Aortic Valve and Root Anatomy
Heads-Up and Hands-On

William F. Northrup III, M.D.

TSDA Boot Camp
University of North Carolina

Chapel Hill, NC

September 11, 2014

Aortic Root Anatomy
Rationale

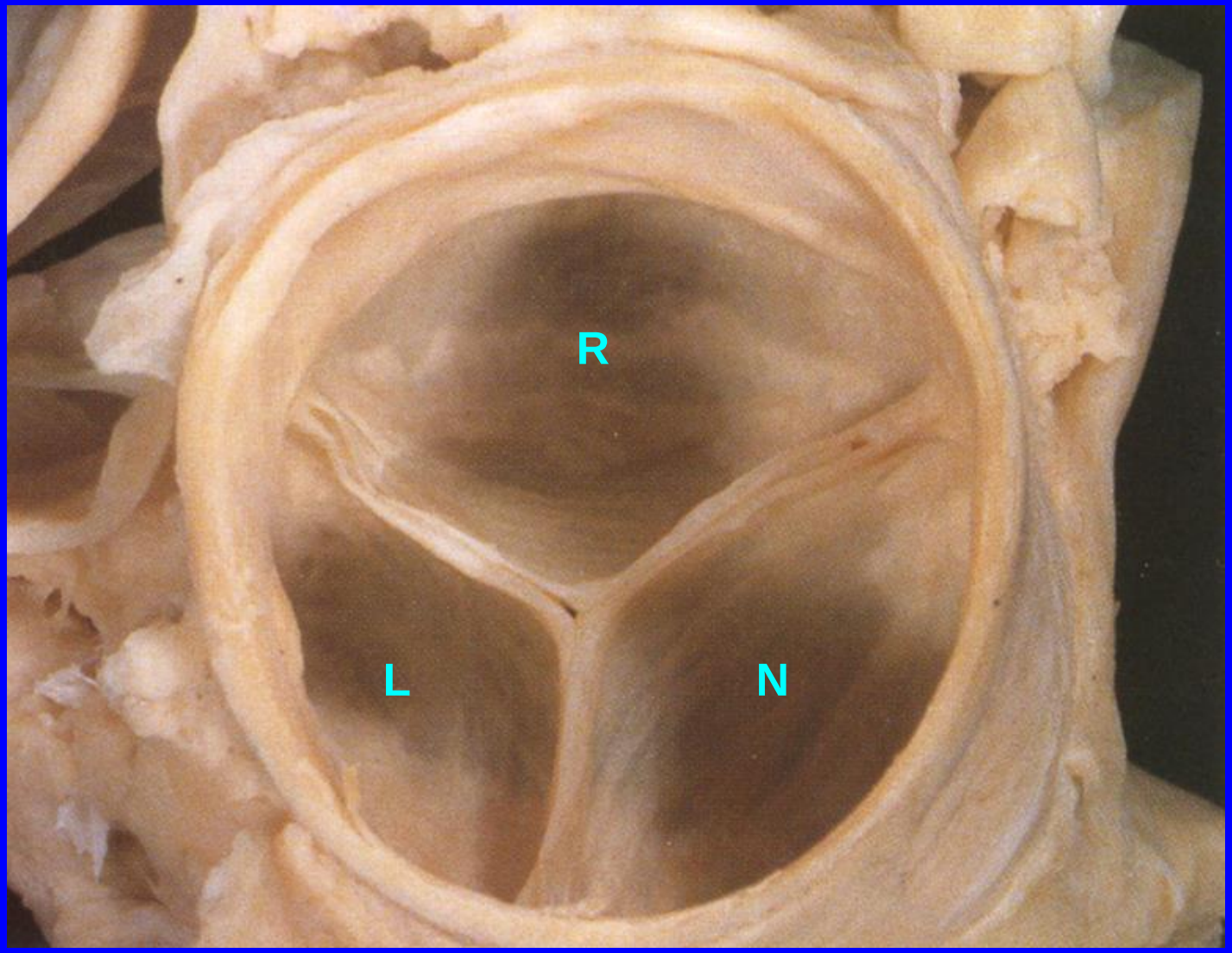
Understanding Cardiac Anatomy: The Prerequisite for Optimal Cardiac Surgery

Robert H. Anderson, MD, and Benson R. Wilcox, MD

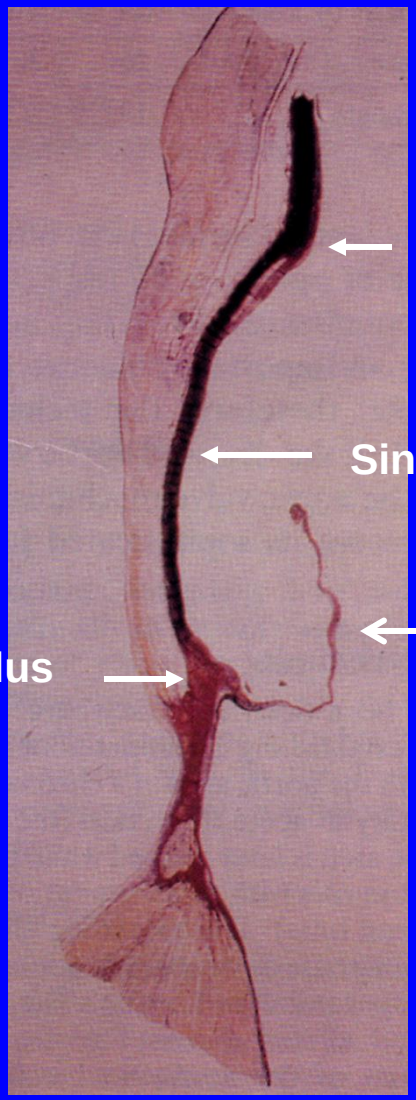
Department of Paediatrics, National Heart & Lung Institute, London, England, and Division of Cardiothoracic Surgery, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Ann Thorac Surg 1995

