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

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TSDA Boot Camp

September 13, 2018
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
Frederick J. Schoen

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The Journal of Heart Valve Disease 1997;6:1-6
Aortic Root Anatomy

Aortic wall within ventricle (interleaflet triangle)

Sinus of Valsalva

Ventriculo-arterial ring and junction

“Annulus” Basal ring

Ventricle within sinus

Aortic Root

Sinutubular junction

True Annulus: Cusp attachment

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

- Left atrium
- Right atrium
- Aortic-mitral curtain
- Septal tricuspid leaflet
- Right coronary
- Left coronary
- Transverse sinus (Outside the heart)
- Conduction system
- Membranous septum
- Pulmonary valve
- Pulmonary artery
- Left and/or right atria
- Inter-atrial septum
Right-Non Interleaflet Triangle
Endocarditis Collateral Damage Potential
Visualizing Anatomy
Build The “Snowman”
With An Hourglass

Two reference points:

Inter-atrial septum

R/L commissure
Cardiac Valve Relationships

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

“Mystery” of the Aortic Root

Left Ventricle

Common Orifice for Inflow and Outflow
Separated by the Trigones and Aortic-Mitral Curtain

- Left Fibrous Trigone
- Right Fibrous Trigone
- Aortic-mitral curtain
- LV perimeter
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

Mitral Valve
Trigone
Aortic-Mitral Fibrous Continuity

- Sino-Tubular Junction
- Aortic Annulus
- VA Junction
- Left Trigone
- Mitral Annulus Plane
- Left-Non Commissure
- Tubular Aorta
- Sinus Aorta
- Aortic “Annulus” (Basal ring) Plane
- Right Trigone
- Aortic-Mitral Curtain
- Anterior Mitral Leaflet
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
- Left fibrous trigone
- Aortic-mitral curtain
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-Mitral Curtain Replaced
Folded Bovine Pericardial Patch
Mitral Annulus Suture Placement

Aortic Annular Plane

Left Fibrous Trigone

Mitral Annular Plane

Left Atrium

Right Fibrous Trigone

Preserved Posterior Mitral Leaflet
Aortic-Mitral Curtain Replaced
Commando: Folded Bovine Pericardial Patch
Mitral Inflow and Aortic Outflow
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 Fibrous Trigone

Right Fibrous Trigone

Left Ventricle
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, PrId*
Tel Hashomer, Israel
Aortic-Mitral Curtain
Clothesline Analogy
Suspending Anterior Mitral Leaflet
Aortic-Mitral Curtain Suspension Bridge Analogy
Cables Support Road (Anterior Mitral Leaflet)
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: \(23.1 \pm 2.0\) mm
  - \(n = 2,214\)

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

J Thorac Cardiovasc Surg 2000
Aortic Valve and Root Anatomy

Normal Annulus Area

Mean indexed aortic valve area: $2.02 \pm 0.52 \text{ cm}^2/\text{m}^2$

$n = 4,636$

Minimum: $1.5 \text{ cm}^2/\text{m}^2$

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 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