure during ventricular systole**
- **Annular contraction during ventricular systole, maintain tension of chords**



M mode echo of MV



Pulsed Doppler tracing of MV

Valvular-ventricular interaction:

- importance of the mitral apparatus in canine left ventricular systolic performance
  ;severing all MV chords → dec. LV performance(circulation 1986)

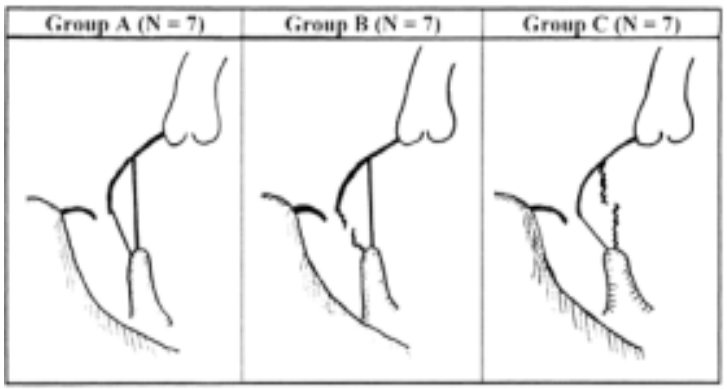
- Randomized Trial of Partial Versus Complete Chordal Preservation Methods of Mitral Valve Replacement (circulation1999)
  - complete retention of the subvalvular apparatus during mitral valve replacement resulted in improved ejection performance and smaller chamber volumes due to reduced systolic wall stress.
- Preserving chordae tendineae during MV surgery ;
  improves postoperative LV function and clinical outcome

Mitral Subvalvar Apparatus

Different functions of primary and secondary chordae

(circulation 1997)

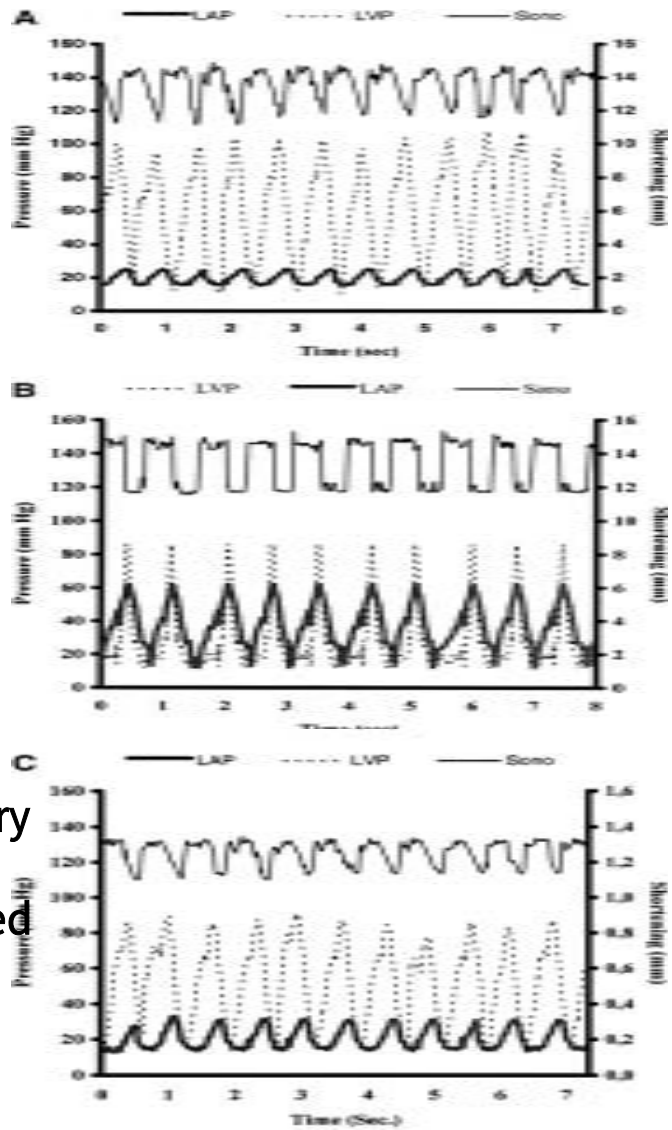
Isolated pig heart model



control

Primary chordae sectioned

secondary chordae sectioned



The primary chordae of the anterior leaflet ; mitral valve competence

Secondary chordae in left ventricular geometry and function.

