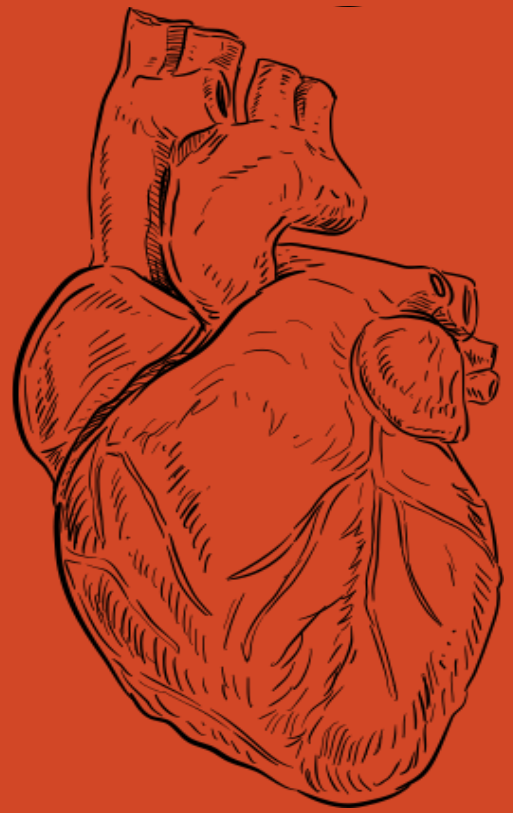


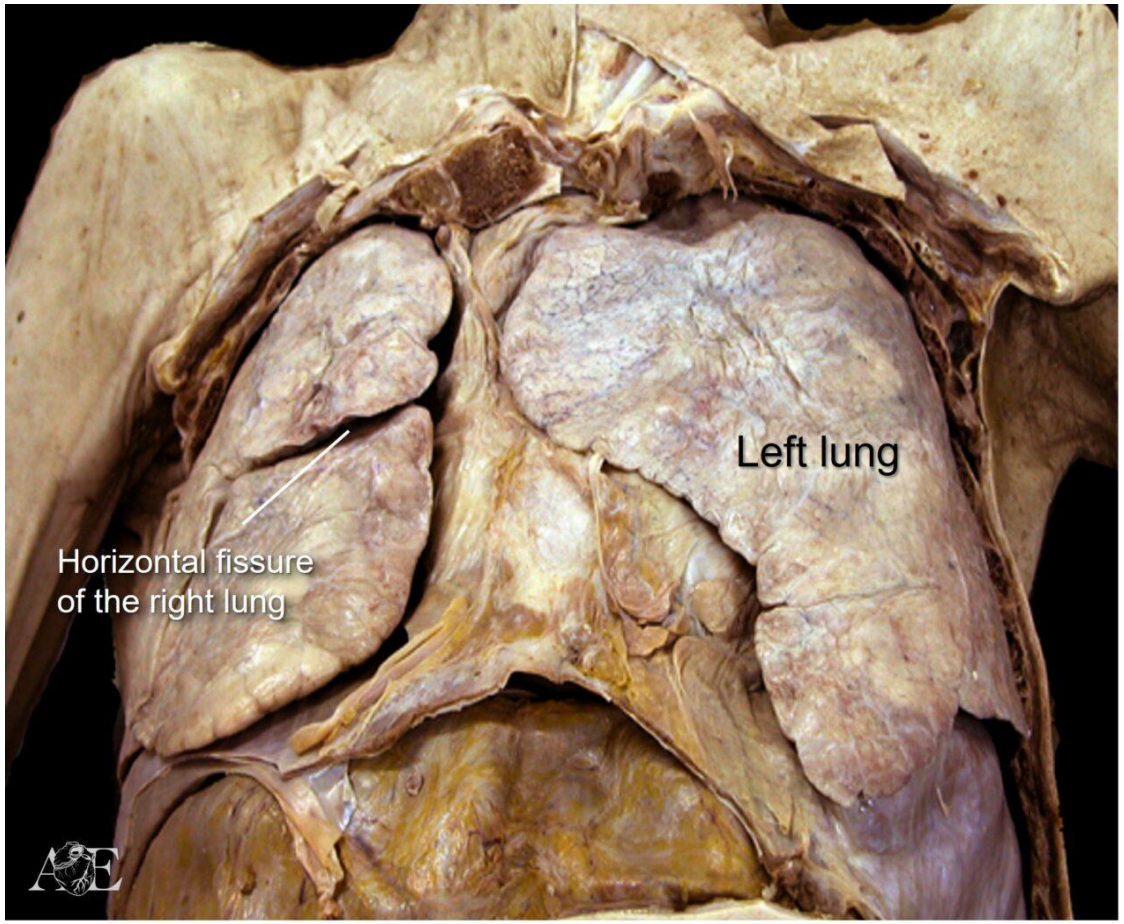
부정맥전문기술인을 위한 심장해부학

