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

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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
Aortic Valve and Root
Short Axis
Aortic Valve and Root Anatomy
Longitudinal Section

- Sino-tubular junction
- Sinus of Valsalva
- Annulus
- Aortic valve cusp
Aortic Root Anatomy

Aortic wall within ventricle (interleaflet triangle)

Sinus of Valsalva

Ventriculo-arterial ring and junction

“Annulus” Basal ring

Ventricle within sinus

Sinutubular junction

Aortic Root

True Annulus: Cusp attachment

Interleaflet triangle

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

Interleaflet Triangle
Septal Tricuspid Leaflet
Membranous Septum
Right Fibrous Trigone
Central Fibrous Body
AV Node
His bundle
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

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

Aortic-mitral curtain
Left Ventricular Inflow/Outflow Tennis Court Analogy

- Aortic Valve
- Mitral Valve
- Aortic-Mitral Curtain
- Trigone
Cardiac Skeleton

- Pulmonary Annulus
- Left Fibrous Trigone
- Aortic-Mitral Curtain
- Mitral Annulus
- Aortic Annulus
- Membranous Septum
- Right Fibrous Trigone
- Tricuspid Annulus
Visualizing Anatomy
Build The “Snowman”

Two reference points:

Inter-atrial septum

R/L commissure
Cardiac Anatomy
Cardiac Skeleton of Aortic, Mitral Valves

- Non-left commissure
- Sino-tubular junction
- Right fibrous trigone
- Aortic-mitral curtain
- Non-Left interleaflet triangle
- Left fibrous trigone
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

Left Fibrous Trigone
Aortic-Mitral Curtain
Right Fibrous Trigone
Aortic Root Relationships

- Aortic-mitral curtain
- Membranous septum
- R/N interleaflet triangle
- R/N interleaflet triangle
- Basal ring “Annulus”
- N/L interleaflet triangle
- Left fibrous trigone
- Right fibrous trigone
- Sino-tubular junction

Diagram labels include:
- R (right)
- N (non)
- L (left)
Aortic-Mitral Fibrous Continuity

- Sino-Tubular Junction
- Aortic Annulus
- VA Junction
- Left Trigone
- Mitral Annulus Plane
- Aortic-Mitral Curtain
- Anterior Mitral Leaflet
- Left-Non Commissure
- Tubular Aorta
- Sinus Aorta
- Aortic “Annulus” (Basal ring) Plane
- Right Trigone
Aortic-Mitral Curtain
Tennis Net Analogy
(Static)
Aortic-Mitral Curtain
Hammock Analogy
Dynamic Cyclical Deformation
Aortic-Mitral Curtain
Dynamic Physiology

Aortic Outflow
Diastole

Systole

Mitral Inflow

Left Fibrous Trigone

Right Fibrous Trigone

Left Ventricle
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 Raanan, MD,‡ Dan Spiegelstein, MD,‡ Ilan Hay, MD,* Elio Di Segni, MD,* † Michael Eldar, MD,* Ehud Schwammenthal, MD, PhD*

Tel Hashomer, Israel

Elipticity  Deformation

Min diameter: 21 mm
Max diameter: 24
Mean diameter: 22.5
Perimeter: 71 mm
Ellipticity: 1:1.14

Min diameter: 21 mm
Max diameter: 29
Mean diameter: 25
Perimeter: 79 mm
Ellipticity: 1:1.38
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
Ronald C. Elkins, MD
David M. Fronk, MS

- **Adult male mean aortic valve diameter:**
  - \( 23.1 \pm 2.0 \text{ mm} \)
  - \( n = 2,214 \)

- **Adult female mean aortic valve diameter:**
  - \( 21.0 \pm 1.8 \text{ mm} \)
  - \( n = 1,156 \)

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
Ronald C. Elkins, MD
David M. Fronk, MS

Mean indexed aortic valve area: 2.02 ± 0.52 cm²/m²
n = 4,636

Minimum: 1.5 cm²/m²

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

Left sinus tissue annulus too short for sewing ring
Thank You

Leonardo da Vinci, Aortic Sinus Vortices, ca. 1513