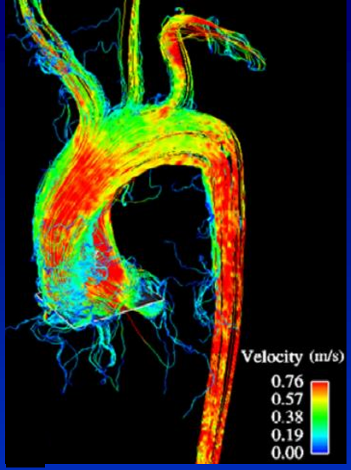
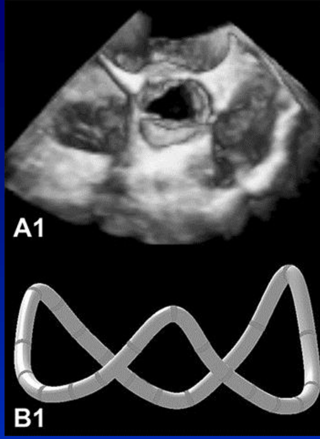


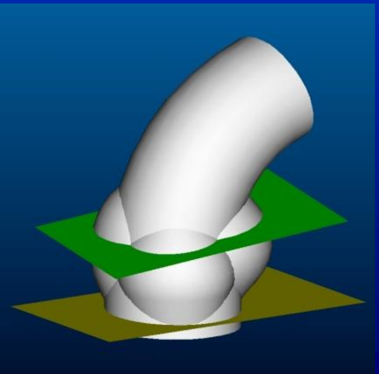


Anatomy of aortic valve and root

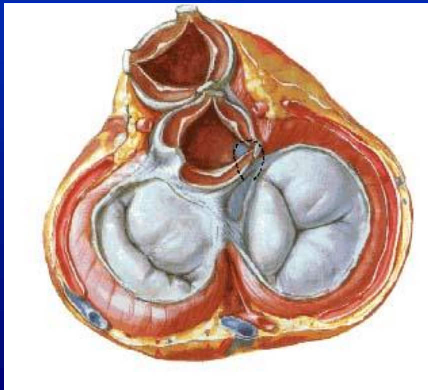
Emmanuel Lansac,

Isabelle Di Centa

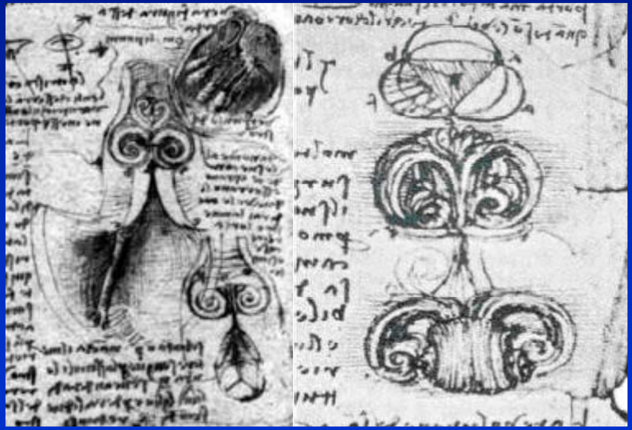
Cardiac Surgery
Institut Mutualiste Montsouris,
Paris, France



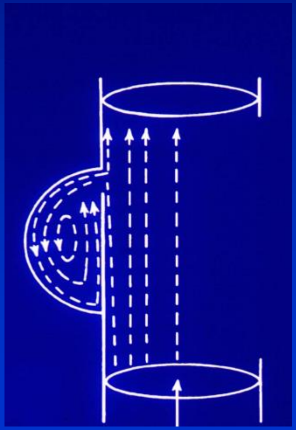
L'INSTITUT MUTUALISTE MONTSOURIS



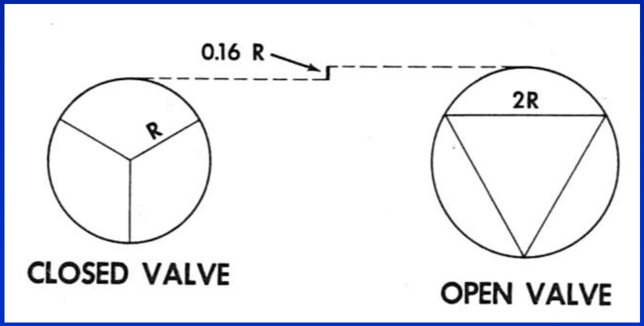
The aortic valve : a passive or dynamic structure?



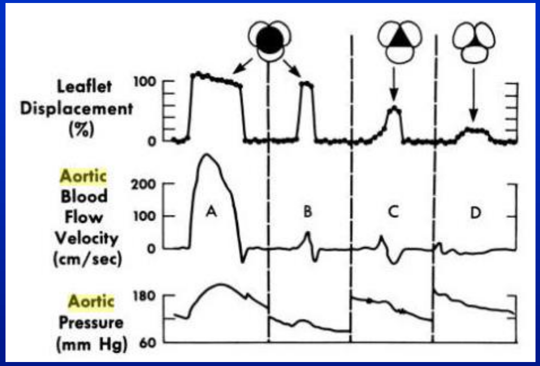
Leonardo da Vinci 1508
Quadr Anat IV

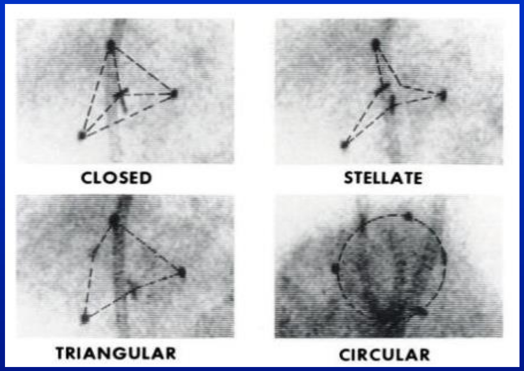


Belhouse Cir Res 1969
In vitro Vortex formation

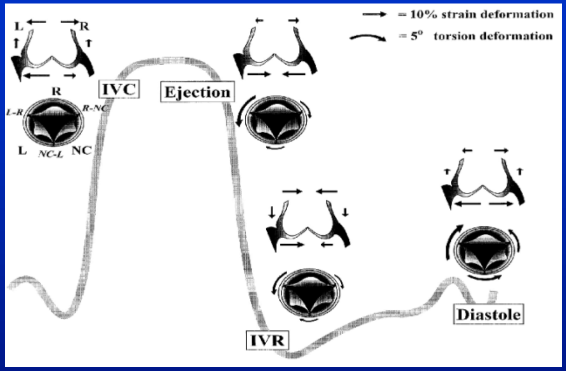


Brewer JTCVS 1976
Interdependence of valve opening and root expansion

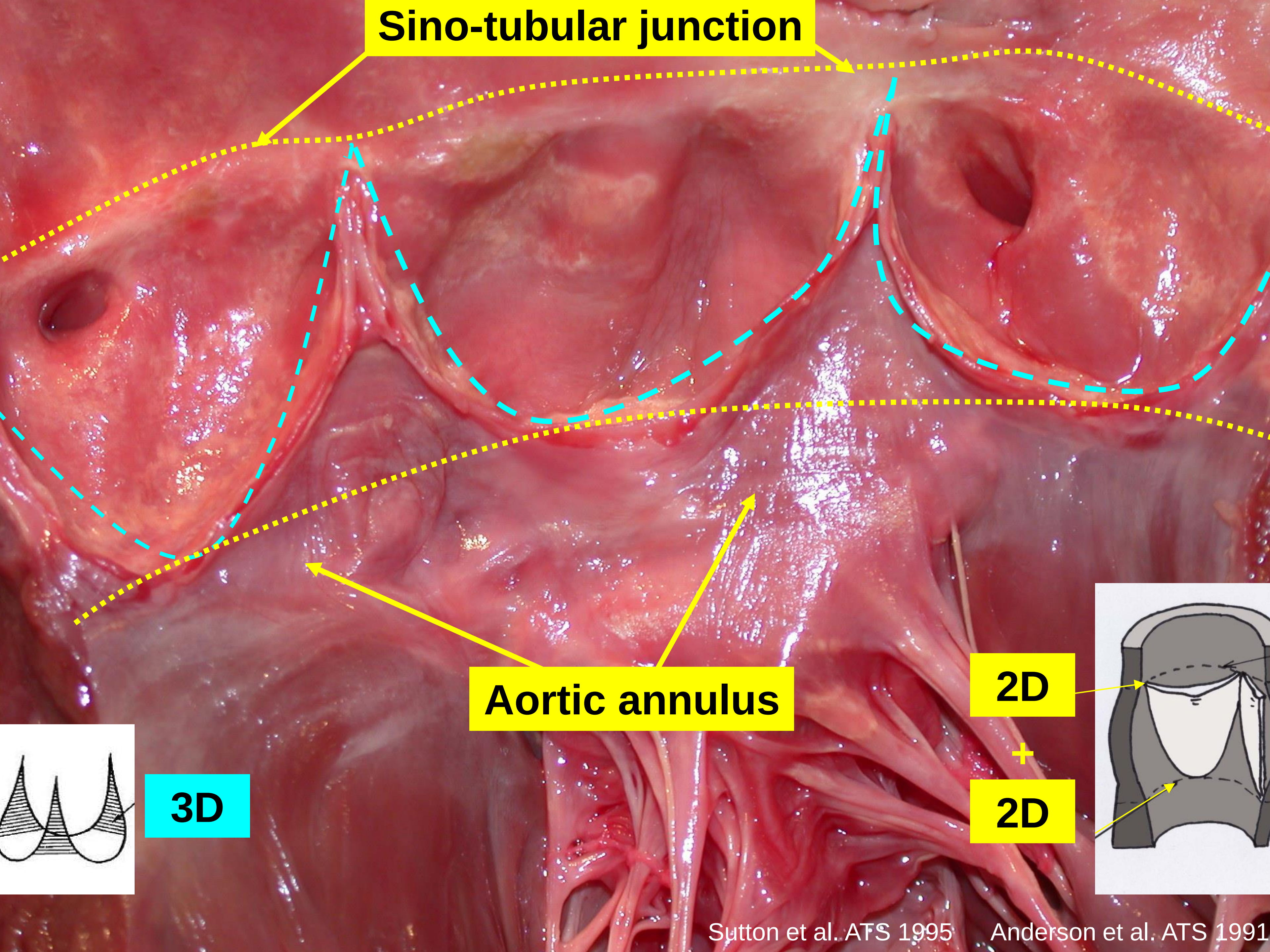




Thubrikar JTCVS 1979 : In vivo 9% commissural expansion prior ejection
Circular orifice