-

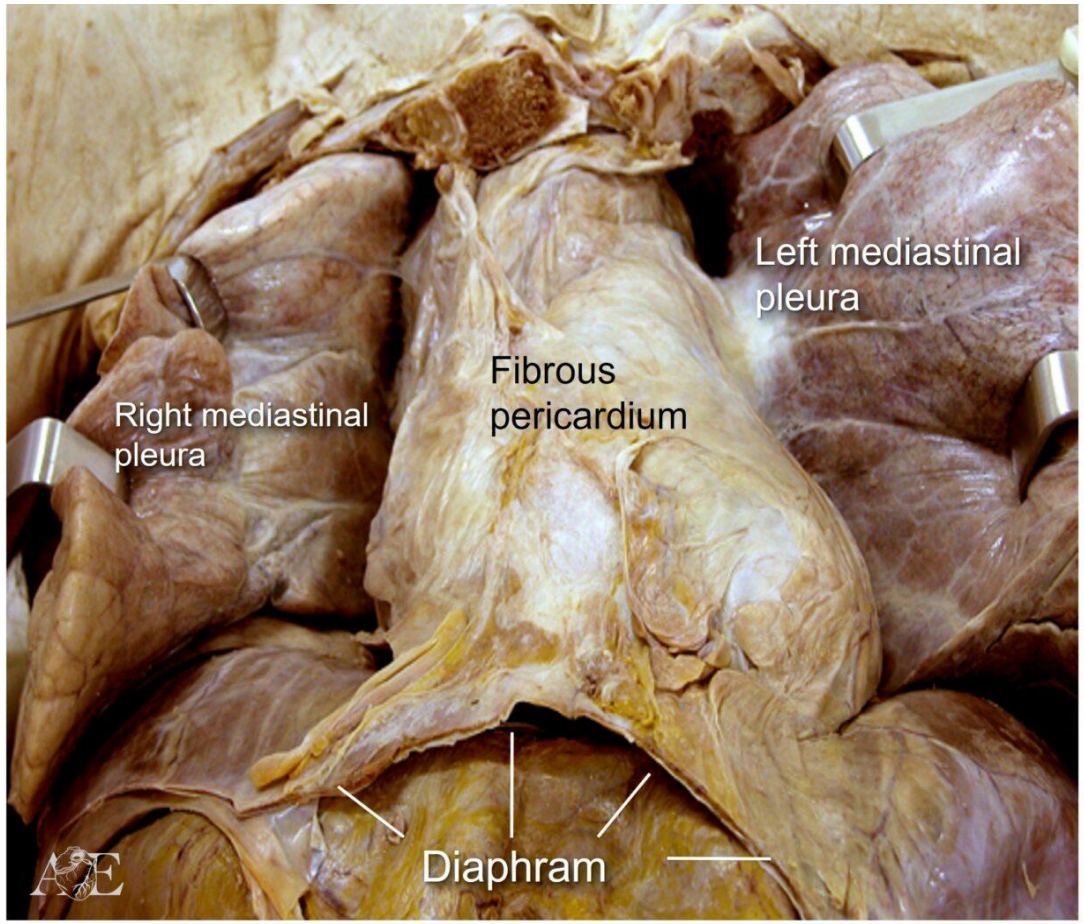
Clinical anatomy of Right atrium

인제대학교 상계백병원 이정호 RT, CEPS