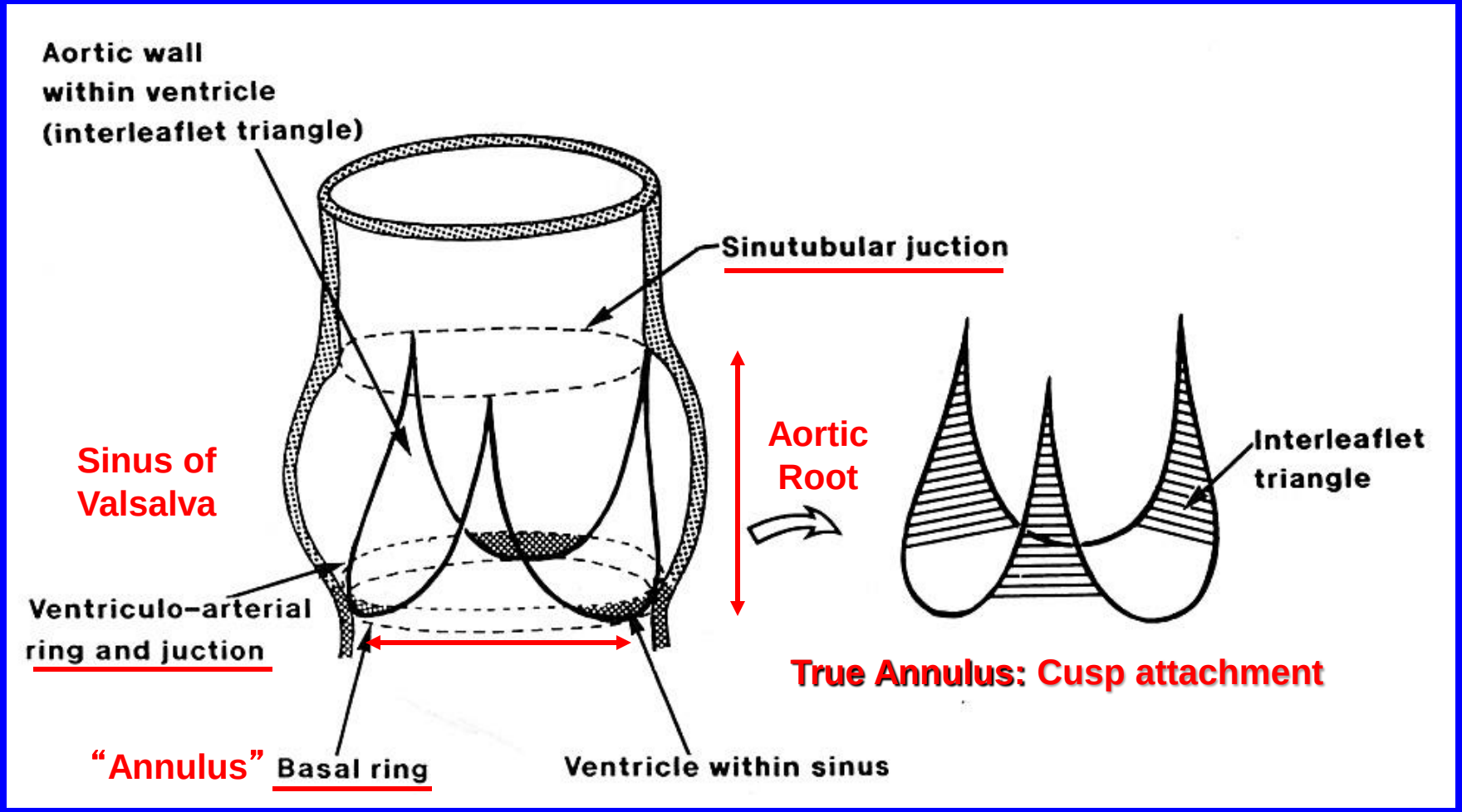
Aortic Valve and Root
Short Axis



Aortic Valve and Root Anatomy
Longitudinal Section



Aortic Root Anatomy

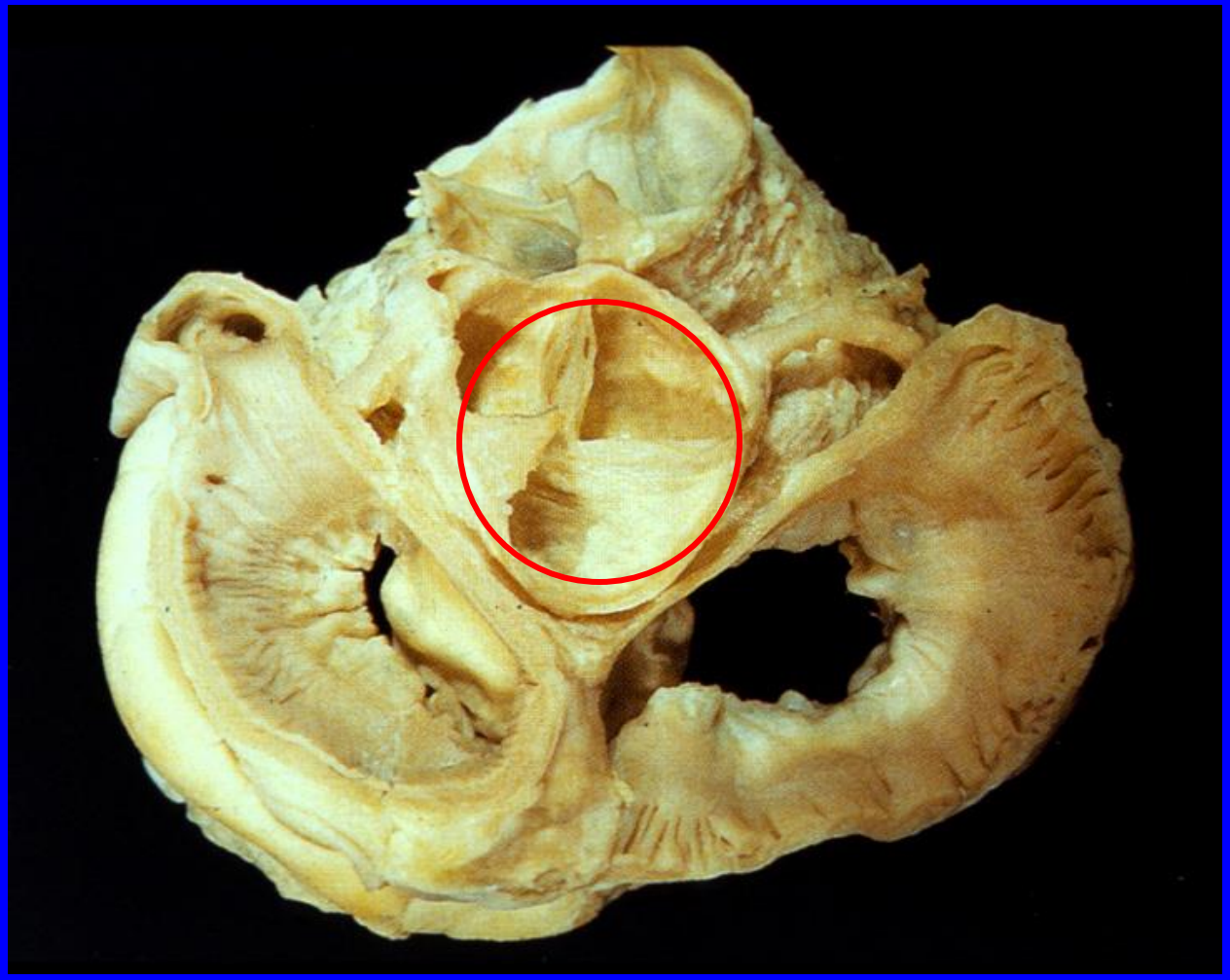


London Group, Ann Thorac Surg 1995

Aortic Root

Is in the *middle* of the heart, surrounded by *everything* else.

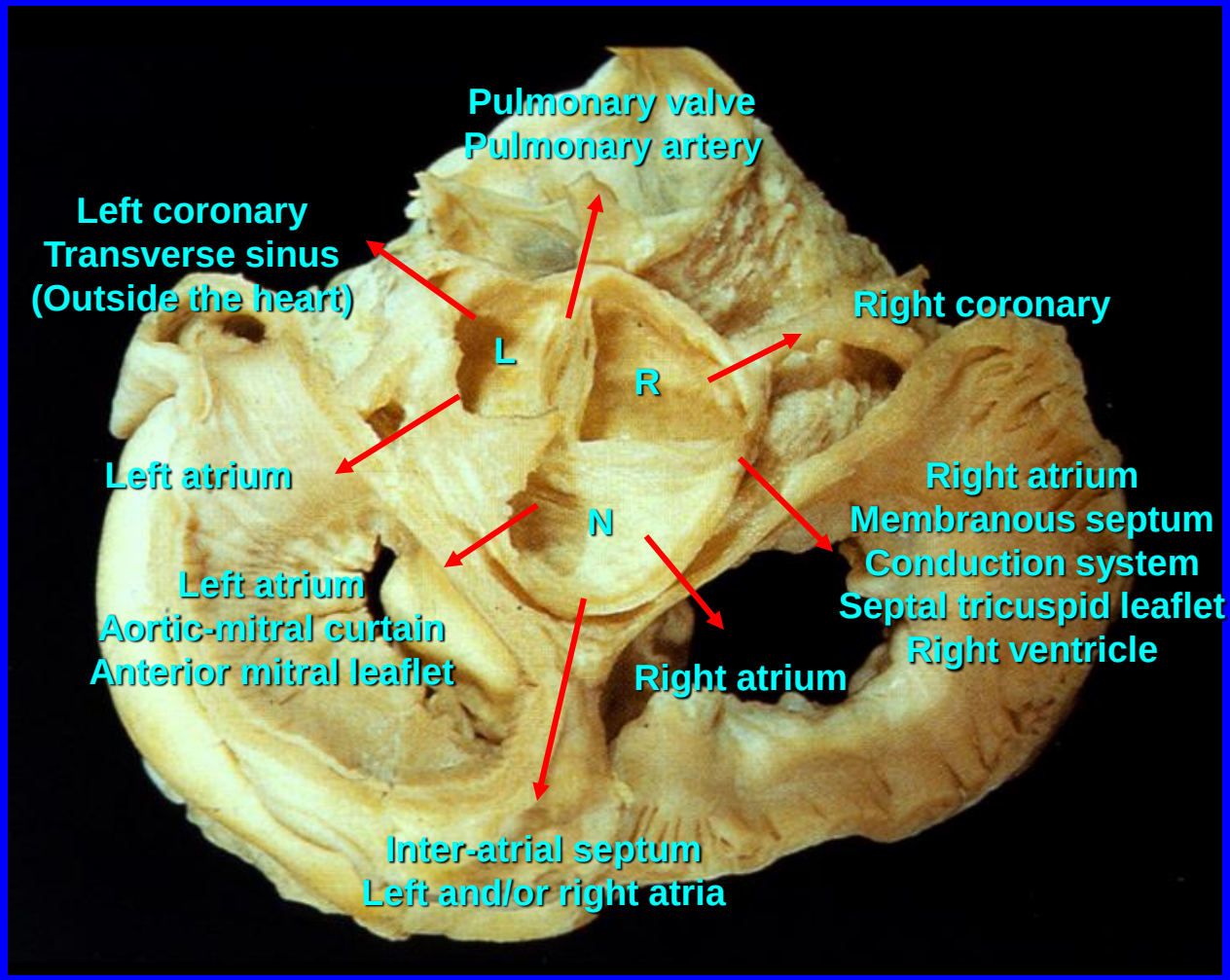
Cardiac Anatomy
Overview of Valves
Aortic Root in the Middle of the Heart



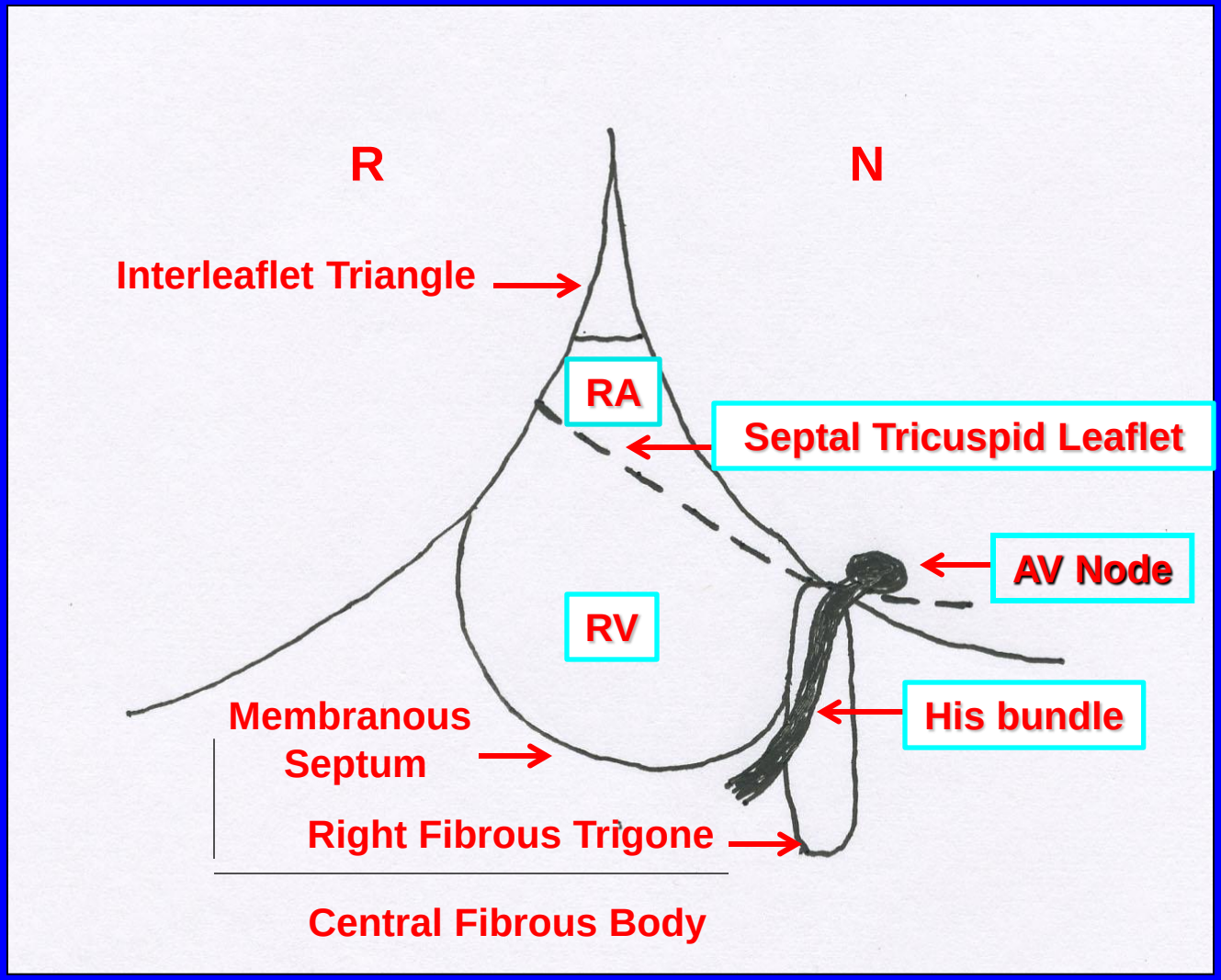
Aortic Root

The Intimate Neighborhood: *Everything* Else

Pathways for Periannular Abscess Penetration



Right-Non Interleaflet Triangle
Endocarditis Collateral Damage Potential



Cardiac Anatomy
Can We "Demystify" Apparent Complexity?