Function of Strut chords

- Surgery on Strut chords
  - Strut chords transposition for AMV prolapse repair (JACC 1995)
  - Cutting strut chords for ischemic MR repair (circulation 2001)

- Strut chords;
  - Limit the lateral movement of AMV leaflet.
  - During diastole, midportion (btw 2 stay chords) unimpaired
  - Studies using sonomicrometeric crystal implantation under CPS in sheep model (circulation 2003)
- Cutting strut chords (radio-opaque markers)
  - Don't cause delayed leaflet coaptation or MR (ATS 2001)
  - Acute regional LV systolic dysfunction near chordal insertion sites (circulation 2003)

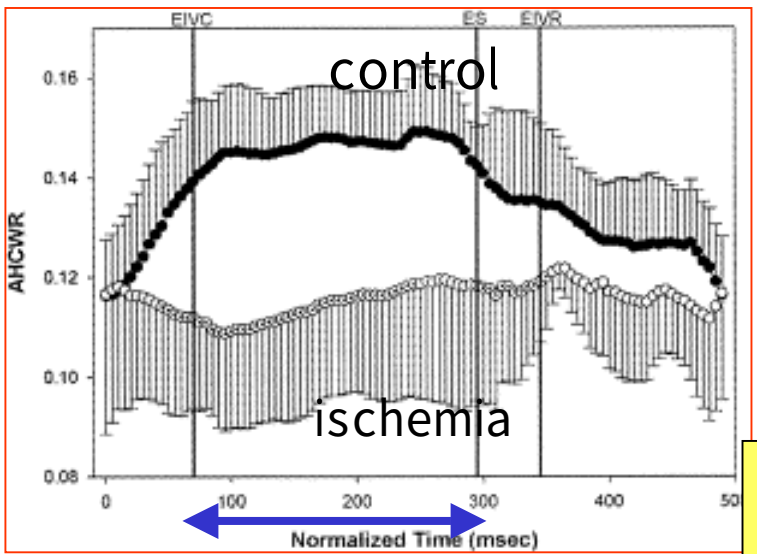
Mitral valve annulus

- Saddle shape; accentuates during systole
- Changes on annular area (3D echo study)
- peak - mid diastole, 20-40% area change(Am J Physiol Heart Cir Physiol, 2004)
- Infuenced by inotropic state, not HR (ATS 2004)
- Shortenig of MV annulus (J Heart Valve Dis 2003);

  AP dimension 6 %, mediolateral plan 13%
- Normal vs functional MR (Am Heart J 2000)
  - At mid-systole in normal annuli, area and perimeter reach a minimum, nonplanarity is greatest
  - FMR had a larger area, perimeter, and interpeak span than in normal subjects (P <.001 for all) and reduced cyclic variation.

The effect of regional ischemia on mitral valve annular saddle shape (ATS 2004)

AHCWR; Annular height and commissural width ratio



systole

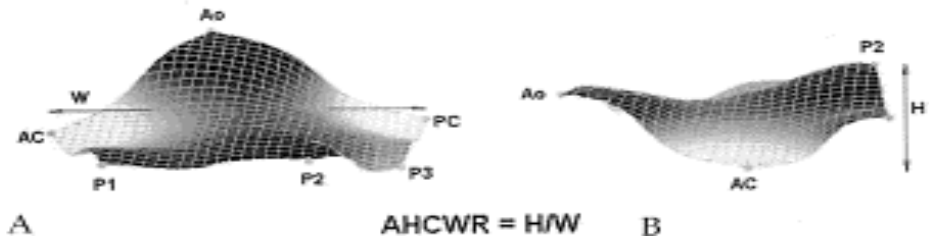
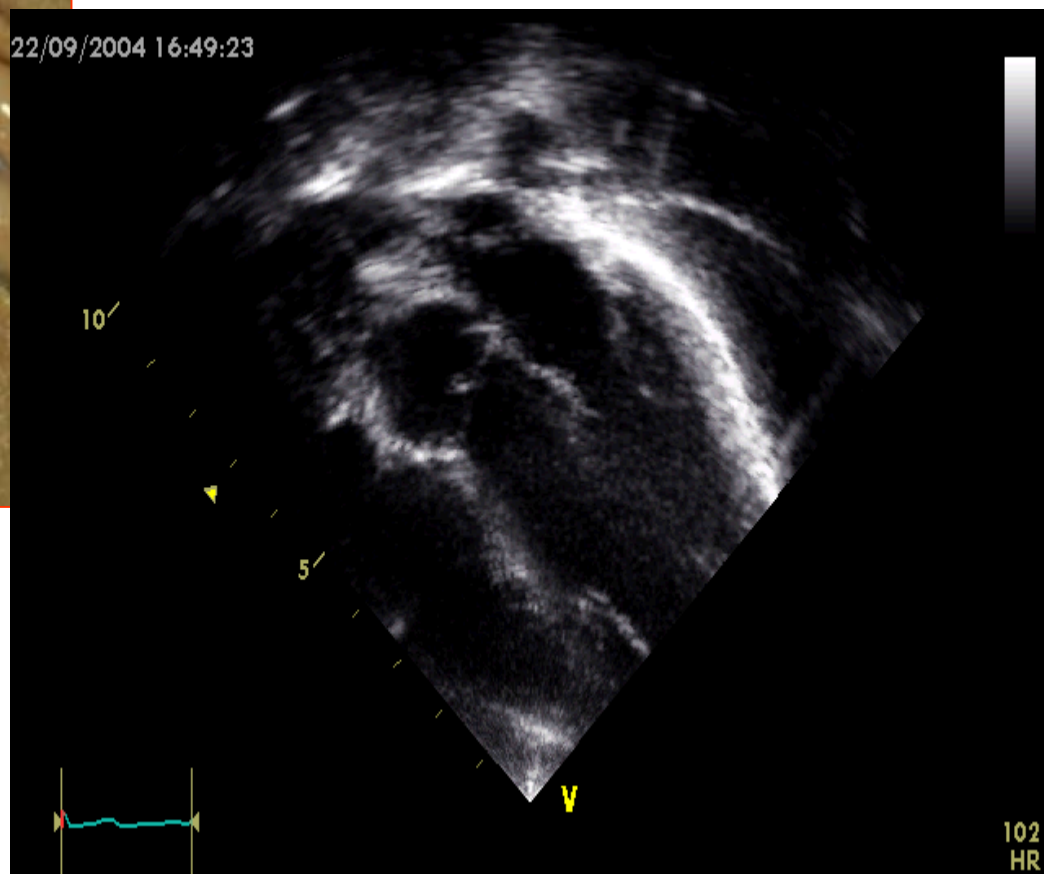