Dagum Circulation 1999
Deformational dynamics of the aortic root (60Hz)



Sino-tubular junction
Aortic annulus
3D
2D
+
2D
Sutton et al. ATS 1995
Anderson et al. ATS 1991

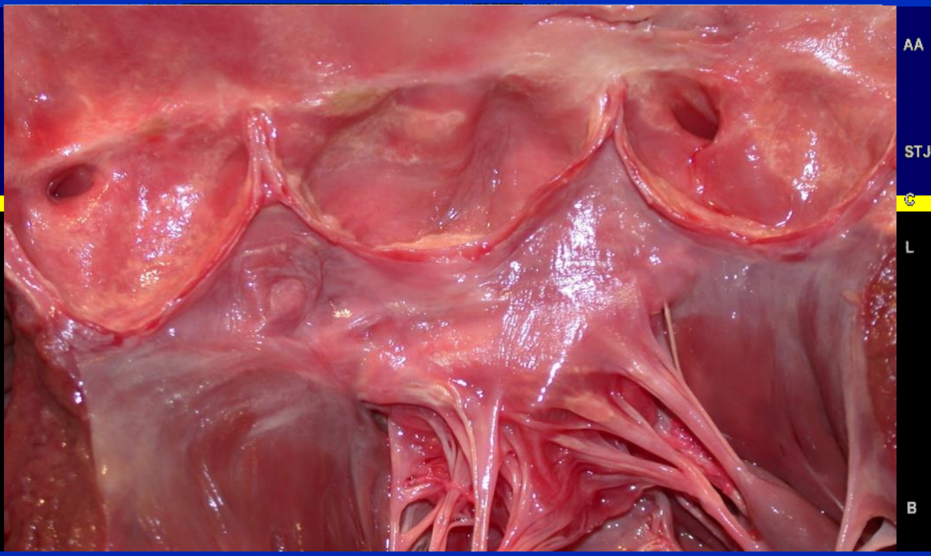
Aortic Root = 2 functional compartments

SUPRAVALVULAR COMPARTMENT:

STJ + ascending aorta → **Aortic Hemodynamics**

SUPRA VALVULAR

SUBVALVULAR



Aortic Hemodynamics

LV Hemodynamics

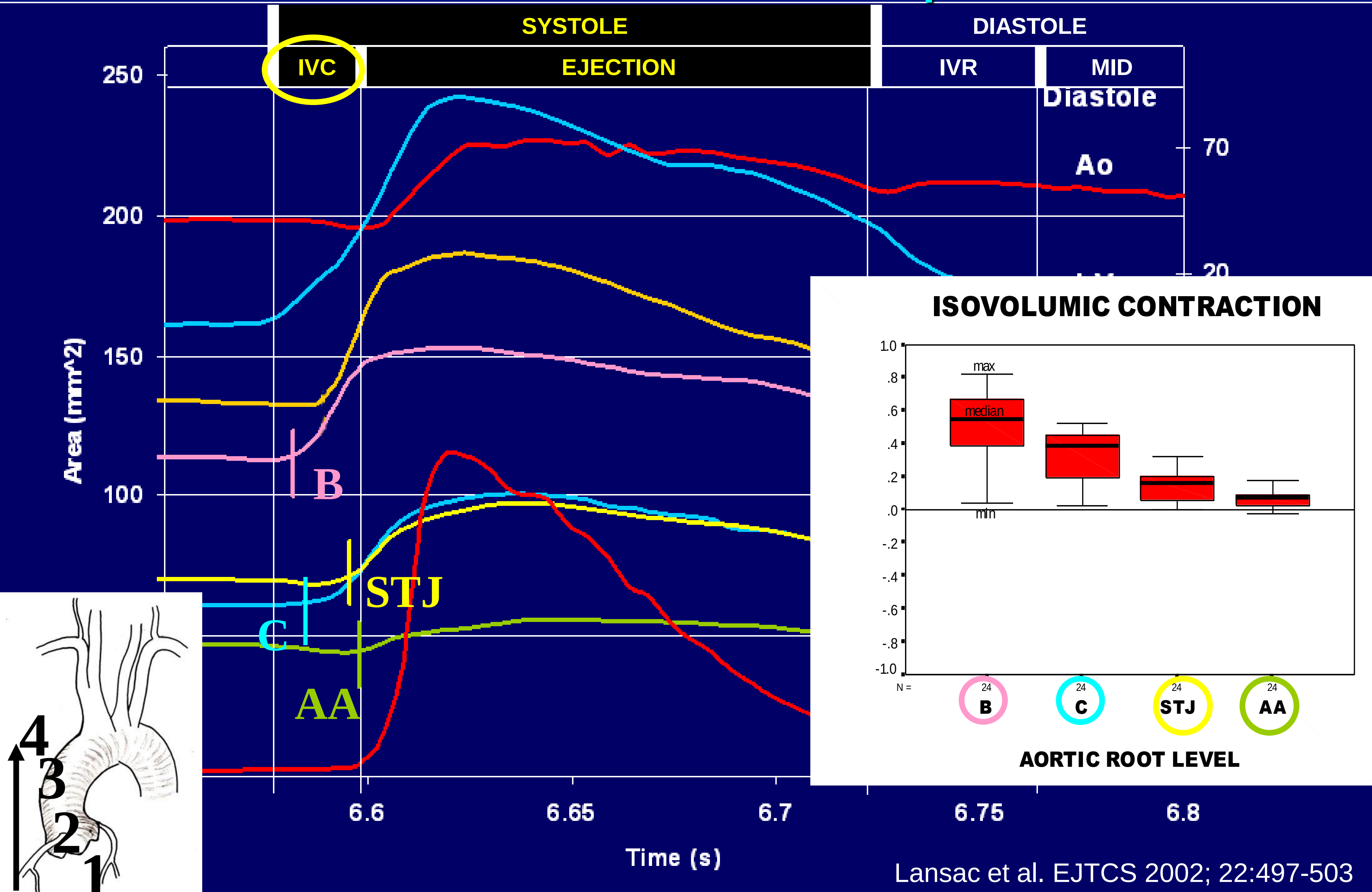
SUBVALVULAR COMPARTMENT:

Aortic annular Base +
Commissures (inter-leaflet triangles) → **LV Hemodynamics**

Sutton et al. ATS 1995 Lansac et al. EJTCS 2002

Aortic root expansion starts prior to ejection

36.7 ± 3.3% of root volume expansion



Lansac et al. EJTCS 2002; 22:497-503

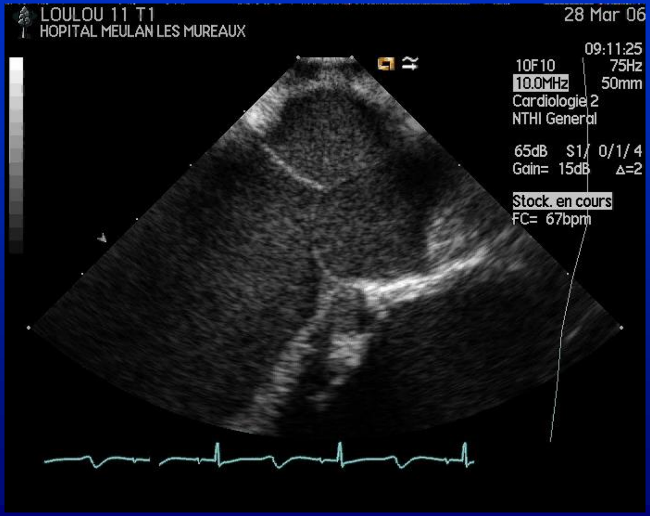
Aortic valve opening starts prior to ejection

(2.1±0.5%)

Related to annular base and commissural (subvalvular compartment) pre-ejectional expansion

Correlated to LV pressure increase (r=0.95)

Due to a redistribution of LV volume below the leaflets (inter-leaflet triangle)