BASIC ANATOMY OF THE HUMAN HEART

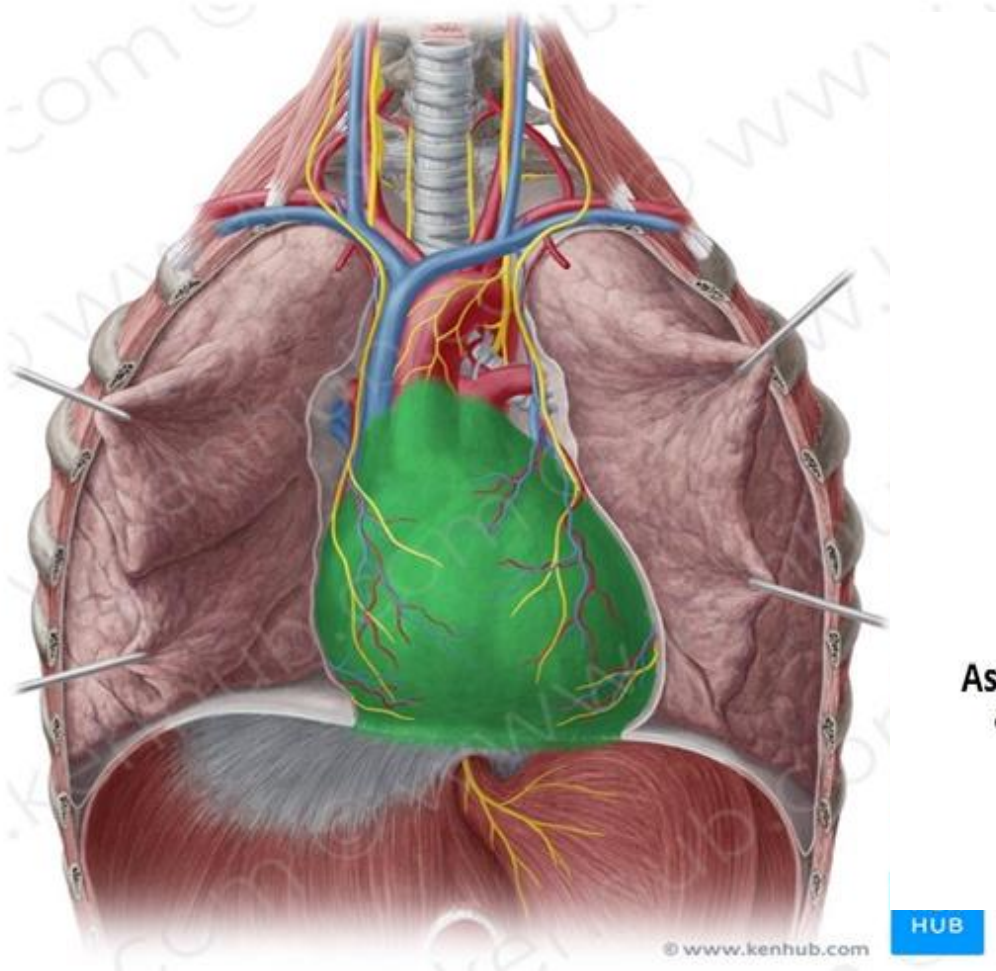


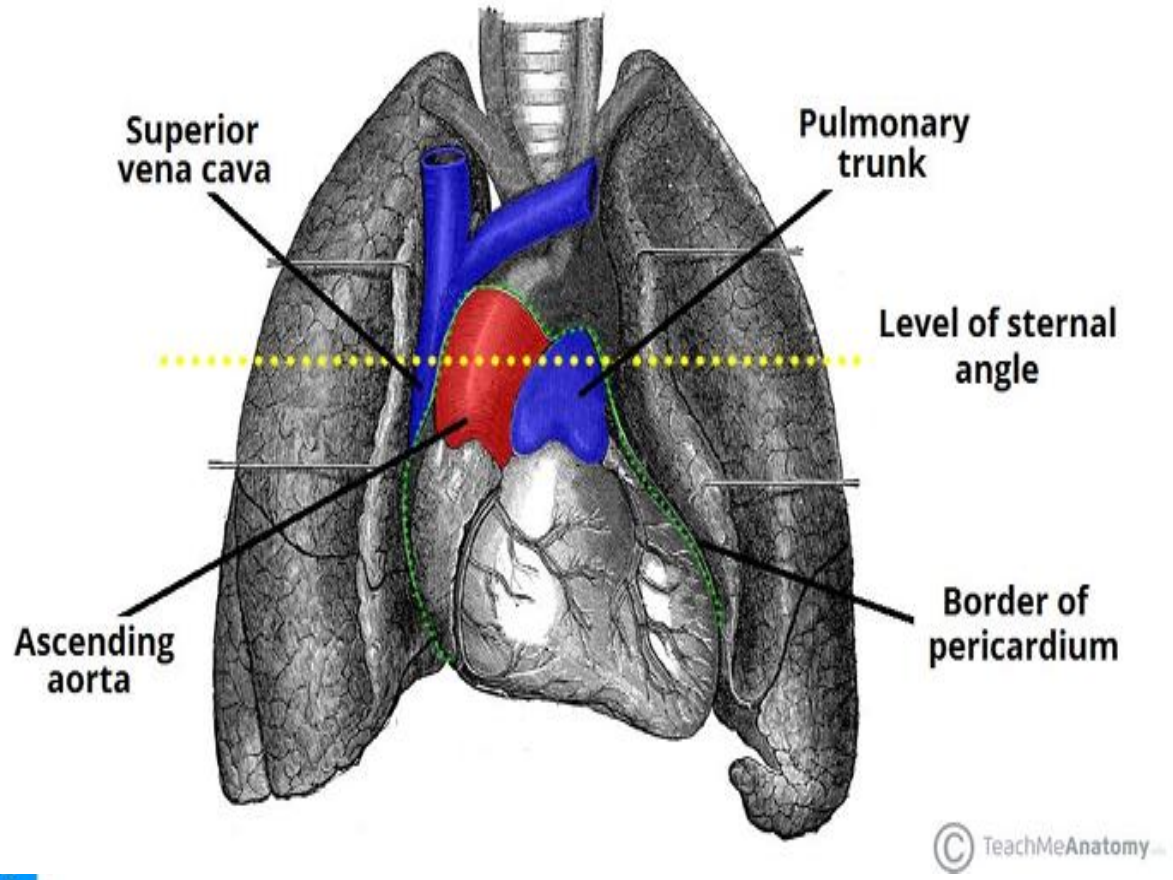