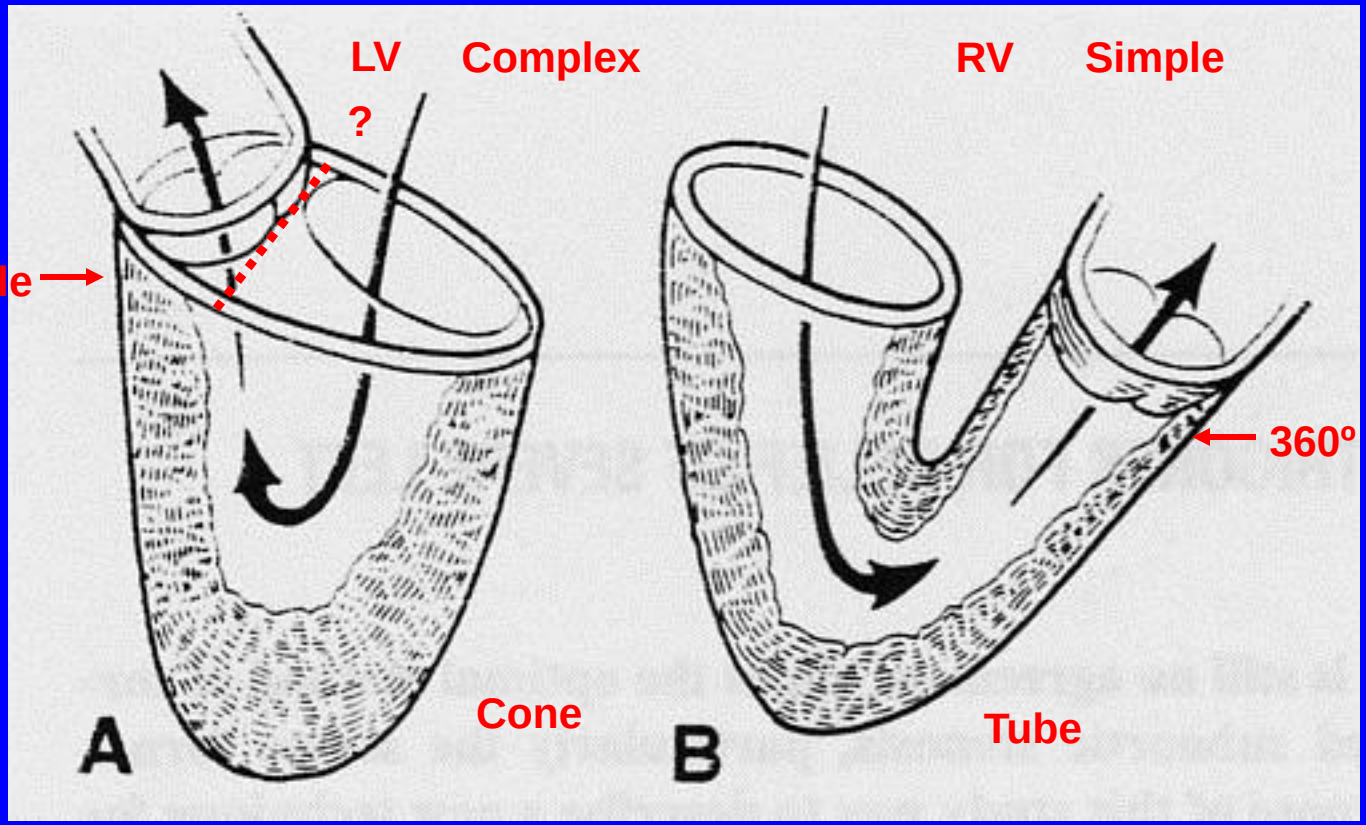
Architecture
Can We "Demystify" Apparent Complexity?

Pont du Gard, Nimes, France, circa 50 A.D., Roman

Architecture
Mystery Solved

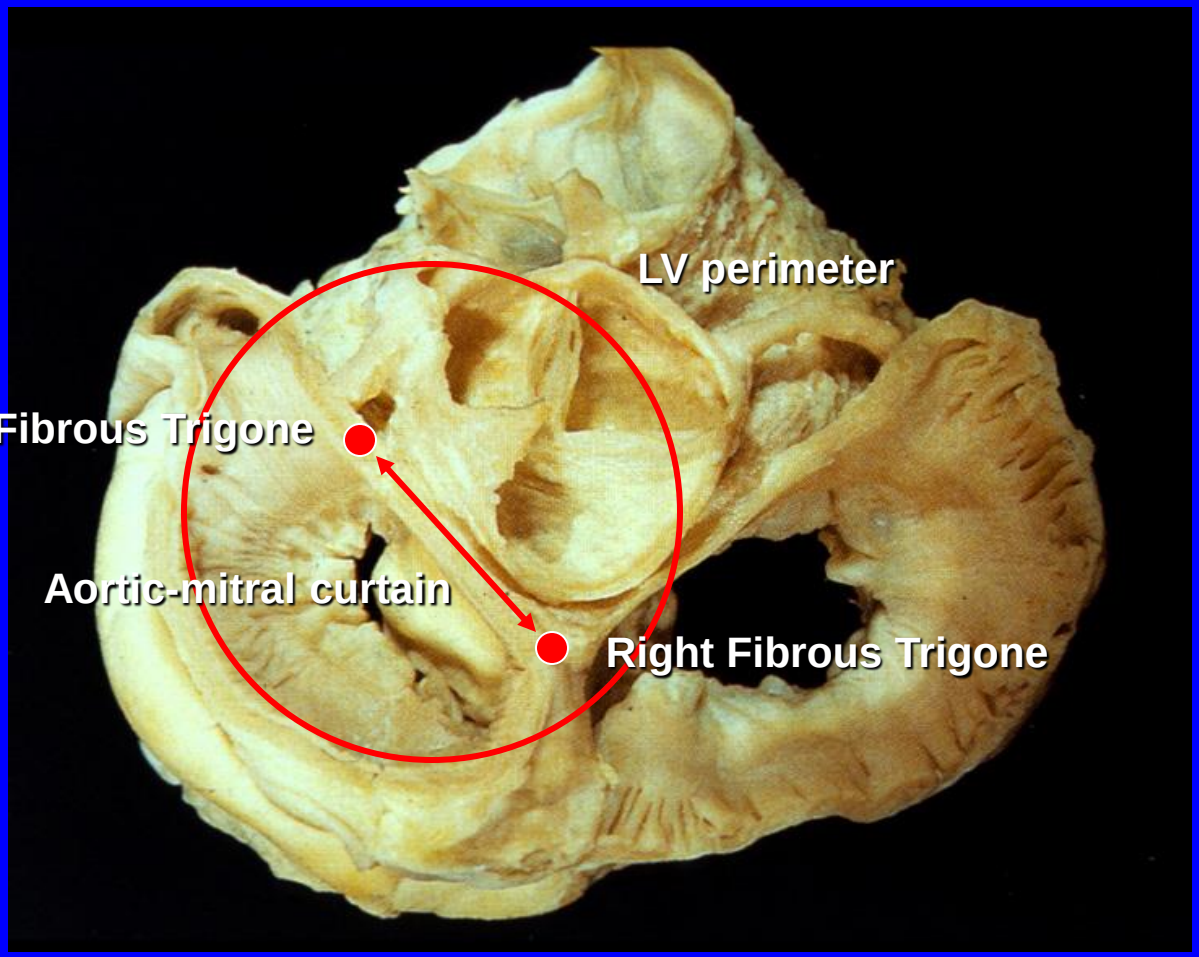
Keystone

Ventricular Anatomy
"Mystery" of the Aortic Root



Yacoub, et al, Ann Thorac Surg 1999

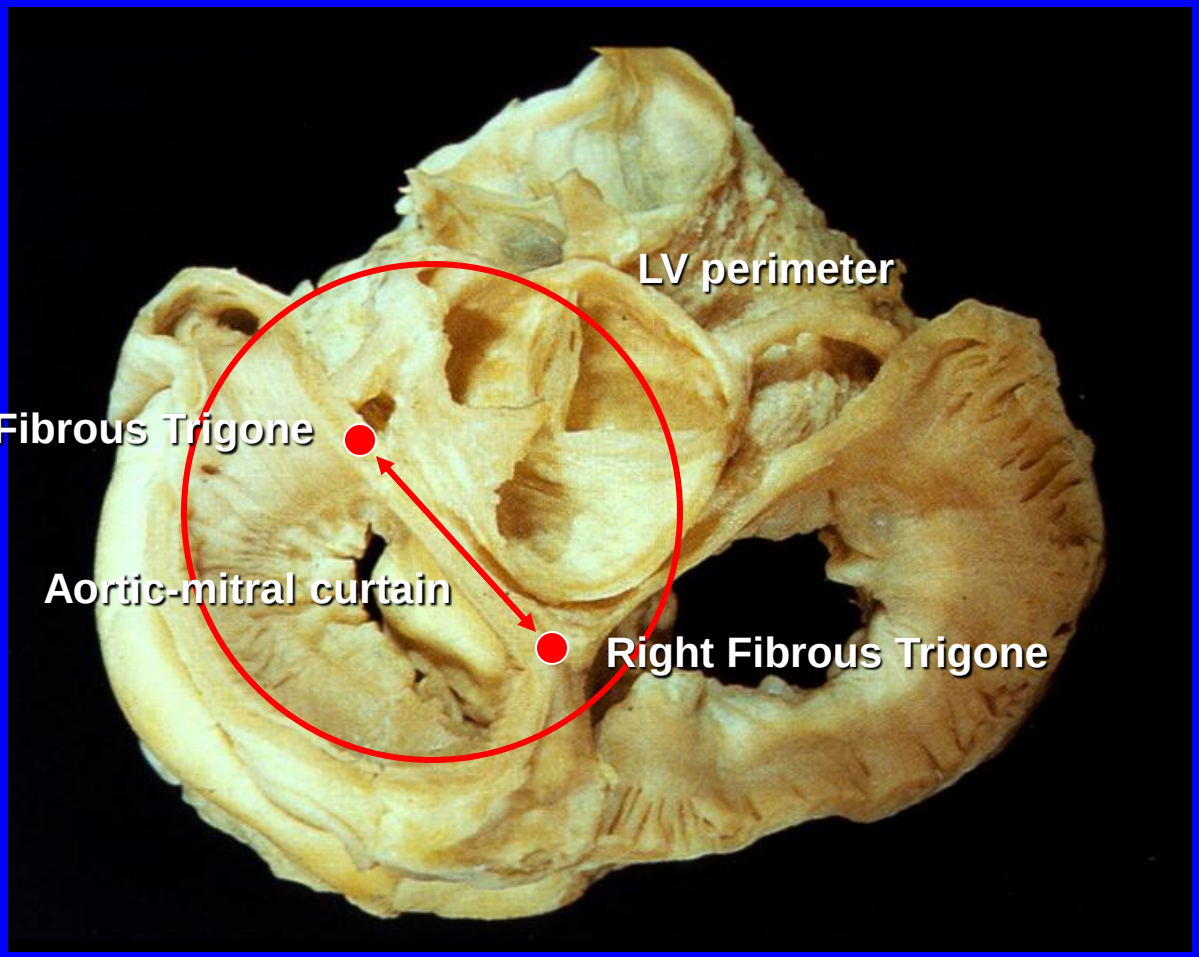
Cardiac Anatomy
"Keystone" of Left Ventricle
Fibrous Trigones and the Aortic-Mitral Curtain