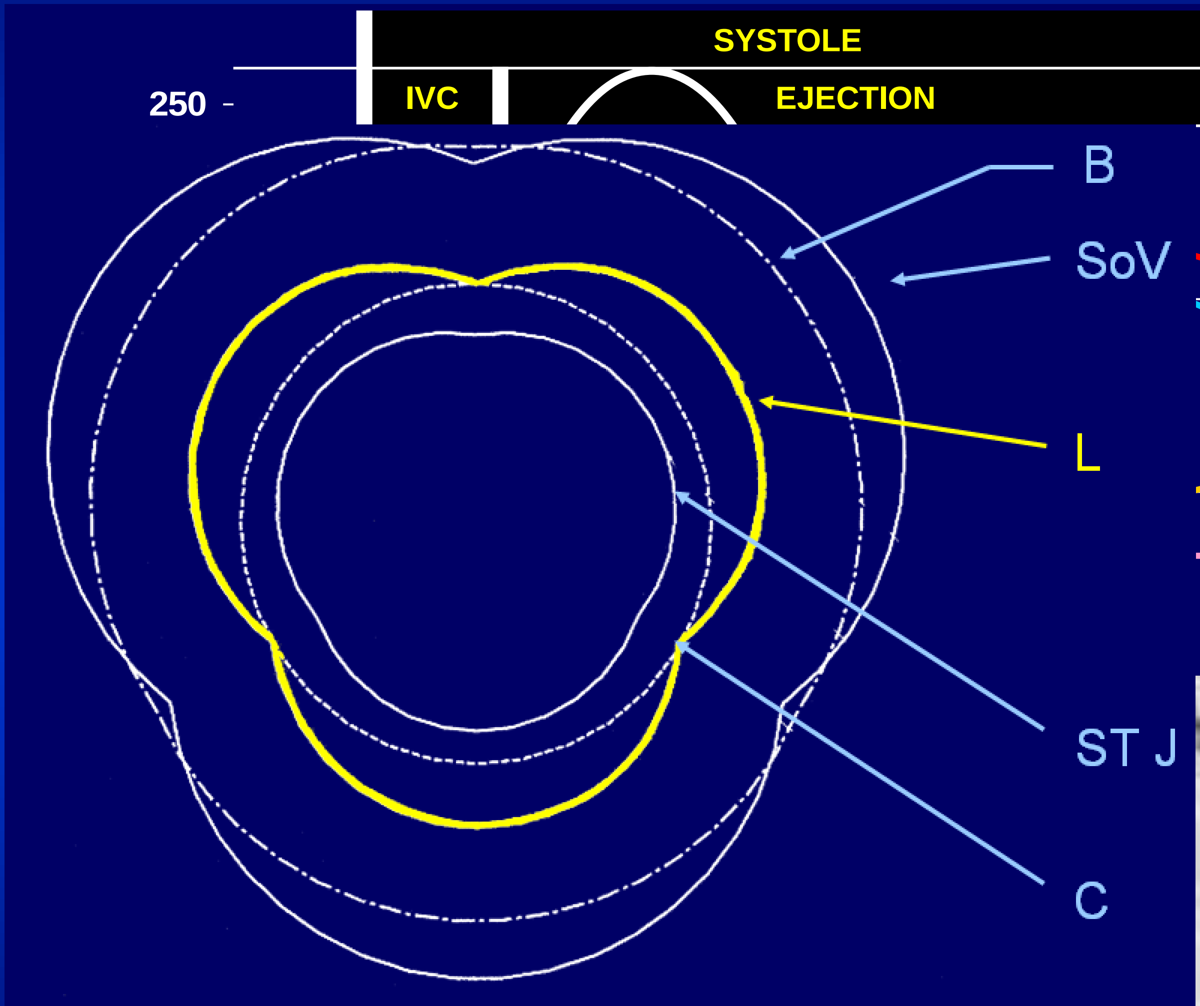


Optimize ejection

Stressless opening

Lansac et al. EJTCS 2002; 22:497-503

Aortic valve opening is maximum during the 1/3 of ejection

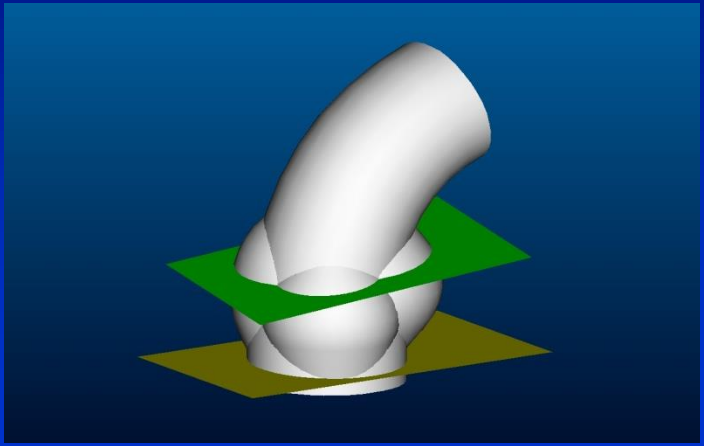


Leaflet area overshot Commissural area by 28.8±3.4%
=
Clover-shaped orifice

Maximizes hemodynamic performance unimpeded blood flow through the sino-tubular junction to the systemic circulation

Aortic root expansion is asymetric
Tilt angle of the aortic valve during cardiac cycle

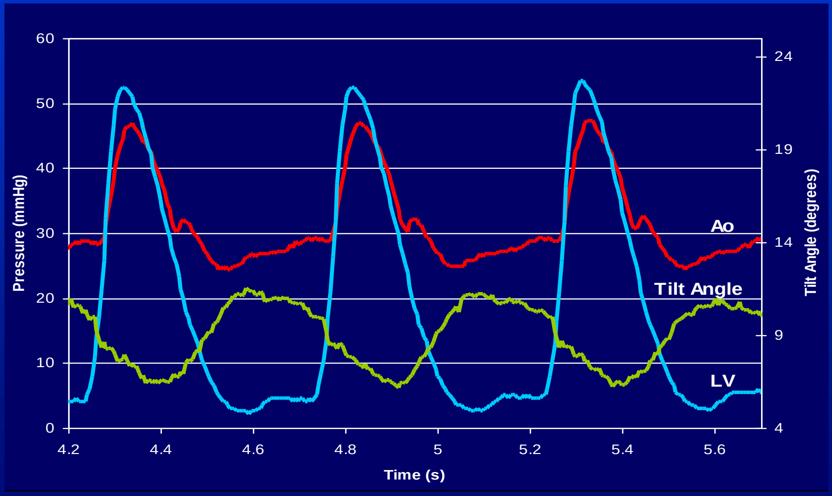
End diastole: 16.3±1.5° postero-left



During systole:- <u>6.6±1.5°</u>

Alignement of LVOT and ascending aorta

➡ **Maximize ejection**



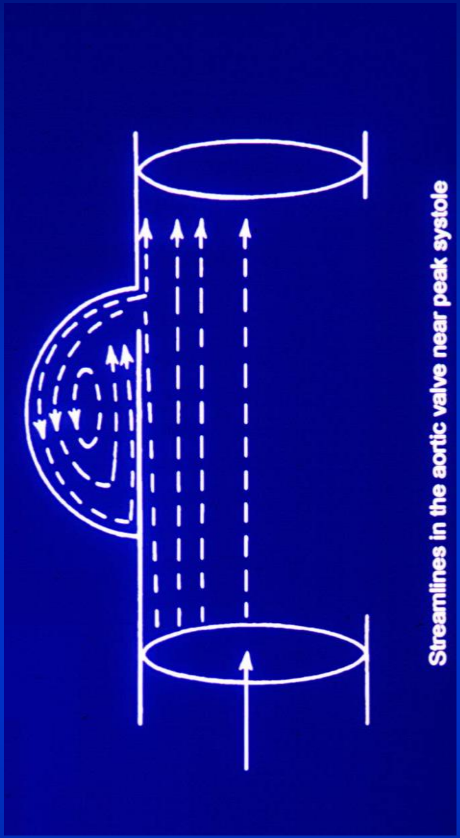
During diastole:+ <u>6.6±1.5°</u>

➡ **Shock absorber**

Lansac et al. JHVD 2005; 14:400-407

Importance of Sinuses of Valsalva

Leonardo da Vinci 1508
Quadr Anat IV



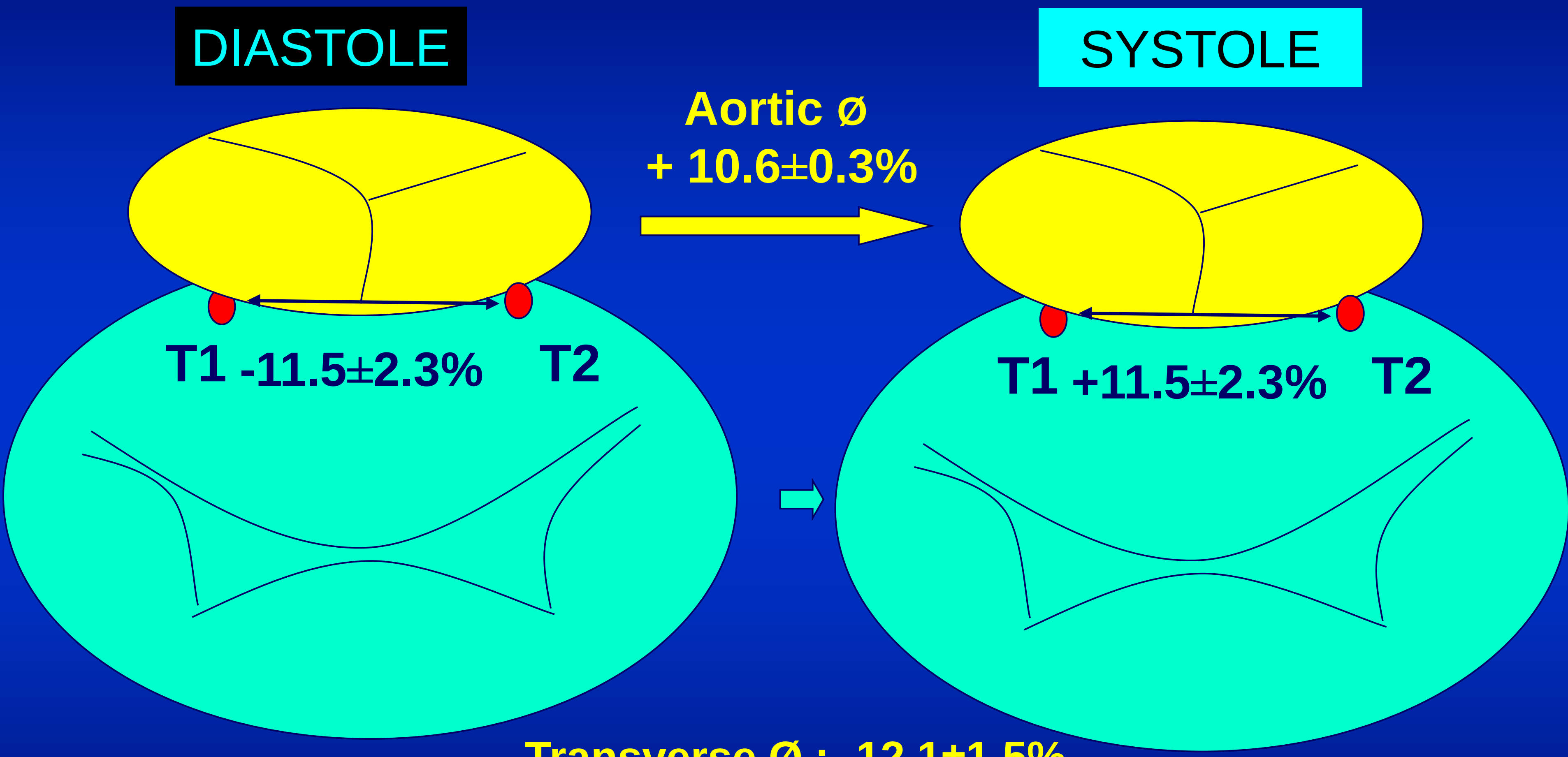
Belhouse Cir Res 1969
In vitro Vortex formation