Thoracic cavity



Middle mediastinum

The Pericardium





The Pericardium: Structure and Function

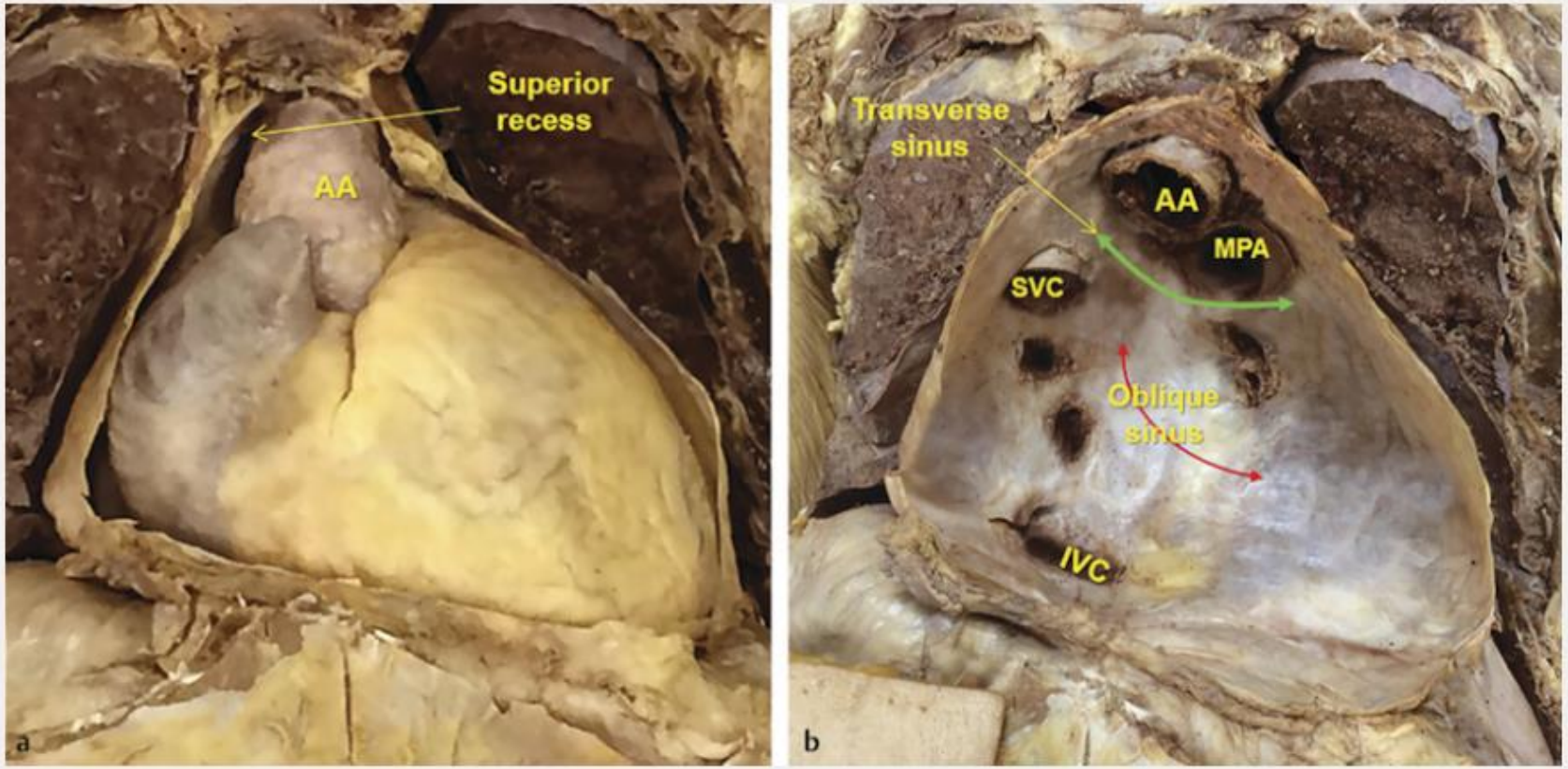
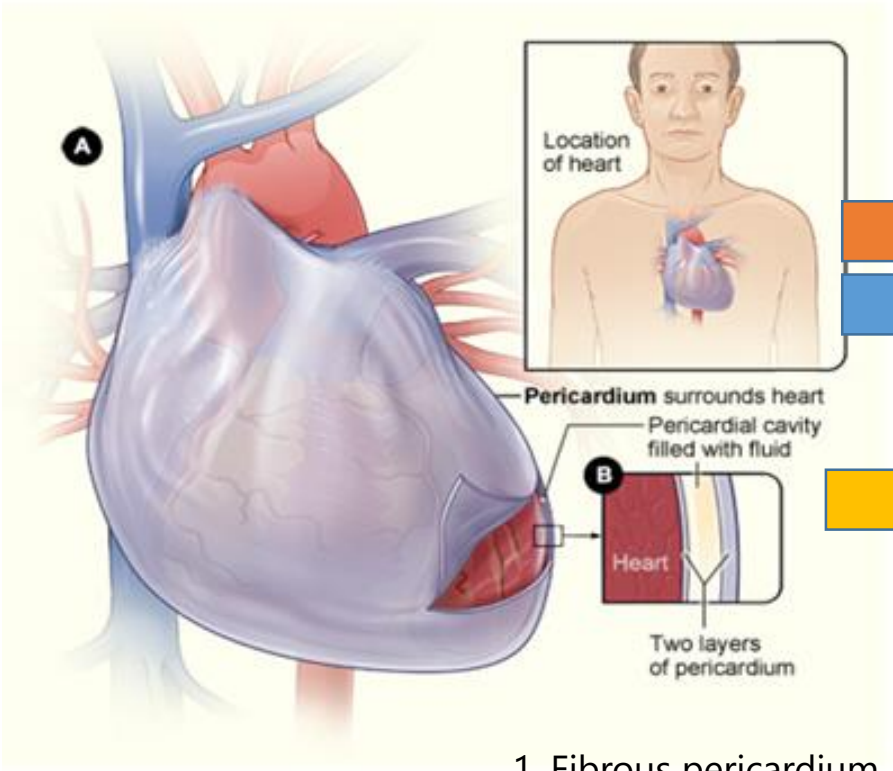