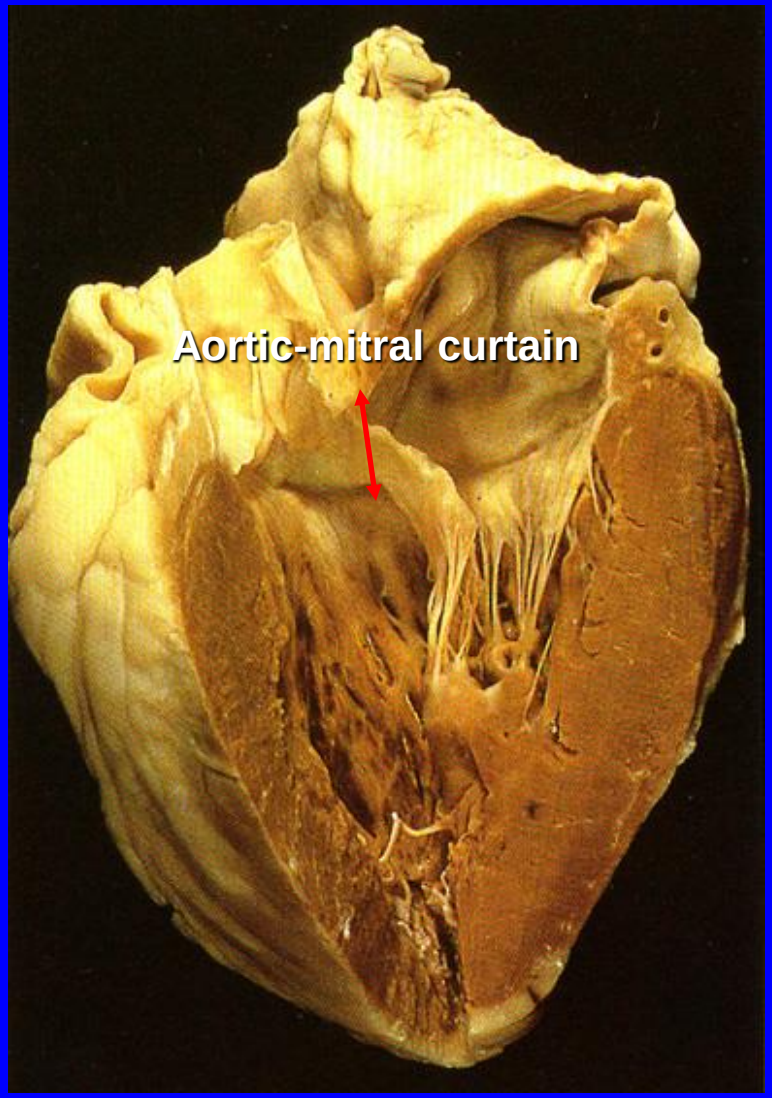
Left Ventricle

Common Orifice for Inflow and Outflow

Separated by the Trigones and Aortic-Mitral Curtain

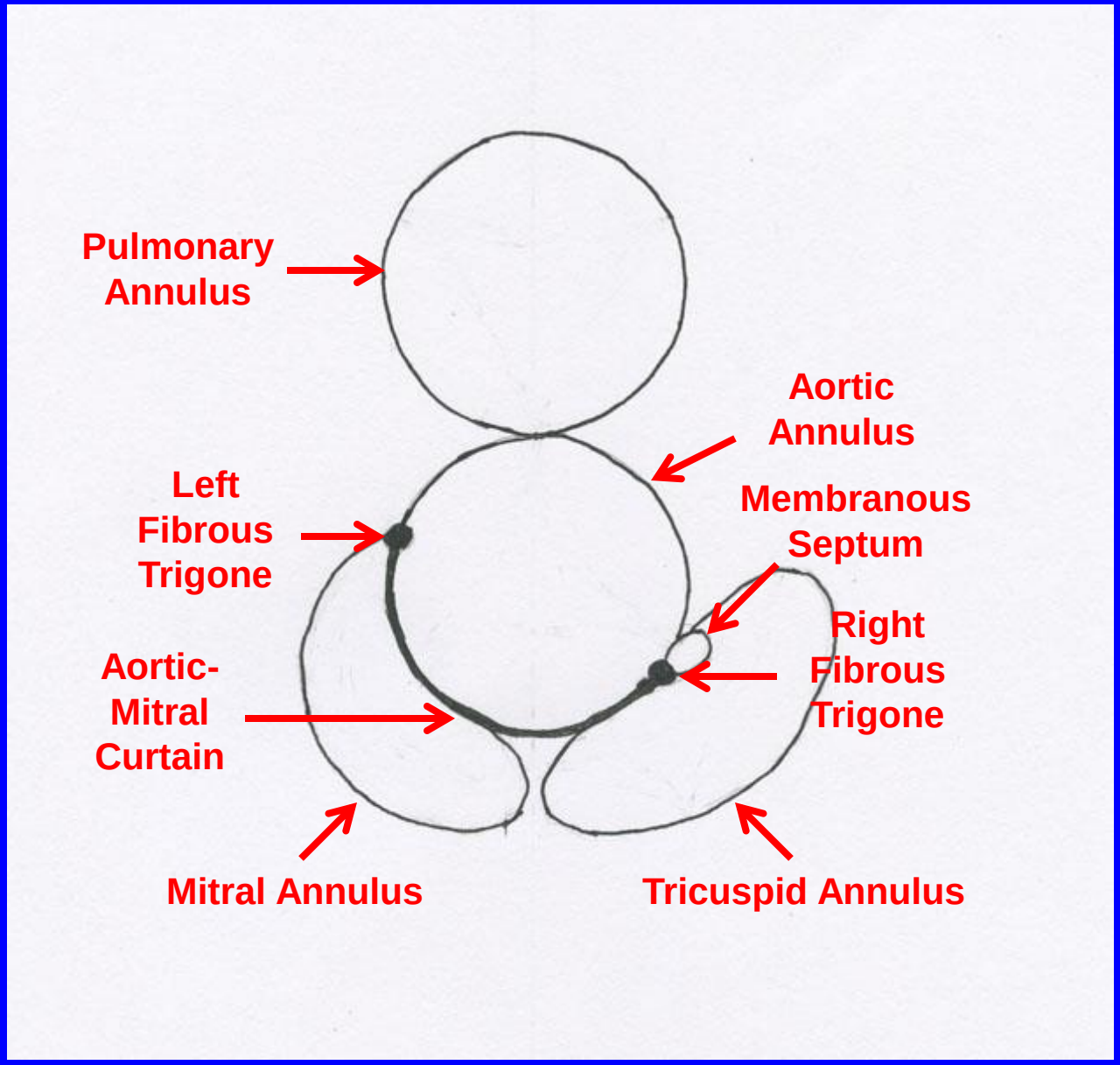


Left Ventricle
Inflow and Outflow: Common Orifice



Left Ventricular Inflow/Outflow
Tennis Court Analogy

Cardiac Skeleton

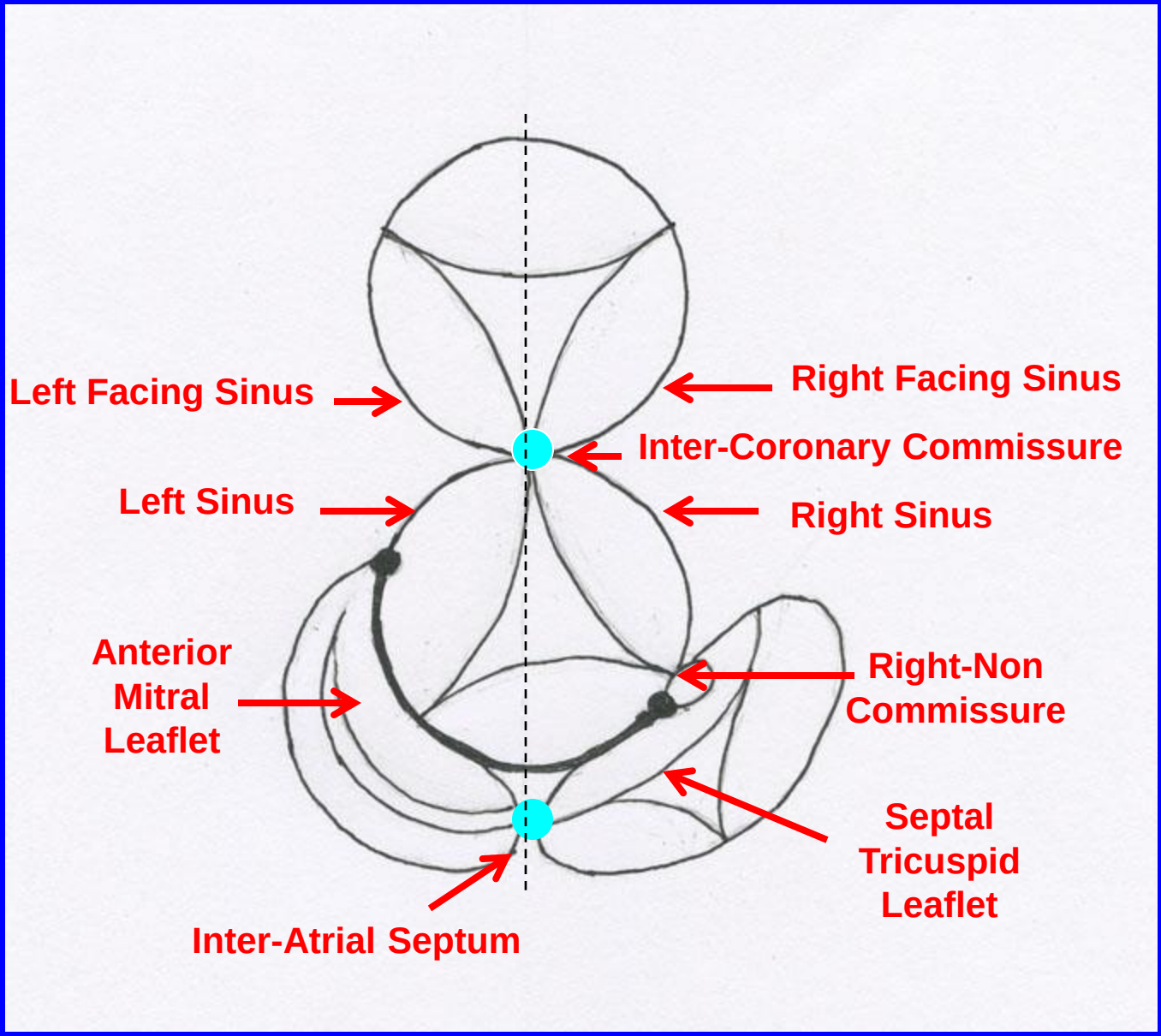


Visualizing Anatomy
Build The “Snowman”