Kilner Circulation 1993
3D MRI

Recirculating flows (vortices) accommodated by the sinuses contribute to efficient and smooth valve closure at end systole

Katawama 2008

Aorto mitral junction dynamics : two to tango



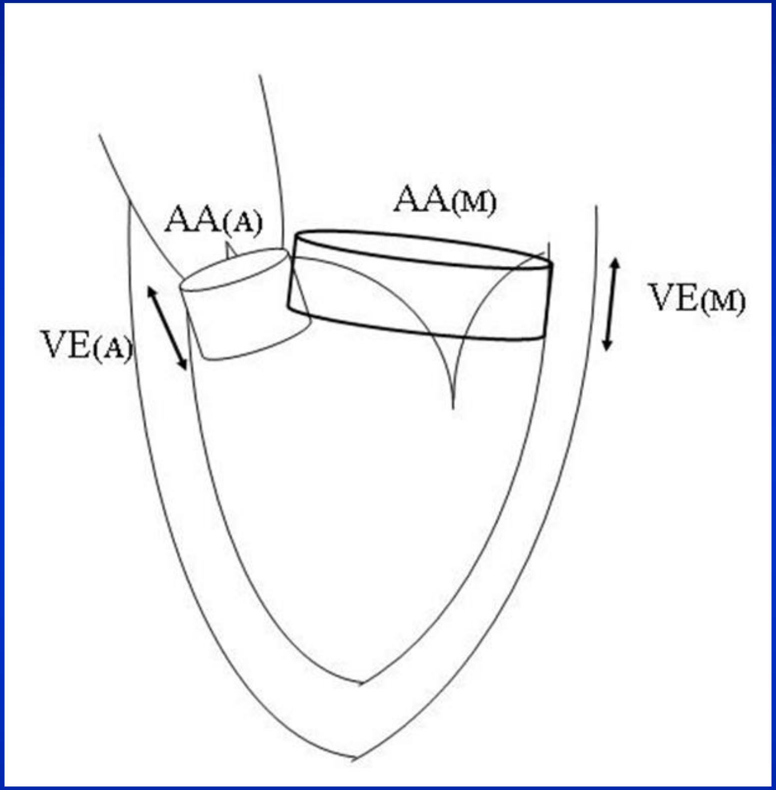
Transverse Ø : -12.1±1.5%
Antero Posterior Ø : -23.6±2.5%

MAXIMIZE LV FILLING

MAXIMIZE EJECTION

Lansac et al. JTCVS 2002; 123:911-918

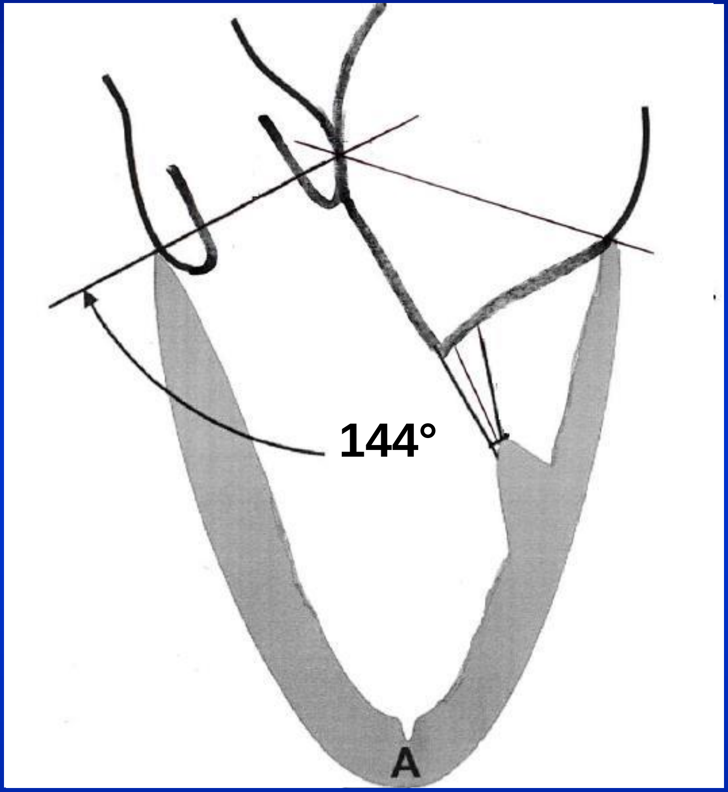
Annulus excursion during cardiac cycle 13 ± 2.3 mm



Annulus excursion contributes to an efficient cardiac output

Sughimoto JHVD 2010

The angle between the mitral and aortic annulus reduces 11 ° in systole.

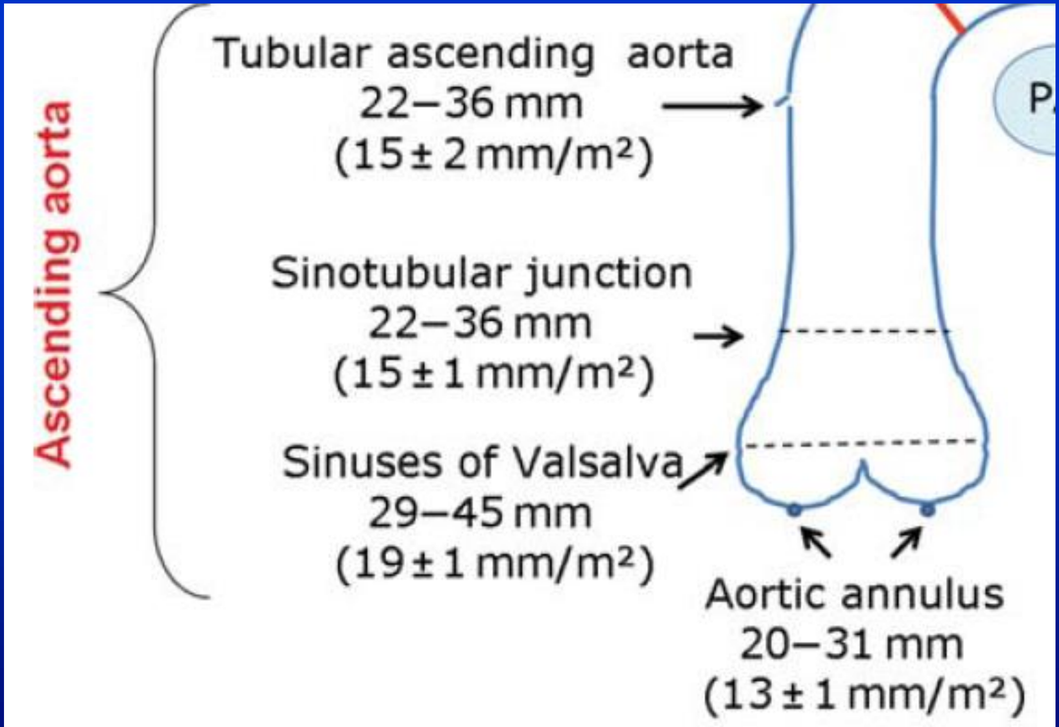


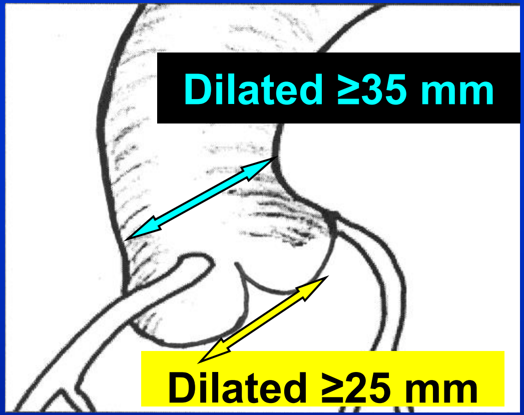
Alignement of LVOT and ascending aorta Maximize ejection

Goetz Am J Physiol Heart Circ 2005, Asian CVT annals 2006

What are the normal diameters of the aortic root?