Fig. 20.3 (a) *Anterior view of the pericardium after removal of the anterior fibrous pericardium.* ***(b)*** *View of the posterior pericardial sac after removal of the heart. AA, ascending aorta; IVC, inferior vena cava; MPA, main pulmonary artery; SVC, superior vena cava. These images are provided courtesy of Professor Damián Sánchez-Quintana, MD, PhD.*

The Pericardium and layers



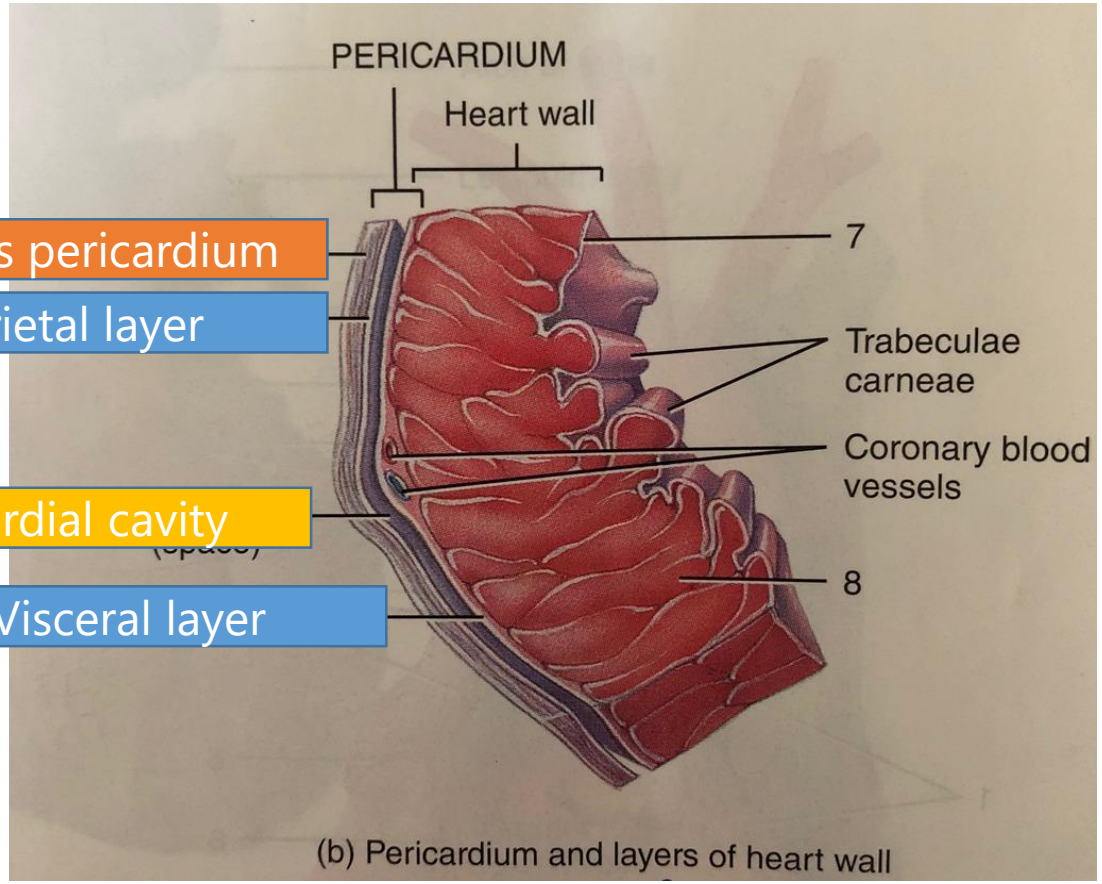
1. Fibrous pericardium
2. Serous pericardium