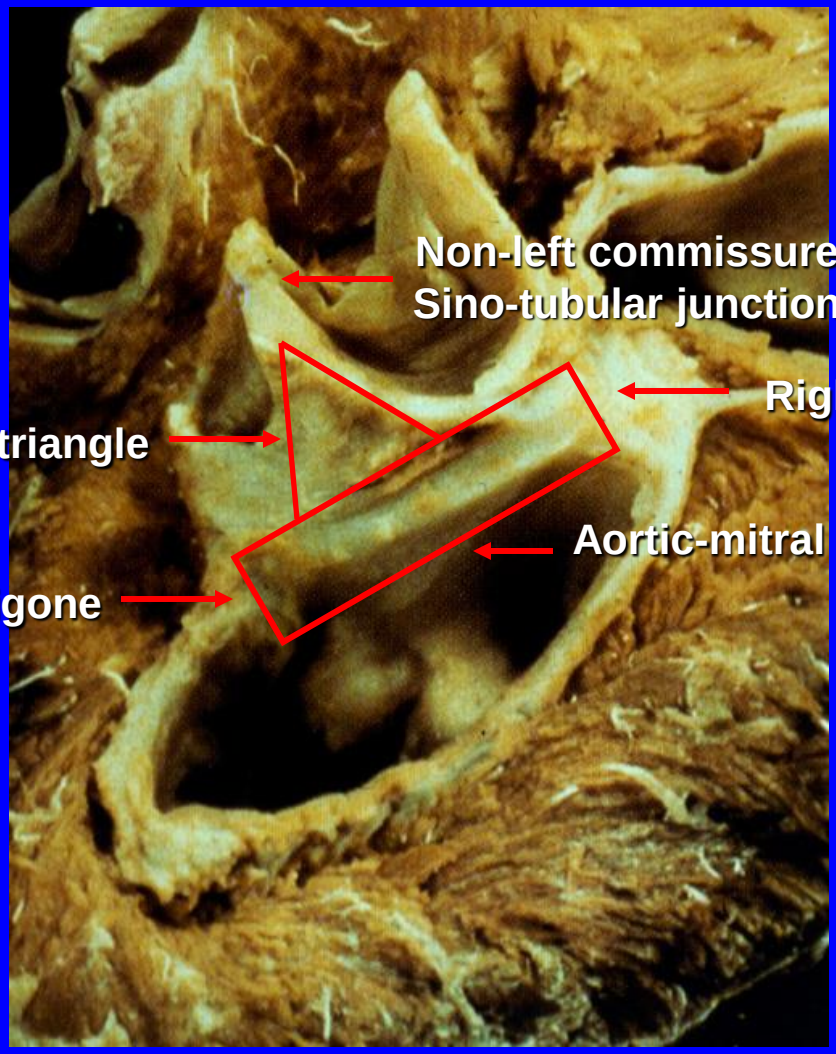
Two reference points:

- **Inter-atrial septum**
- **R/L commissure**

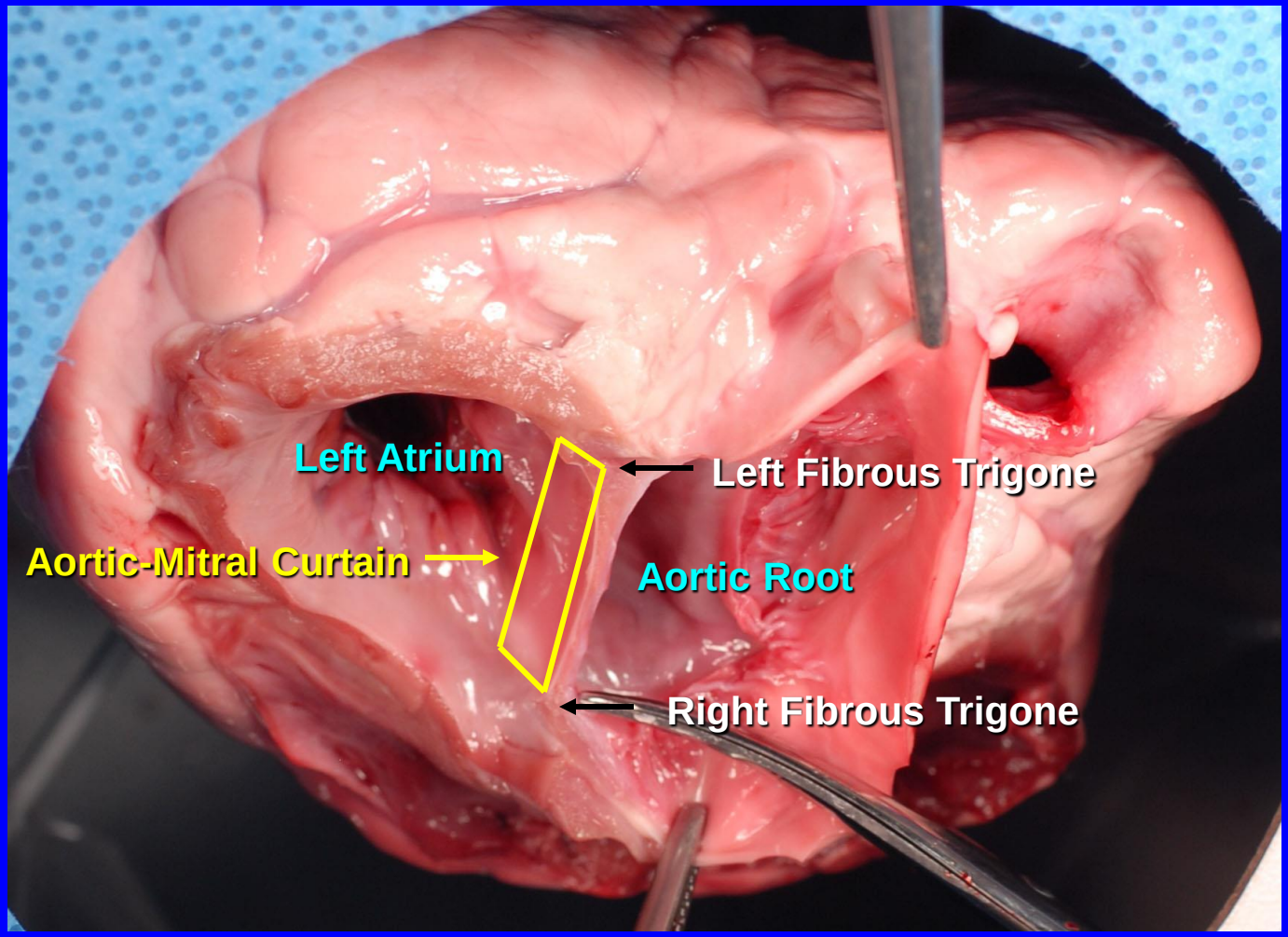
Cardiac Valve Relationships



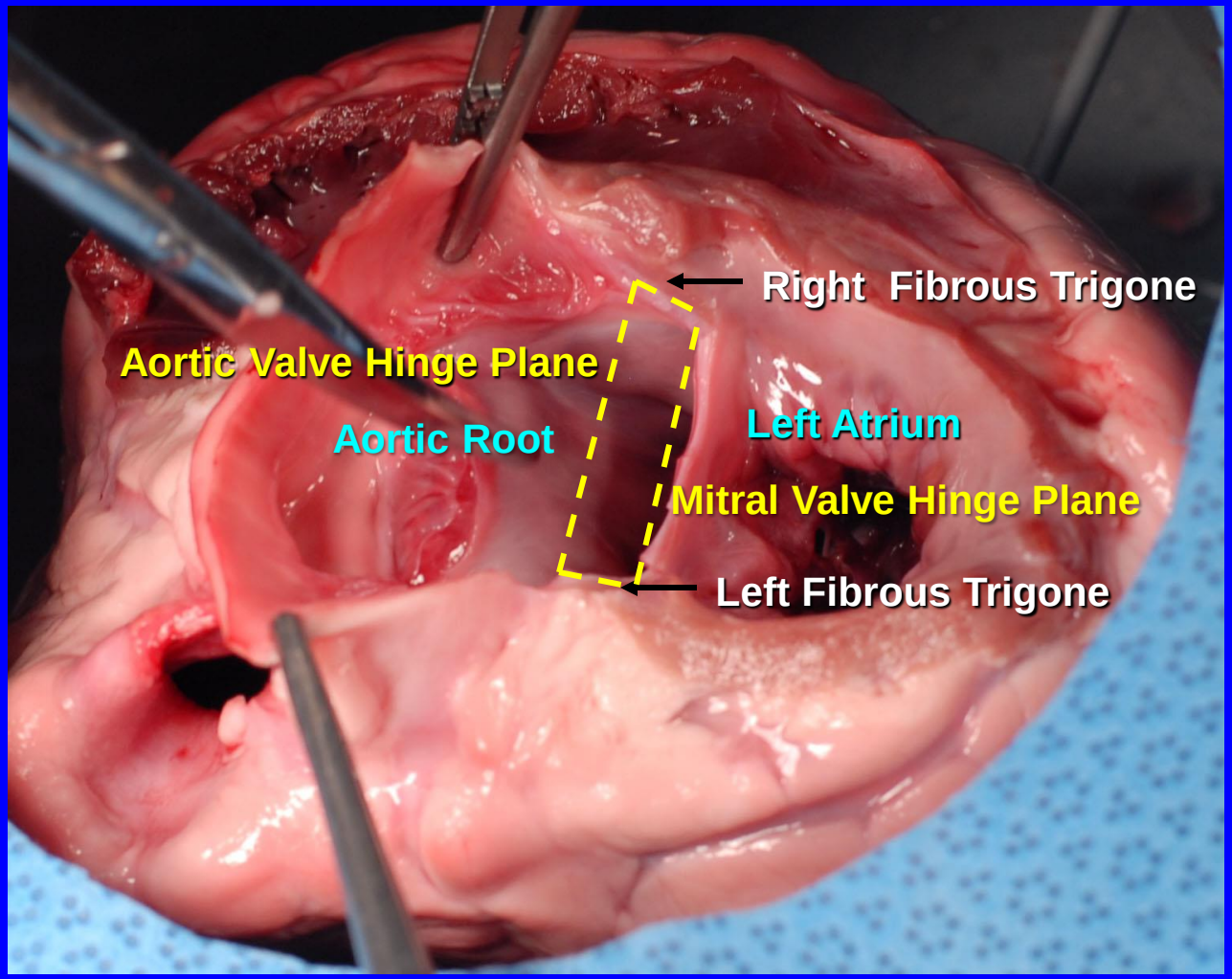
Cardiac Anatomy
Cardiac Skeleton of Aortic, Mitral Valves