N	1132
Annulus Ø	22.3±1,4 (20.5-32.4)
STJ Ø	26.7±2.2 (31.2-23.4)
STJ/ annulus	1.2±0.1 (1.1-1.3)

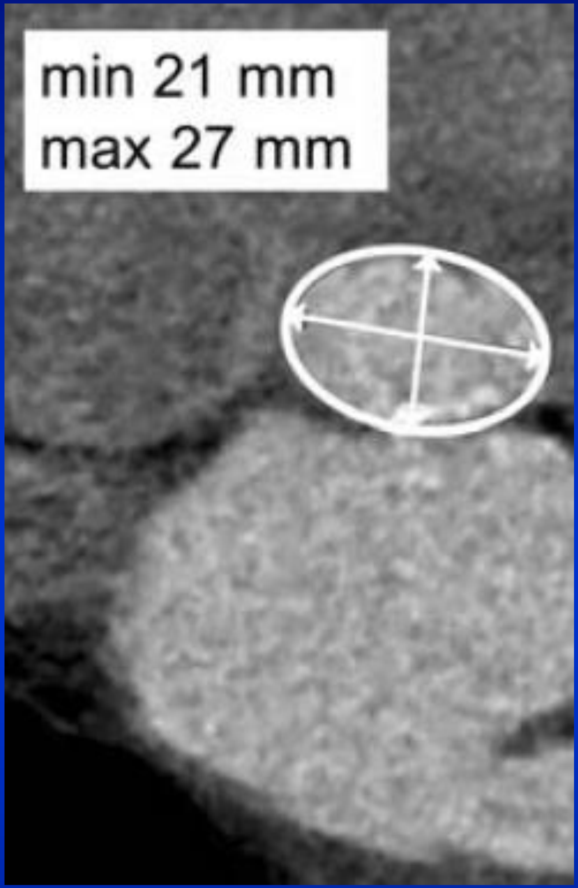


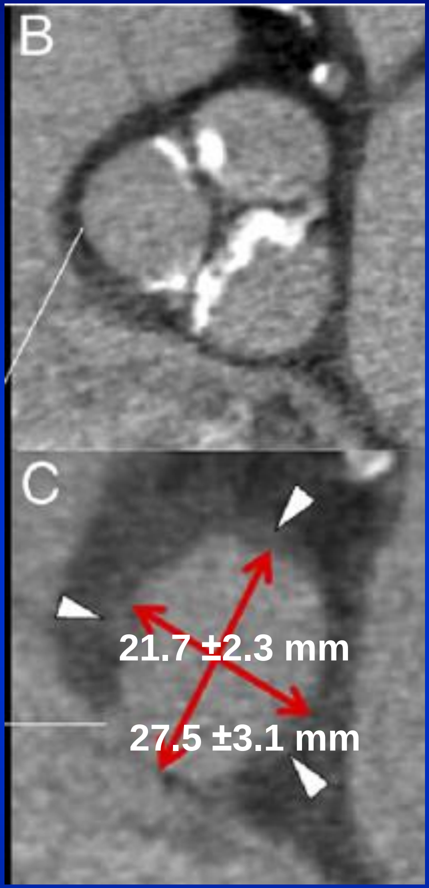


STJ> Annulus
Ratio = 1.2 (1.1-1.3)

Roman 1987 Nistri 1999 Varnous 2003 Maselli 2005 Babee 2007 Tamas 2007 Soncini 2009 Bierbach 2010 Zhu 2011

Geometry of the aortic annulus





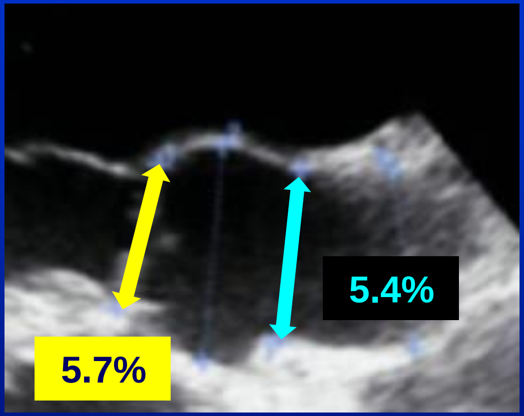
Echo diameter in long axes correspond to smallest diameter

maximum CT-Ø / minimum CT-Ø =1.26

Aortic annulus is oval shaped

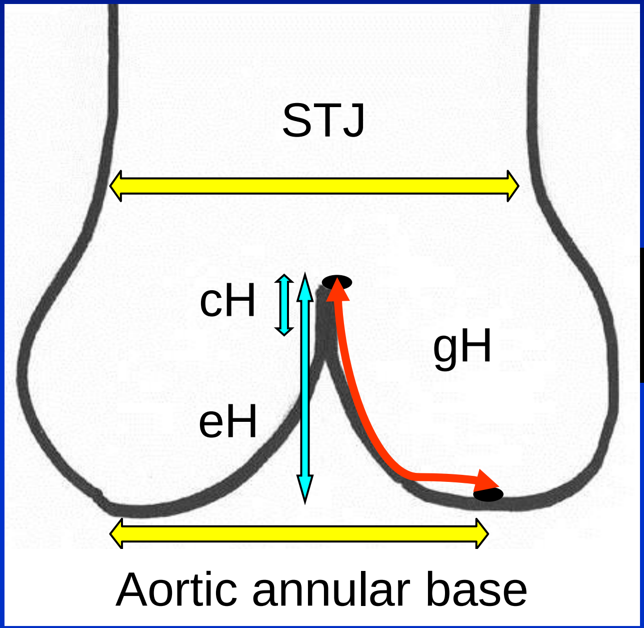
Expansibility of the aortic root

	Leygh 1999 Echo	De Paulis 2002 Echo	Varnous 2003 Echo	Kazui 2004 Echo	Maselli 2005 Echo	Matsumori 2007 Echo	De Heer 2011 CT scan	Zhu 2001 Echo
N	599							
Annular base	5.7% (2.5-9.6)							
SoV	4.3% (0.5-10.3)							
STJ	5.4% (1.7-9.8)							

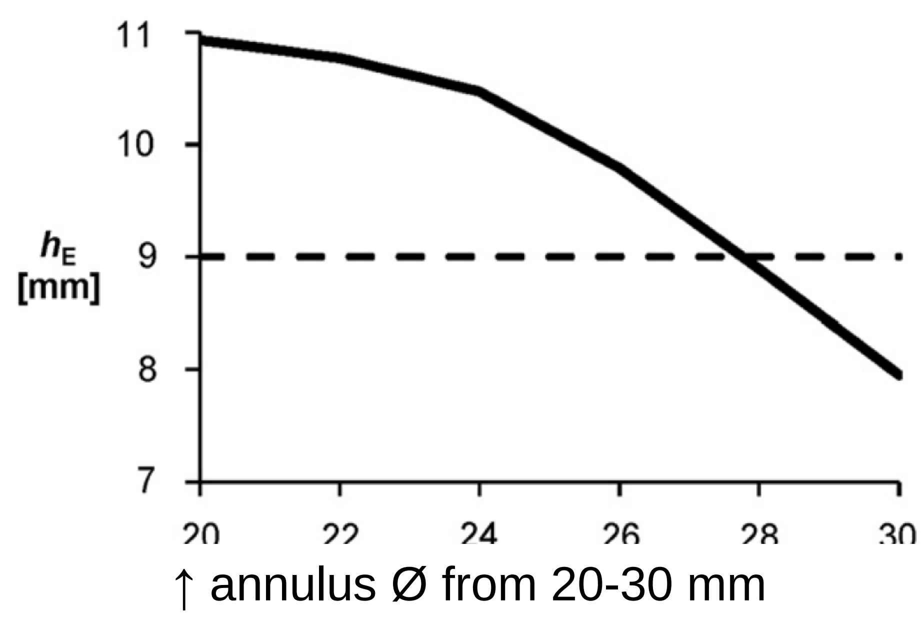


Aortic annulus and STJ expansion

Parameters for valve coaptation



cH= 4-5 mm
eH= >9 mm



↓ eH from 10.9 to 8.0 mm

↓ cH from 3.3 to 0.3 mm

gH

Bicuspid : nonfused 24±2 mm

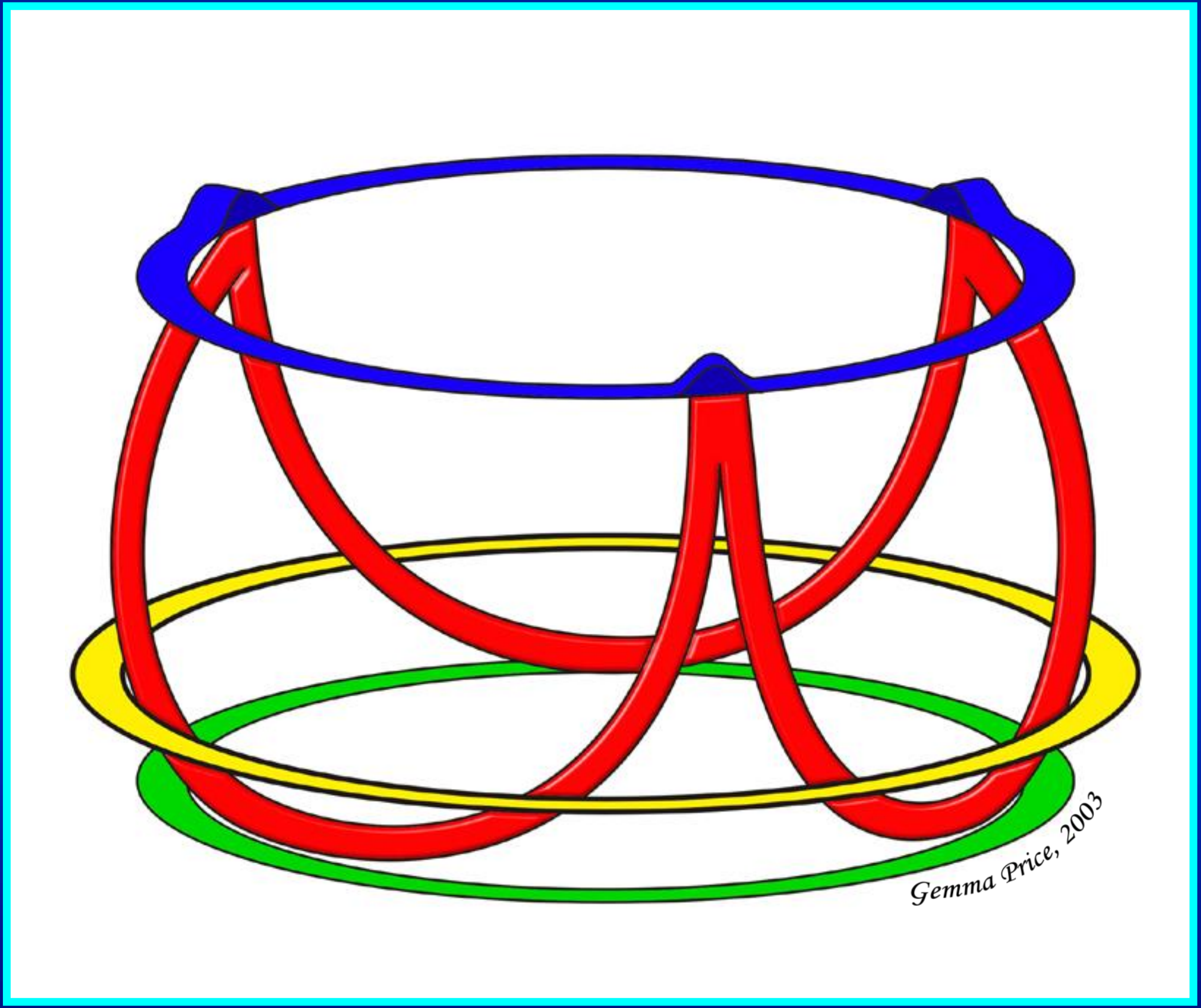
Tricuspid :
NC : 21±2 / LC : 20±2 / RC 20±2

Correlates with body height, weight, BSA, sinus Ø, aortoventricular Ø

Tamas JHVD 2007 Bierbach EJTCVS 2010

Schäfers JTCVS 2012 Marom JTCVS 2012

What is the aortic annulus from a surgical point of view ?