Fibrous pericardium

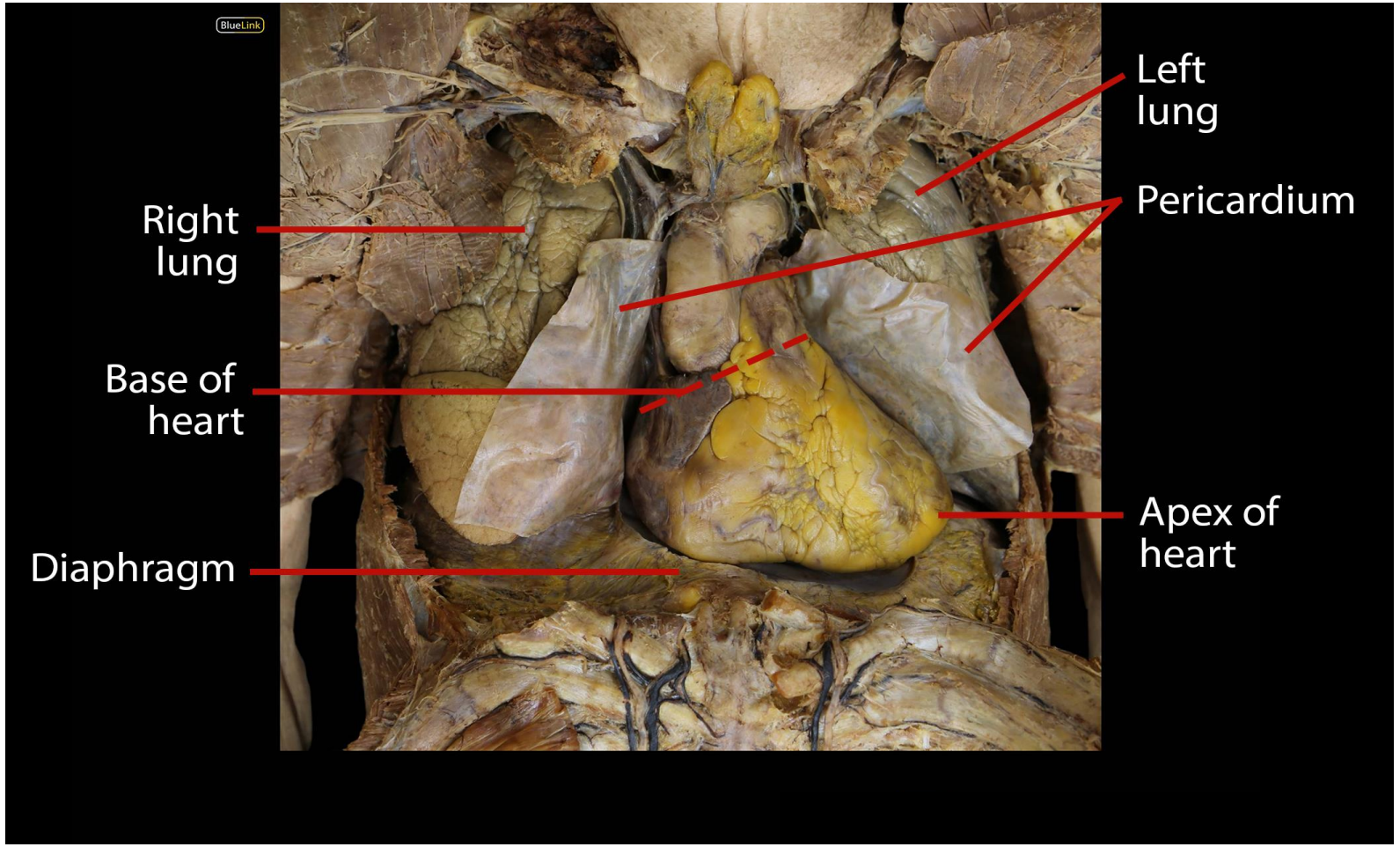
Parietal layer