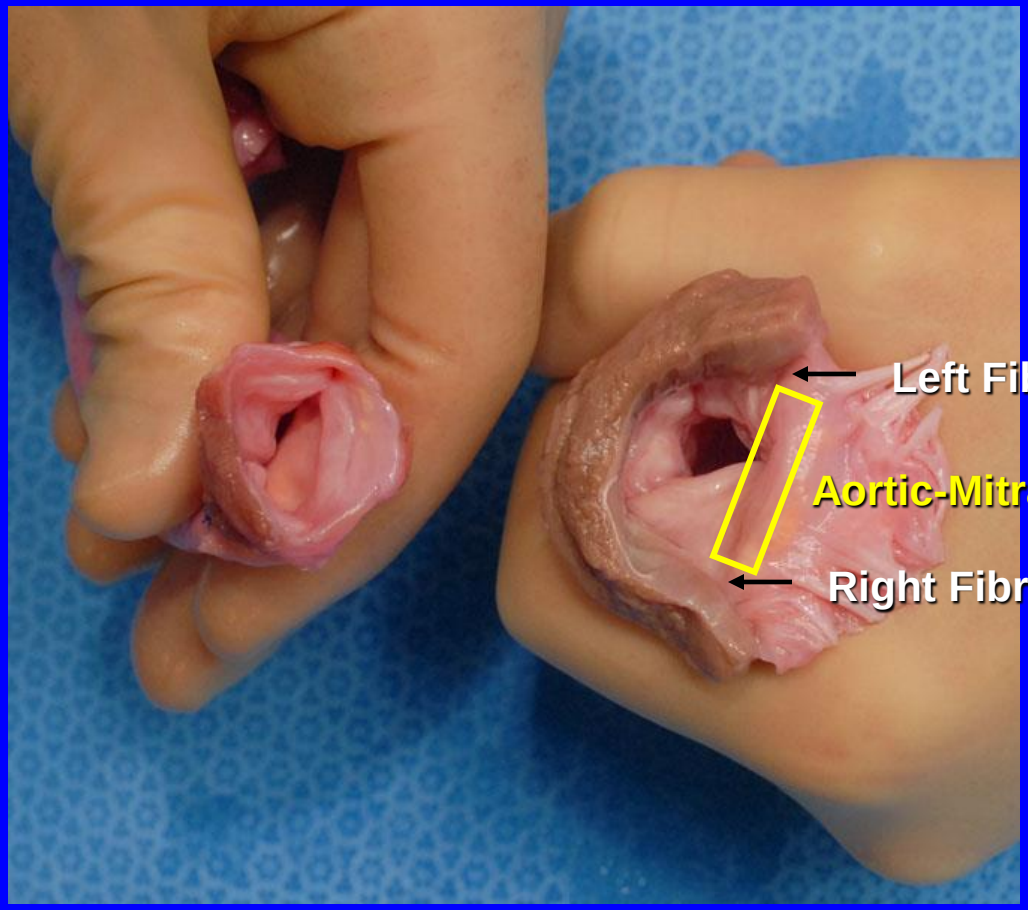
Pig Heart
"High-Fidelity" Biological "Simulator"
Aortic-Mitral Curtain From Outflow Side



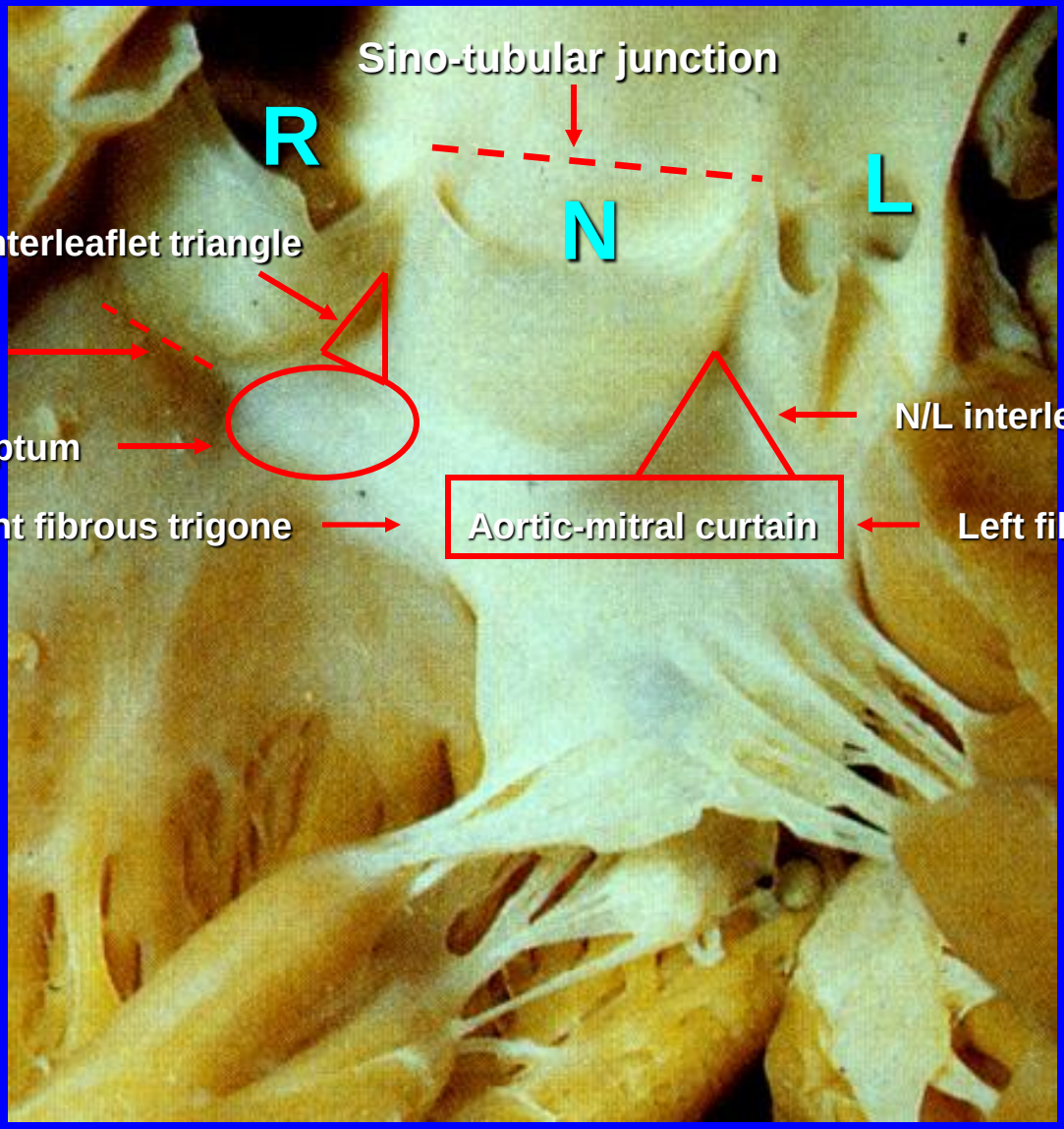
Pig Heart
"High-Fidelity" Biological "Simulator"
Aortic-Mitral Curtain Removed



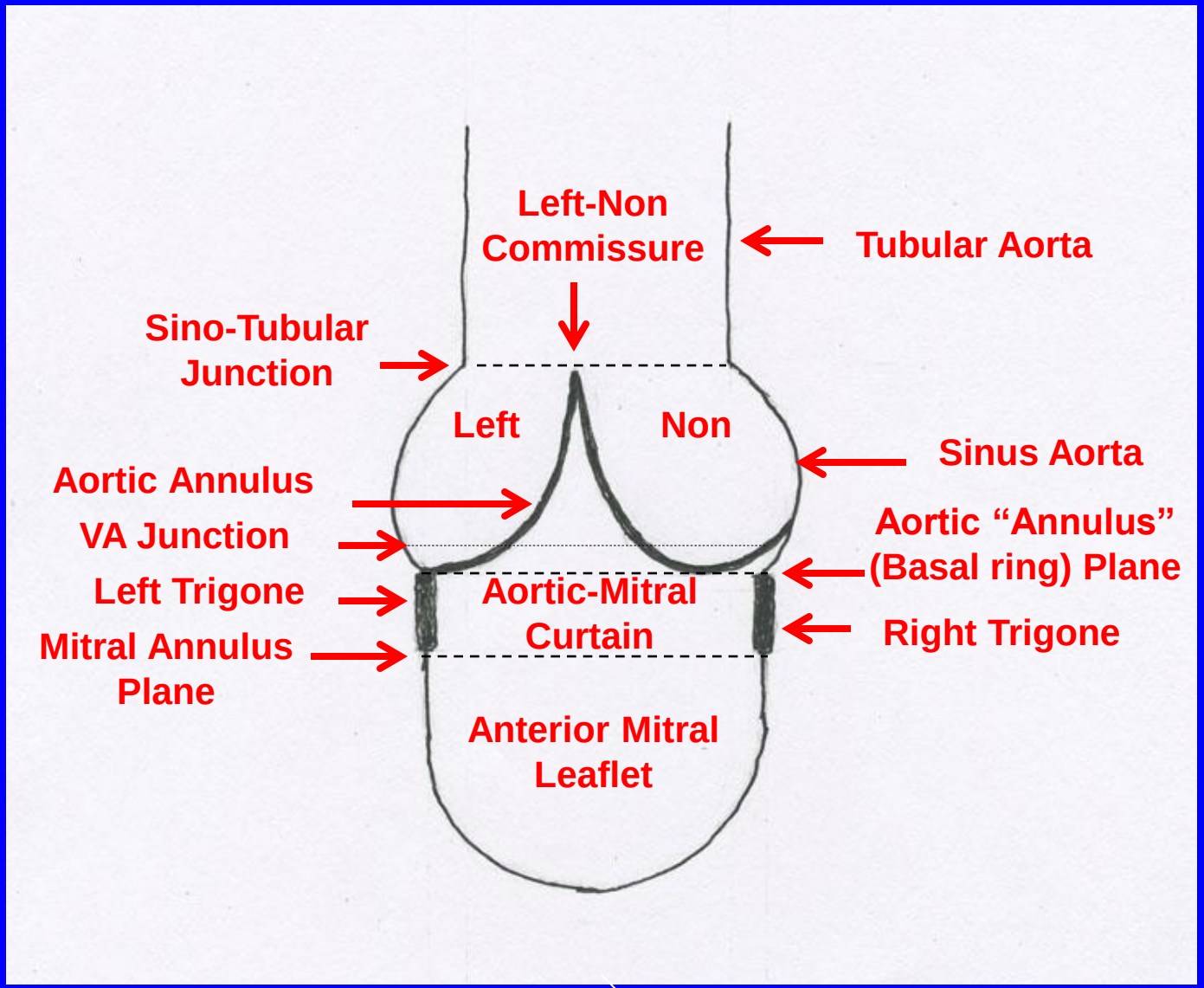
Aortic Allograft
"High-Fidelity" Biological "Simulator"
The Inflow Side Before and After Trimming