STJ

Ventriculo-aortic junction

Virtual ring

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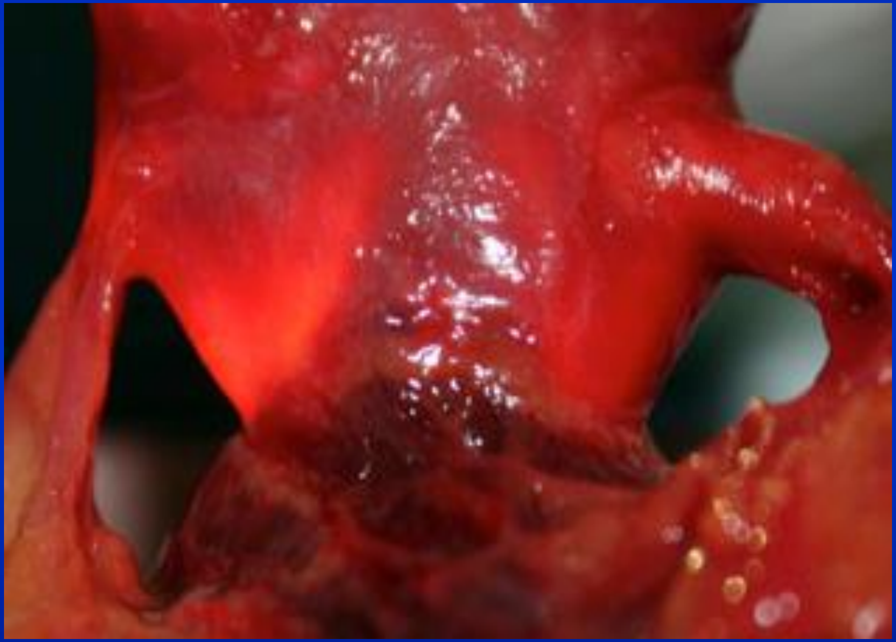
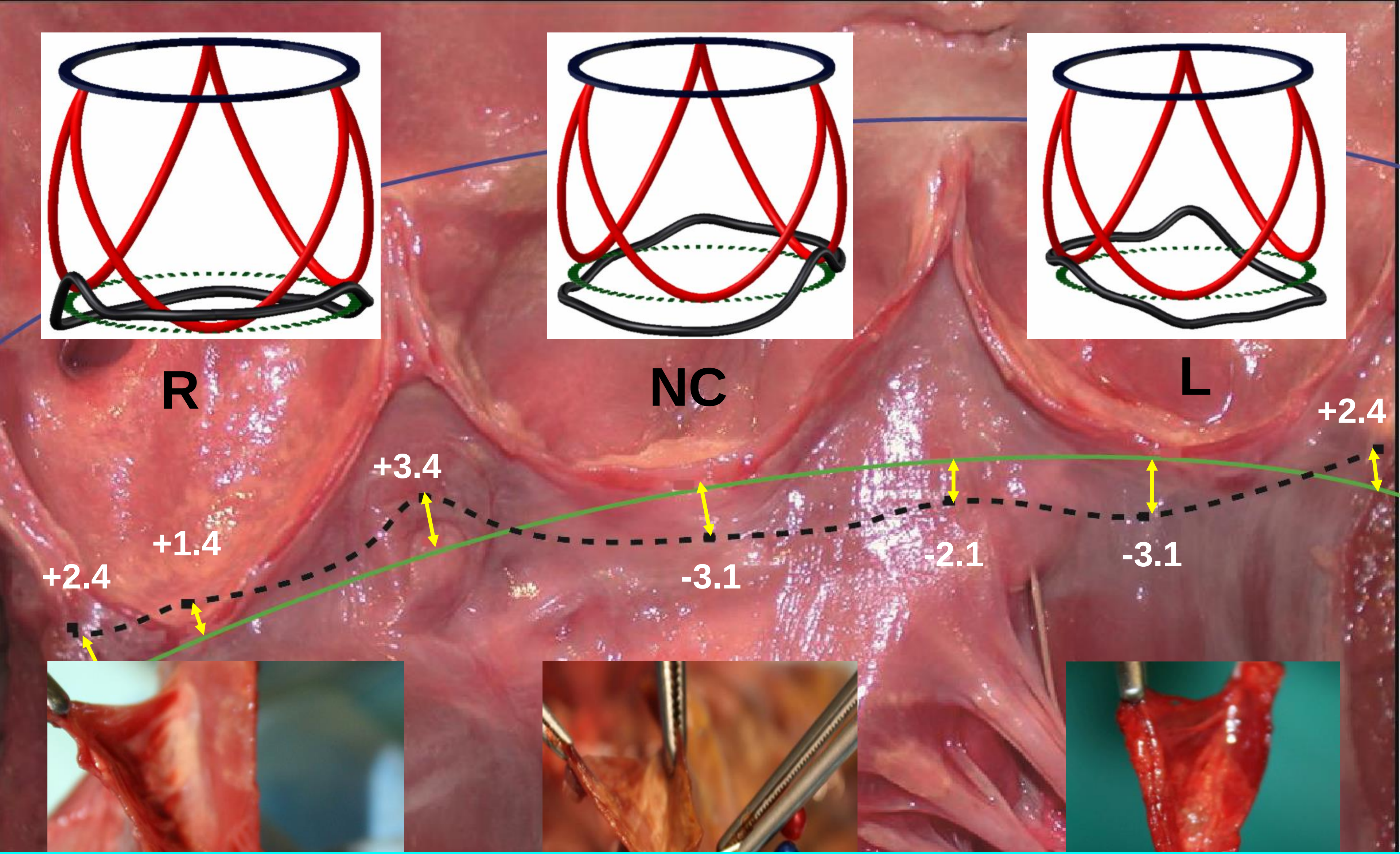
External Dissection of the Subvalvular Plane

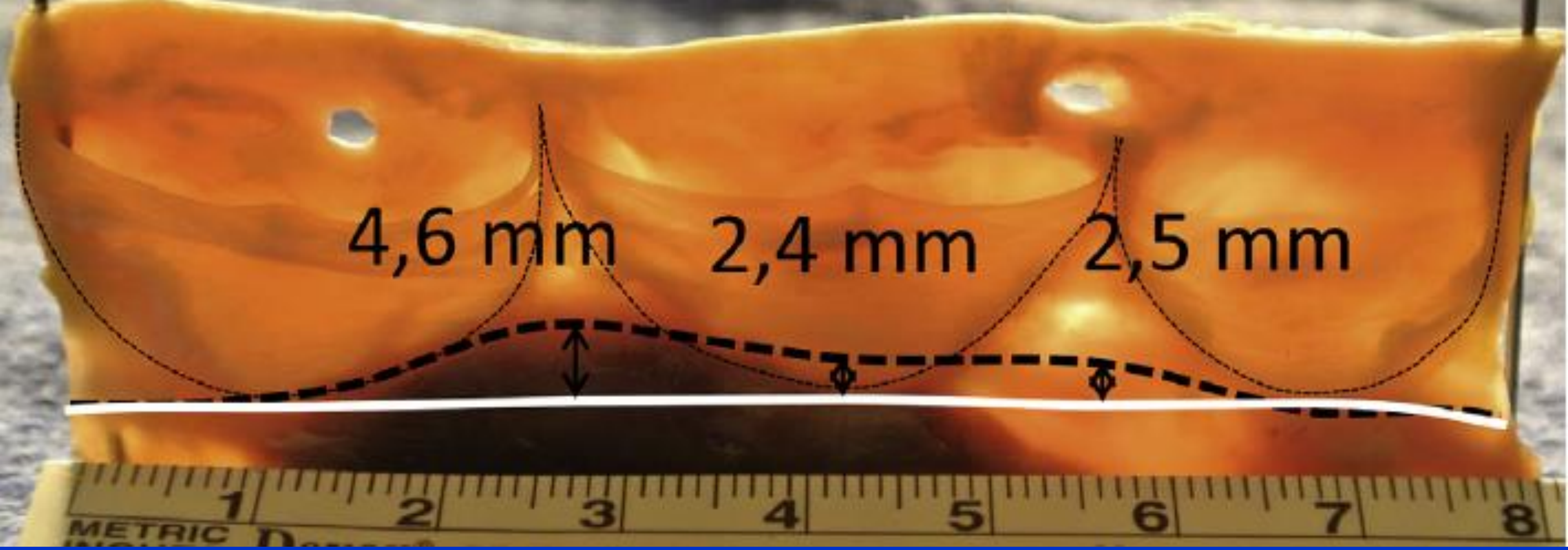




Aortic annuloplasty can be performed in the subvalvular plan, except at the level of the infundibulum where the dissection stops 1,4±1,8 mm above the nadir of the right coronary sinus