Image of a normal ovine mitral annulus at end systole

Normal annular saddle shape;
- accentuates during systole
- eliminated during ischemia ; causes AIMR.

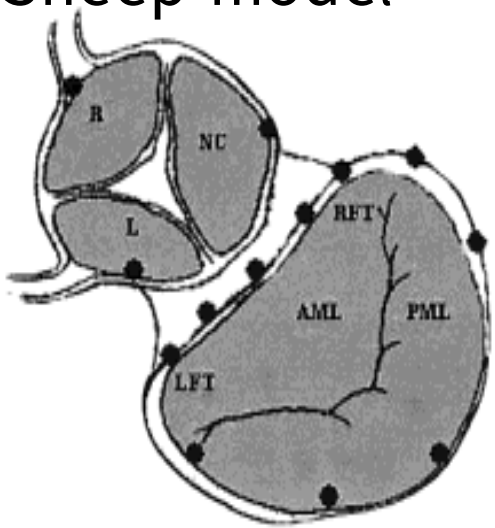
Aorto-mitral continuity



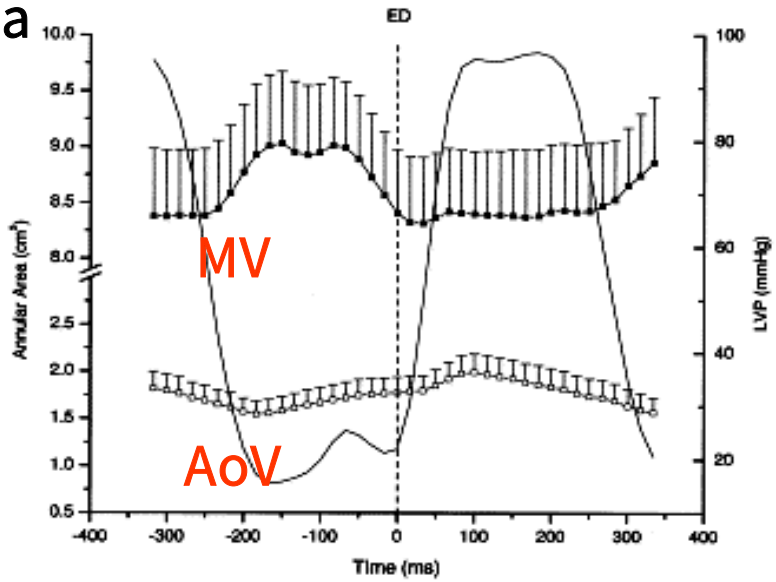
Aorto-mitral annular dynamics

(TimekTA et.al, ATS 2003)