Aortic Root Relationships



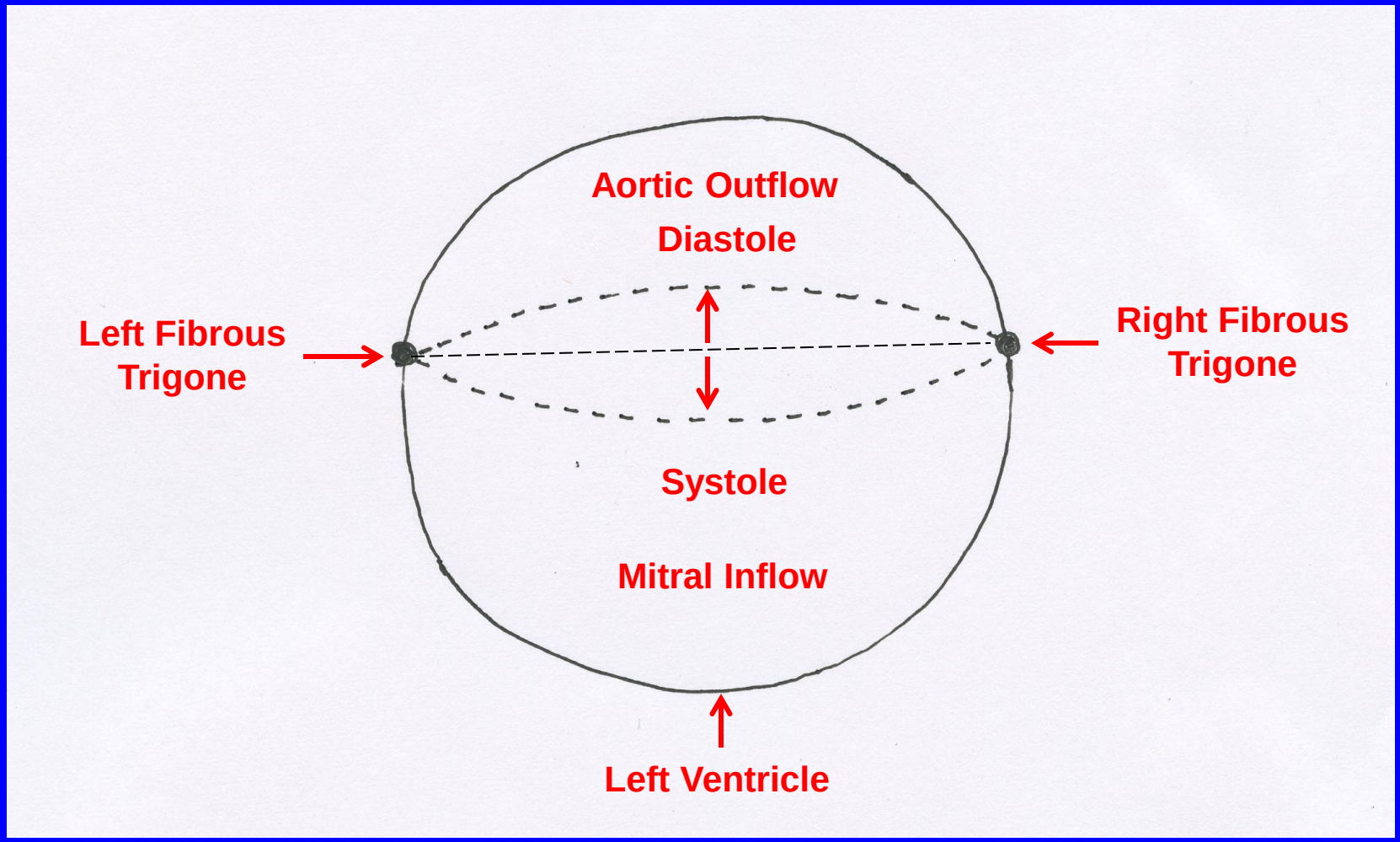
Aortic-Mitral Fibrous Continuity



Aortic-Mitral Curtain
Tennis Net Analogy
(Static)

Aortic-Mitral Curtain
Hammock Analogy
Dynamic Cyclical Deformation

Aortic-Mitral Curtain
Dynamic Physiology



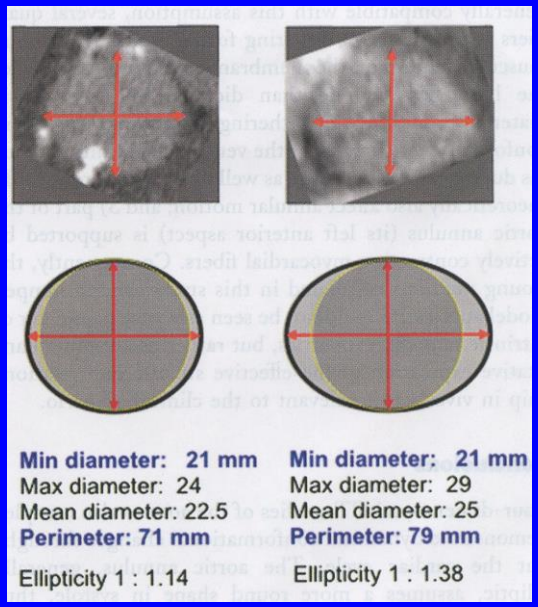
Aortic Annulus

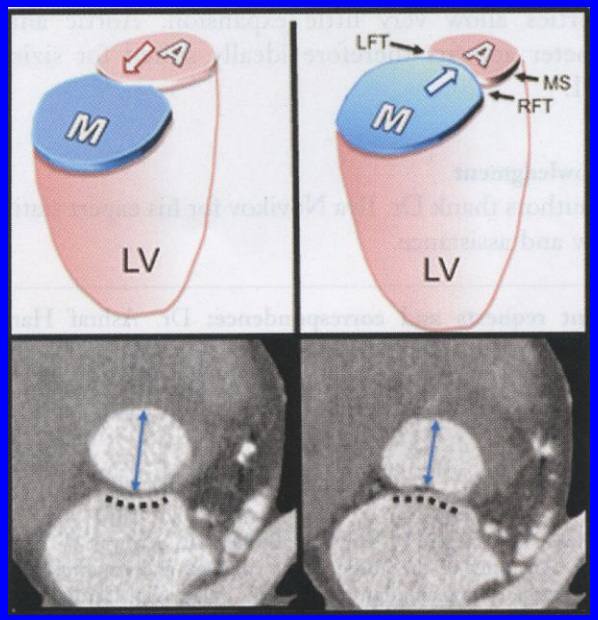
Deformation Dynamics and Mechanical Properties of the Aortic Annulus by 4-Dimensional Computed Tomography

Insights Into the Functional Anatomy of the Aortic Valve Complex and Implications for Transcatheter Aortic Valve Therapy

Ashraf Hamdan, MD,*† Victor Guetta, MD,* Eli Konen, MD,† Orly Goitein, MD,† Amit Segev, MD,* Ehud Raanani, MD,‡ Dan Spiegelstein, MD,‡ Ilan Hay, MD,* Elio Di Segni, MD,*† Michael Eldar, MD,* Ehud Schwammenthal, MD, PHD*

Tel Hashomer, Israel





Elipticity

Deformation

JACC 2012

Aortic-Mitral Curtain
Clothesline Analogy
Suspending Anterior Mitral Leaflet

Aortic-Mitral Curtain
Suspension Bridge Analogy
Cables Support Road (Anterior Mitral Leaflet)

Aortic Annulus

What are the normal dimensions?