(80% below or within 3mm above the nadic of the

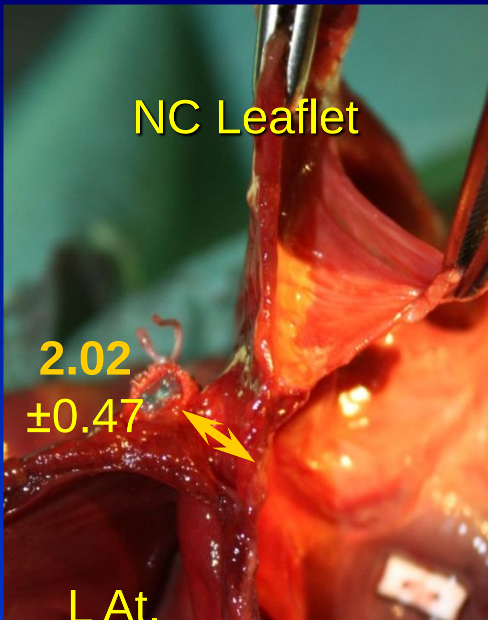
Khelil et al ATS 2015

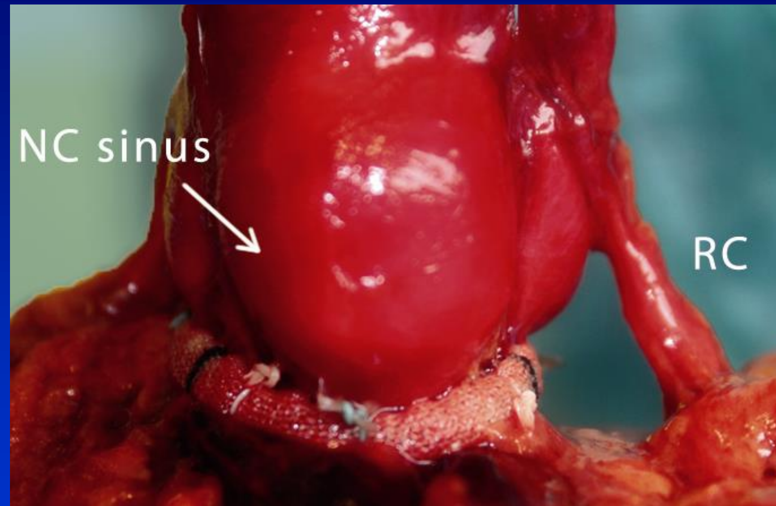


External dissection of the aortic root leads to above the level of the aortic annulus from the LC/RC to the RC/NC commissure.

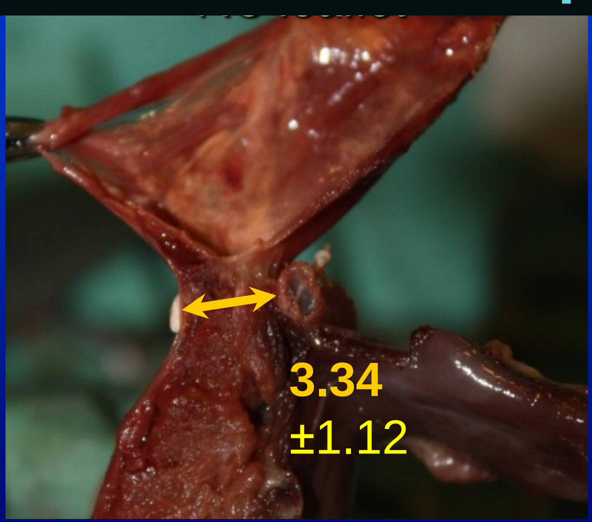
Main limitation of external dissection of the subvalvular plane is the membranous septum

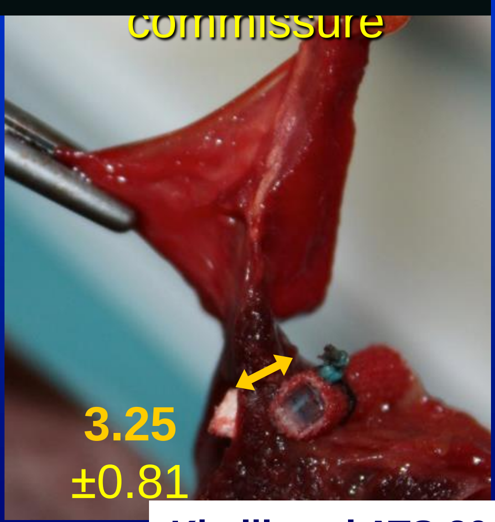
De Kerchove, JTCVS 2015





External aortic annuloplasty induces a minimum of 5 mm reduction of aortic annular base diameter, corresponding to tissue thickness





Khelil et al ATS 2015

Aortic valve
Tricuspid

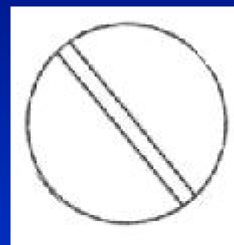
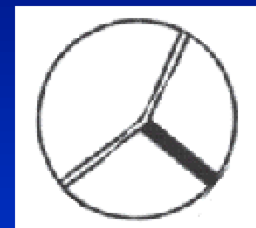
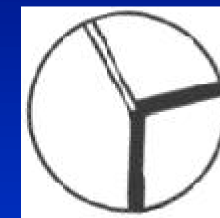
Bicuspid valve

Type 0
0 raphe

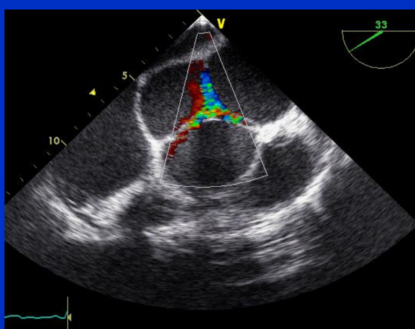
Type 1
1 raphe

Unicuspid valve

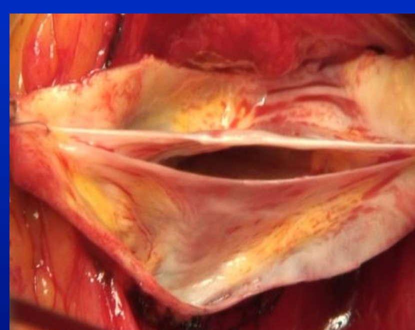
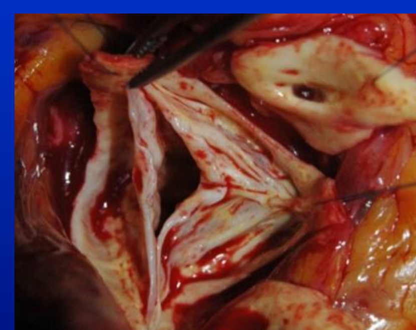
Type 2
2 raphes