Sheep model



Annular area



- Mitral and aortic area change
  Ao annular area; 32+-8%
- change of fibrous annlus ; le
  Ao 6 +-2% vs 18 +-4%,
- aortomitral angle; 88-97^0,

dynamic annular flexion 8 +-2^0, increased by inotropic stimulation

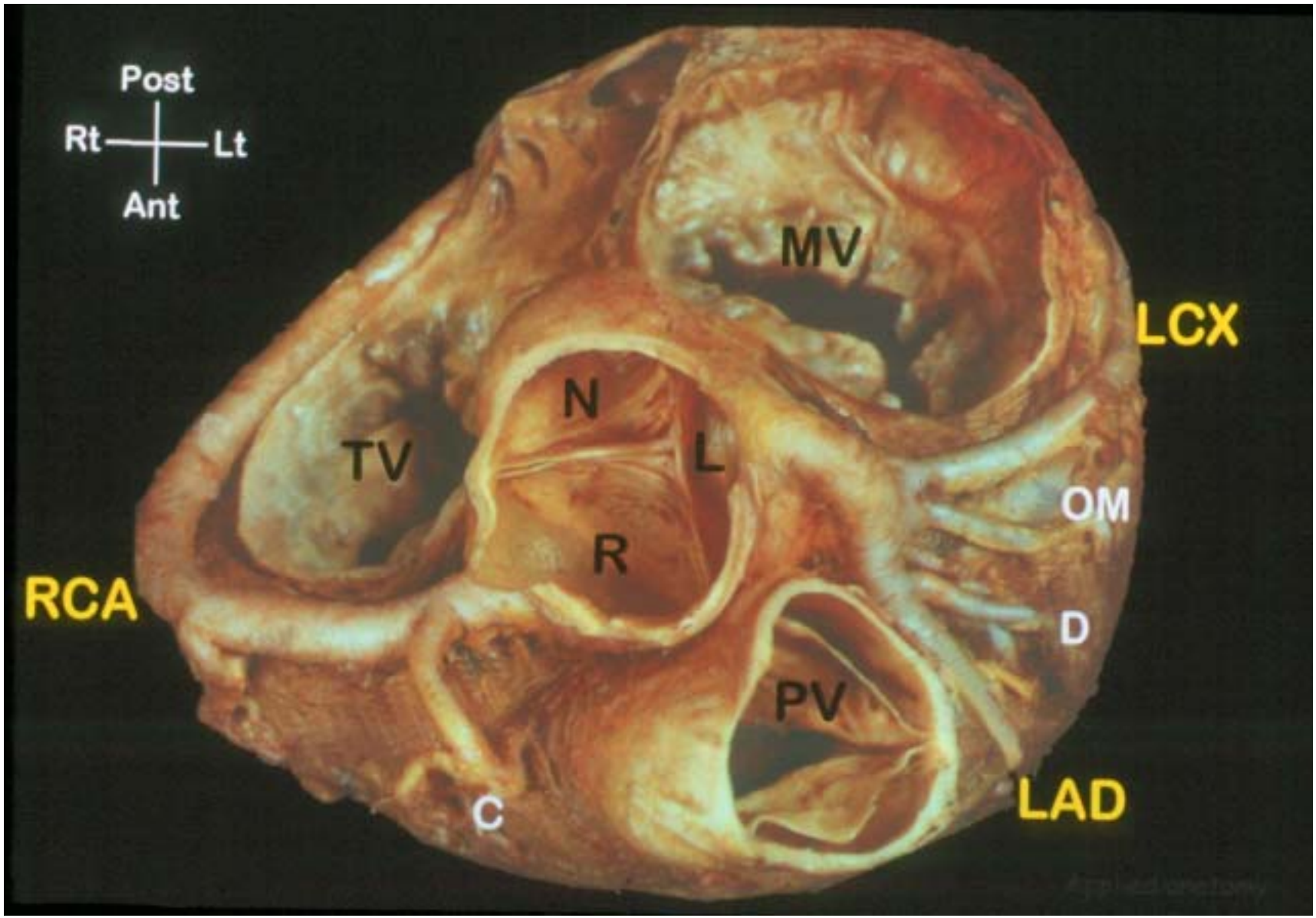
- Aid LV filling and ejection
- common dynamic physiology
  Not mediated by fibrous continuity
- Valvular surgery ;

may have adverse effect on valve function

Summary

- Ao valve and mitral valve anatomy;

  complicated 3 dimensional structures
- Dynamic changes of valve annulus shape, size, angle; according to cardiac cycle and inotropic status
- Valvular-ventricular interaction


Post
Rt
Lt
Ant
MV
LCX
N
TV
L
OM
R
RCA
D
PV
C
LAD

Deviated muscular outlet septum LVOTO associated with VSD

- Posterior deviation of septum
  - Resection of subaortic muscle; Ao valve injury
- Anterior deviation of septum