Aortic Valve and Root Anatomy
The Platform For All Aortic Root Surgery

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TSDA Boot Camp

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Aortic Valve and Root
Short Axis
Aortic Valve Cusp Layers

- Fibrosa
- Corrugations
- Spongiosa
- Ventricularis
- Normal Thickness
Aortic Valve Cusp
Collagen and Elastin Function

Editorial:
Aortic Valve Structure-Function Correlations: Role of Elastic Fibers no Longer a Stretch of the Imagination
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The Journal of Heart Valve Disease 1997;6:1-6
Aortic Root Anatomy

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
In the Middle of the Heart
“Lovefest” With Everything Else
Aortic Root
The Intimate Neighborhood: Everything Else
Pathways for Periannular Abscess Penetration
Right-Non Interleaflet Triangle
Endocarditis Collateral Damage Potential

Interleaflet Triangle
Membranous Septum
Septal Tricuspid Leaflet
His bundle
Right Fibrous Trigone
Central Fibrous Body
RA
RV
AV Node
Visualizing Anatomy
Build The “Snowman”
With An Hourglass

Two reference points:

Inter-atrial septum

R/L comissure
Cardiac Valve Relationships

- Left Sinus
- Right Sinus
- Inter-Atrial Septum
- Inter-Coronary Commissure
- Right-Non Commissure
- Septal Tricuspid Leaflet
- Anterior Mitral Leaflet

Left Facing Sinus → Right Facing Sinus
Left Sinus → Right Sinus
Anterior Mitral Leaflet → Right-Non Commissure
Inter-Atrial Septum
Ventricular Anatomy
“Mystery” of the Aortic Root

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
Aortic-Mitral Fibrous Continuity

- Sino-Tubular Junction
- Aortic Annulus
- VA Junction
- Left Trigone
- Mitral Annulus Plane
- Left-Non Commissure
- Non
- Aortic-Mitral Curtain
- Anterior Mitral Leaflet
- Tubular Aorta
- Sinus Aorta
- Aortic “Annulus” (Basal ring) Plane
- Right Trigone
Aortic Root
Changing Shape With Age

Child, young adult
Isosceles trapezoid

Older adult
Square
Cardiac Anatomy
Cardiac Skeleton of Aortic, Mitral Valves

Non-left commissure
Sino-tubular junction

Right fibrous trigone

Non-Left interleaflet triangle

Aortic-mitral curtain

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-Mitral Curtain Replaced Commando: Folded Bovine Pericardial Patch

- Aortic Patch
- Aortic Annular Plane
- Left Fibrous Trigone
- Right Fibrous Trigone
- Mitral Annular Plane
- Open Left Atrium
- Left Atrial Patch
Aortic-Mitral Curtain Replaced
Folded Bovine Pericardial Patch
Mitral Annulus Suture Placement

Left Fibrous Trigone

Aortic Annular Plane

Mitral Annular Plane

Preserved Posterior Mitral Leaflet

Right Fibrous Trigone

Left Atrium
Aortic-Mitral Curtain Replaced
Commando: Folded Bovine Pericardial Patch
Mitral Inflow and Aortic Outflow

Left Coronary Ostium  Left-Right Commissure
Aorta
Aortic Annular Plane
LVOT
Right Coronary Ostium

Left Atrium
Aortic Allograft in Hemi-Commando “Simulated” Endocarditis

Repair of Excavated Anterior Mitral Leaflet (AML)

Northrup WF III, Ann Thorac Surg 2010
Aortic Allograft
“High-Fidelity” Biological “Simulator”
The Inflow Side Before and After Trimming

Left Fibrous Trigone
Aortic-Mitral Curtain
Right Fibrous 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 Ventricle
  - Left Fibrous Trigone
  - Right Fibrous Trigone
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

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Elipticity

JACC 2012

Deformation
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 ± 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

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 With Coronaries Must be Avoided!

1. Valve or Graft Position Problem:
   Coronary opposite commissure or strut (misaligned circumferential orientation)

2. Coronary Position Problem on Graft:
   Coronary misaligned or moved (out of its original position, axis)
Aortic Valve and Root Surgery
Why Should I Know Anatomy?

Simple operations can go badly.

Complex reconstructions (e.g., in extensive endocarditis) would be impossible.
Aortic Valve Replacement
Symmetrical Prosthesis in Asymmetrical Root
Be Careful With Carrel Triangulation!

Use symmetrical valve-sizer for “commissural” suture sites
Thank You

Leonardo da Vinci, Aortic Sinus Vortices, ca. 1513