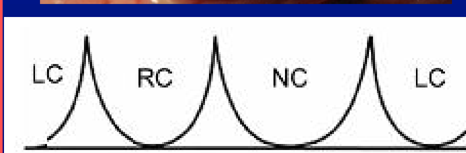





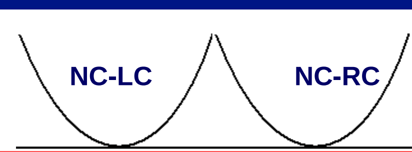
Good candidates for repair

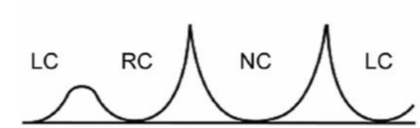


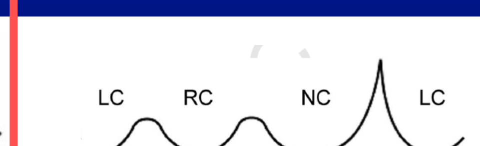


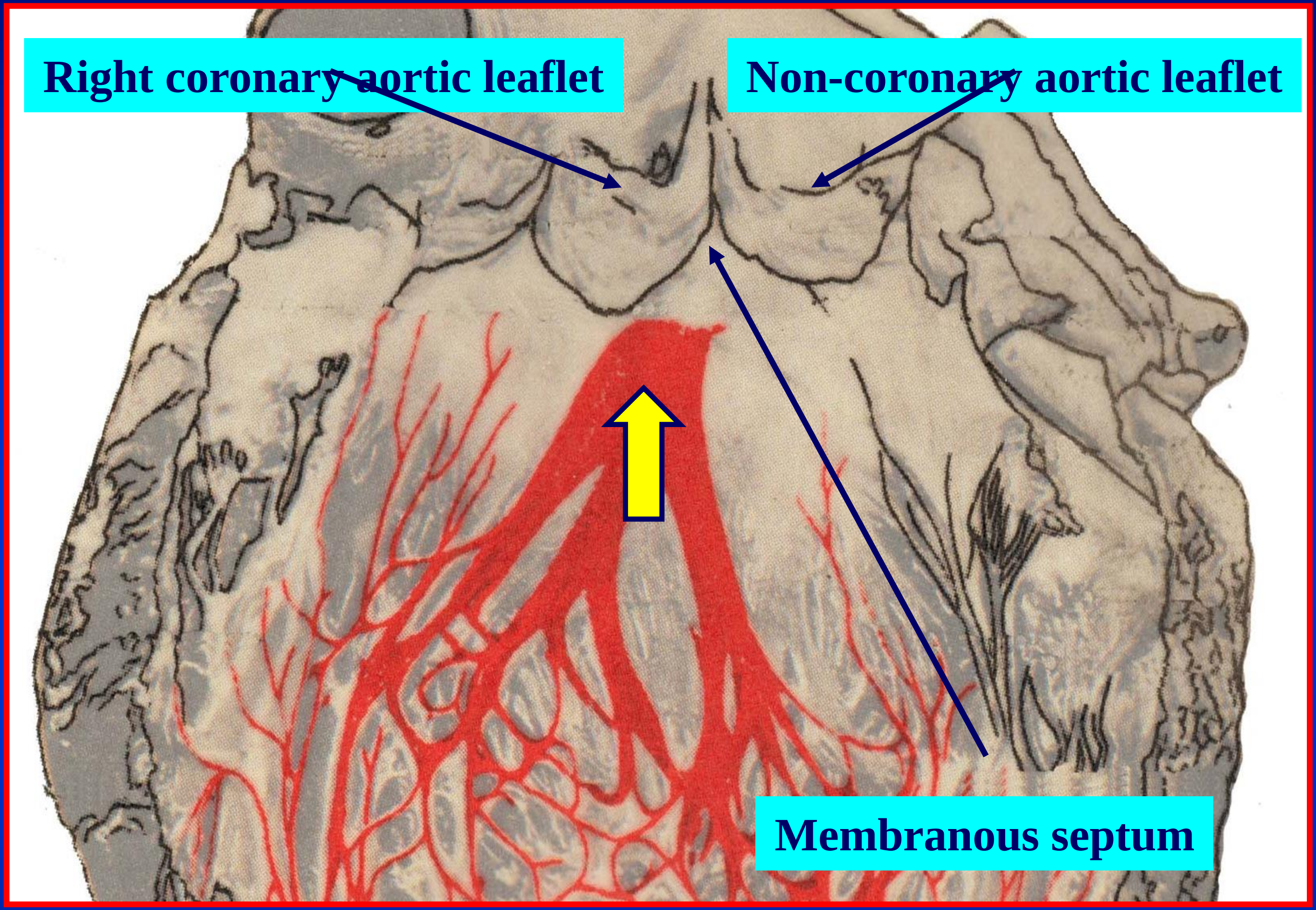









Landmarks to AV conduction system



Left bundle branch descends from nadir of hinge of right coronary leaflet

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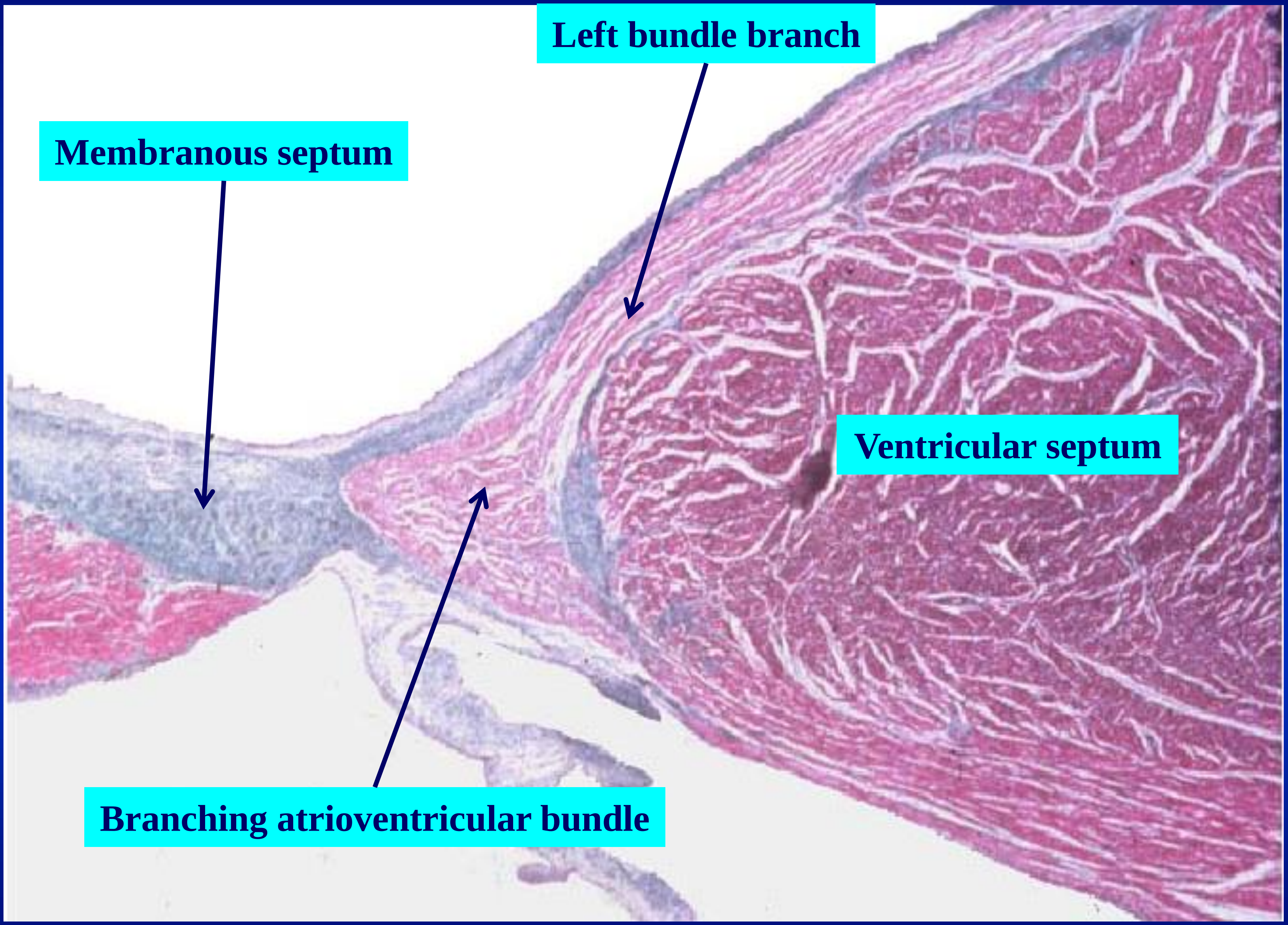

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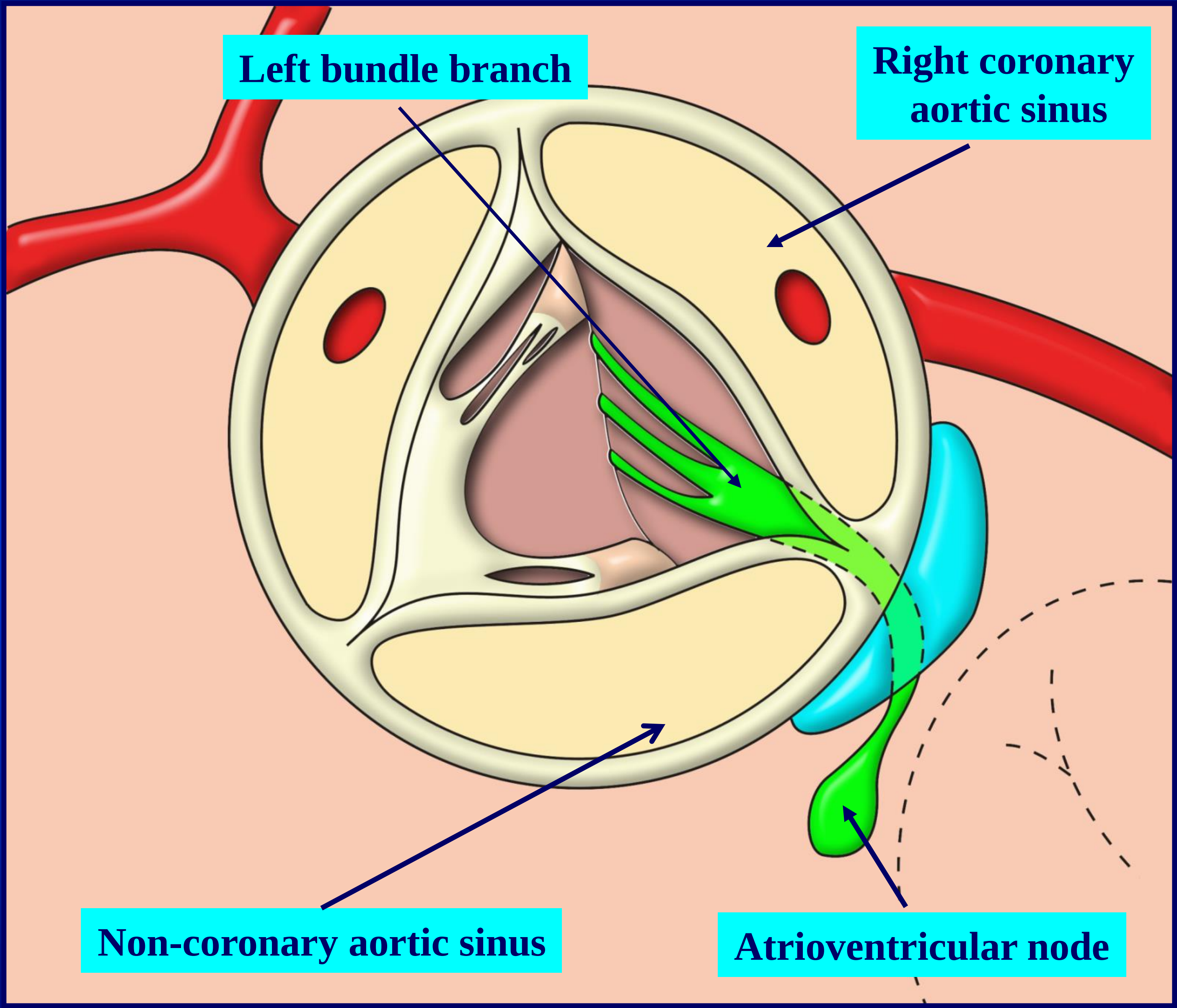

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Dynamic anatomy

Valve repair

Aortic Root expansion
=
Stress less opening and closure of the valve

Dilated STJ > 35 mm

Treatment of dilated diameters
Aortic annular base Ø
STJ Ø

Clover shape orifice

Preserves root dynamics
Neosinuses of valsalva
Systolic expansion
(interleaflet triangles)

Cusp effective height

Restores cusp effective height

Dilated annulus >25 mm

Annulus < STJ
Ratio 1.2

Restores ratio

Durability of a native valve

Durability of repair