Aortic Valve and Root Anatomy
Annulus Diameter

BODY SURFACE AREA AS A PREDICTOR OF AORTIC AND PULMONARY VALVE DIAMETER

Scott B. Capps, MS[a]
Ronald C. Elkins, MD[b]
David M. Fronk, MS[a]

- **Adult male mean aortic valve diameter: 23.1 ± 2.0 mm**
  - **n =2,214**
- **Adult female mean aortic valve diameter: 21.0 ± 1.8 mm**
  - **n=1,156**

J Thorac Cardiovasc Surg 2000

Aortic Valve and Root Anatomy
Normal Annulus Area

BODY SURFACE AREA AS A PREDICTOR OF AORTIC AND PULMONARY VALVE DIAMETER

Scott B. Capps, MS[a]
Ronald C. Elkins, MD[b]
David M. Fronk, MS[a]

Mean indexed aortic valve area:

2.02 ± 0.52 cm^2/m^2

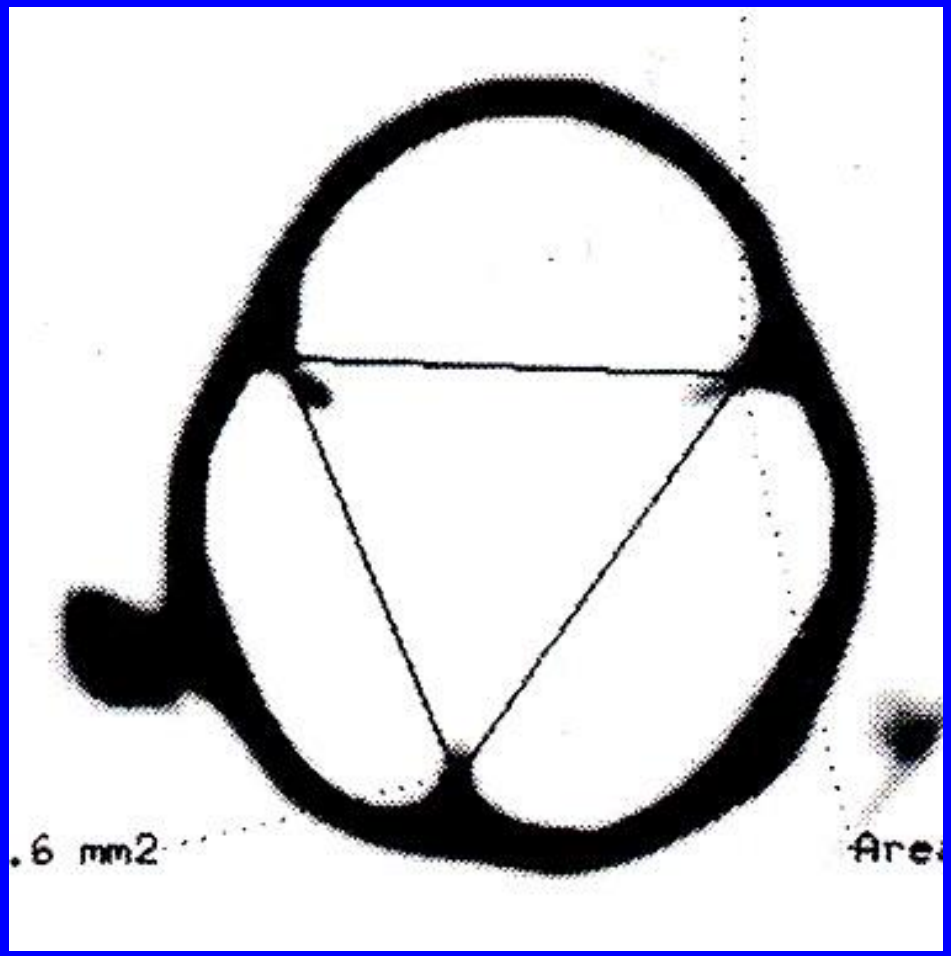
n = 4,636

Minimum: 1.5 cm^2/m^2

J Thorac Cardiovasc Surg 2000

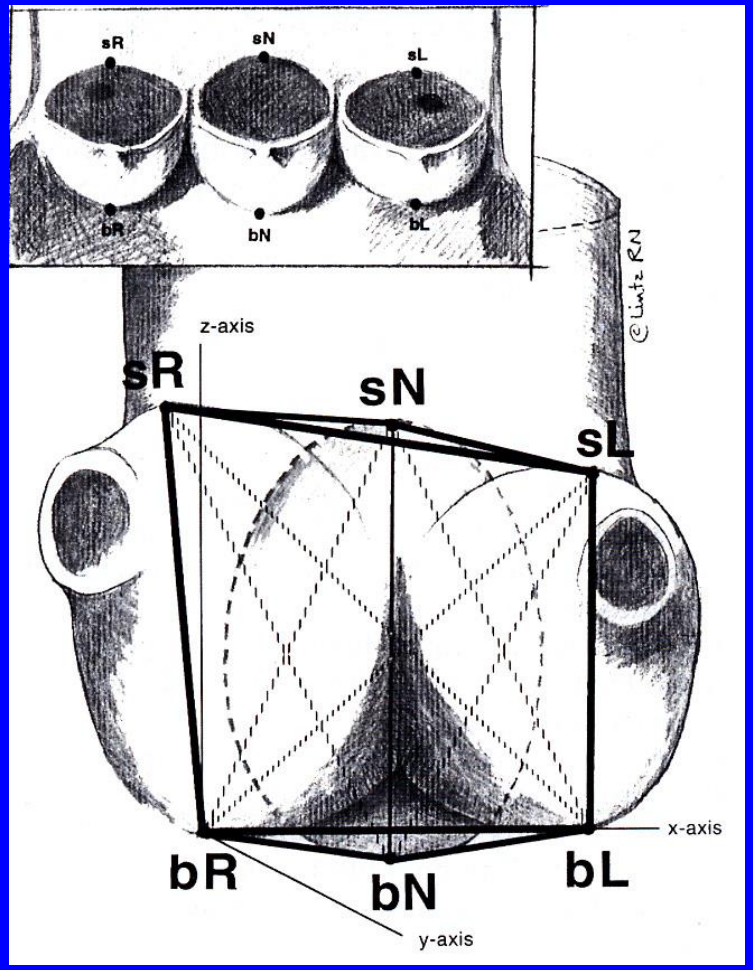
Aortic Root Anatomy
Sinus Symmetry?

Aortic Valve and Root Anatomy
Circumferential Asymmetry



Duran Group, J Heart Valve Dis 1999

Aortic Valve and Root Anatomy
Longitudinal Asymmetry



Duran Group, J Heart Valve Dis 1999

Aortic Valve and Root Surgery

What is the relevance of the anatomy ?

Aortic Root Surgery
Expected Mismatches
New Root (Valve, Graft) vs. Old Root (Patient)

Sinus dimensions

Annulus diameters

Coronary positions

All Aortic Root and Valve Replacements

One Fact

Must Be Remembered!

Sinus dimensions of the new root and valve replace those of the old root.

Except:

Valve-sparing aortic replacements:
Graft fits valve (vs. Valve fits graft)

Aortic Valve and Root Surgery
Two Critical Position Mistakes
Must be Avoided!

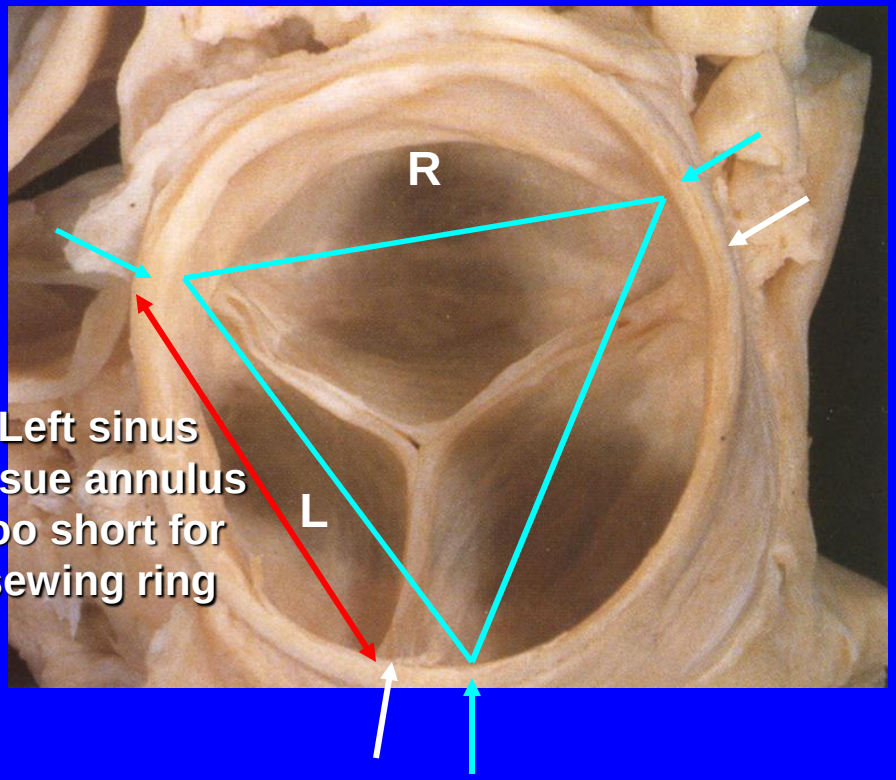
1. **Valve or Graft Position Problem:**
Patient's coronary on commissure or strut (misaligned circumferential orientation)

2. Coronary Position Problem with Graft:
Patient' s coronary misaligned or moved (out of its original position, axis)

Aortic Valve and Root Surgery

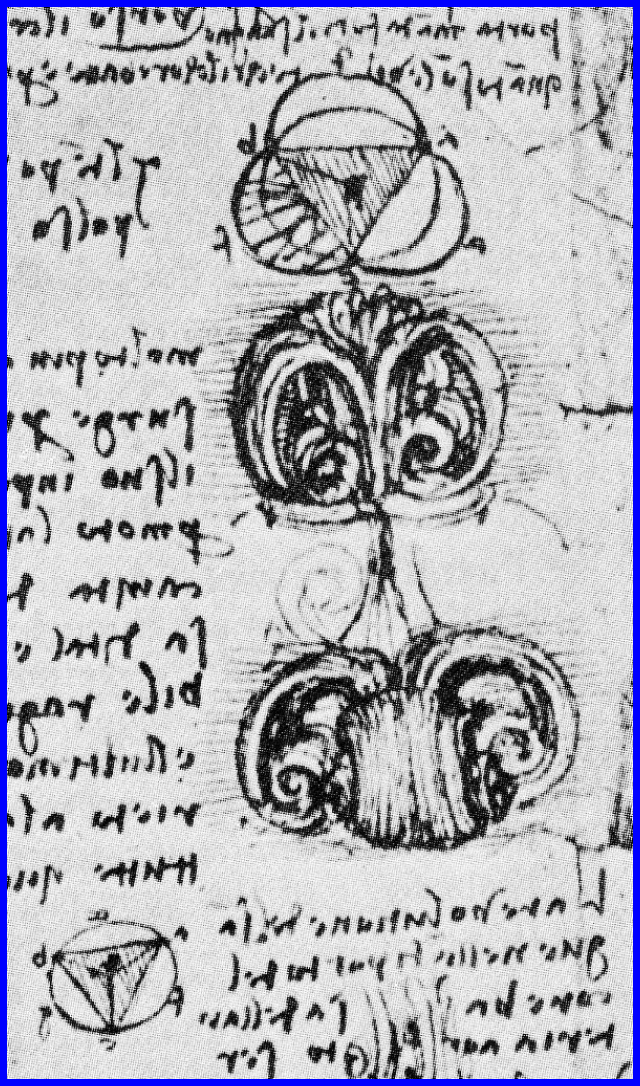
Complex reconstructions
(e.g., in extensive endocarditis)
would be impossible
without a clear understanding
of the anatomy.

Aortic Valve Replacement
Symmetrical Prosthesis in Asymmetrical Root
Be Careful With Triangulation!



Use symmetrical valve-sizer for “commissural” suture sites

Thank You



Leonardo da Vinci, Aortic Sinus Vortices, ca. 1513