Pericardial cavity

Visceral layer

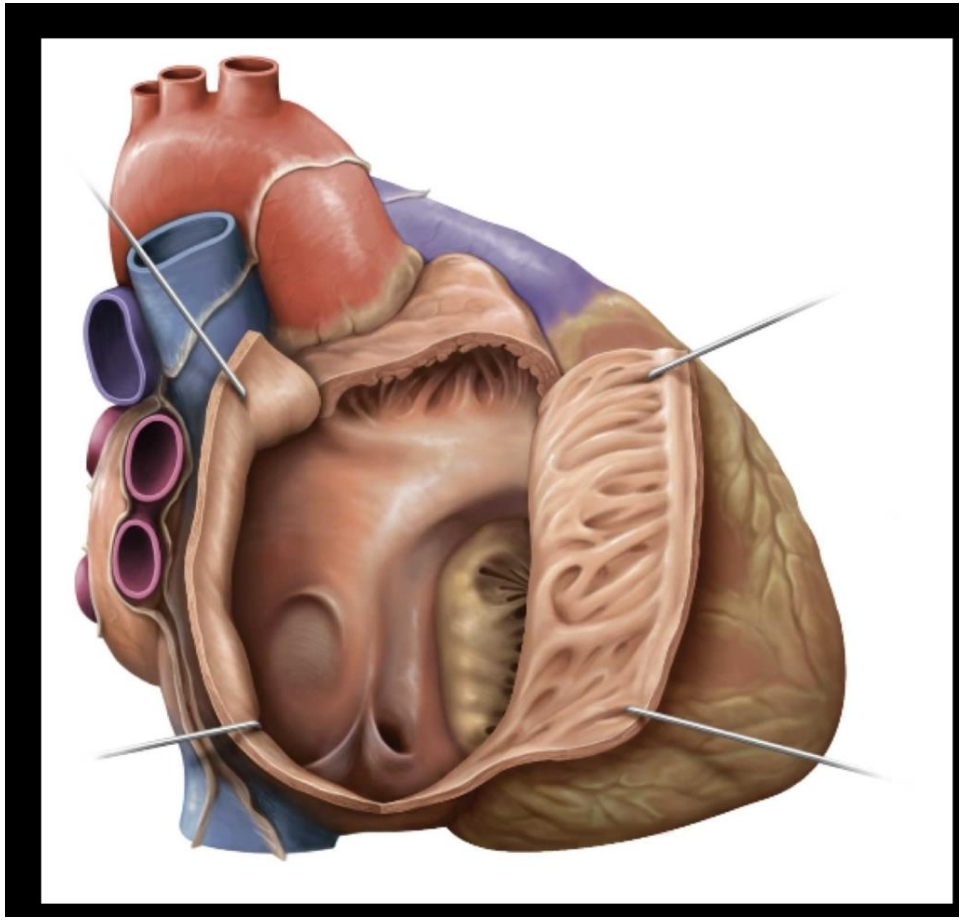


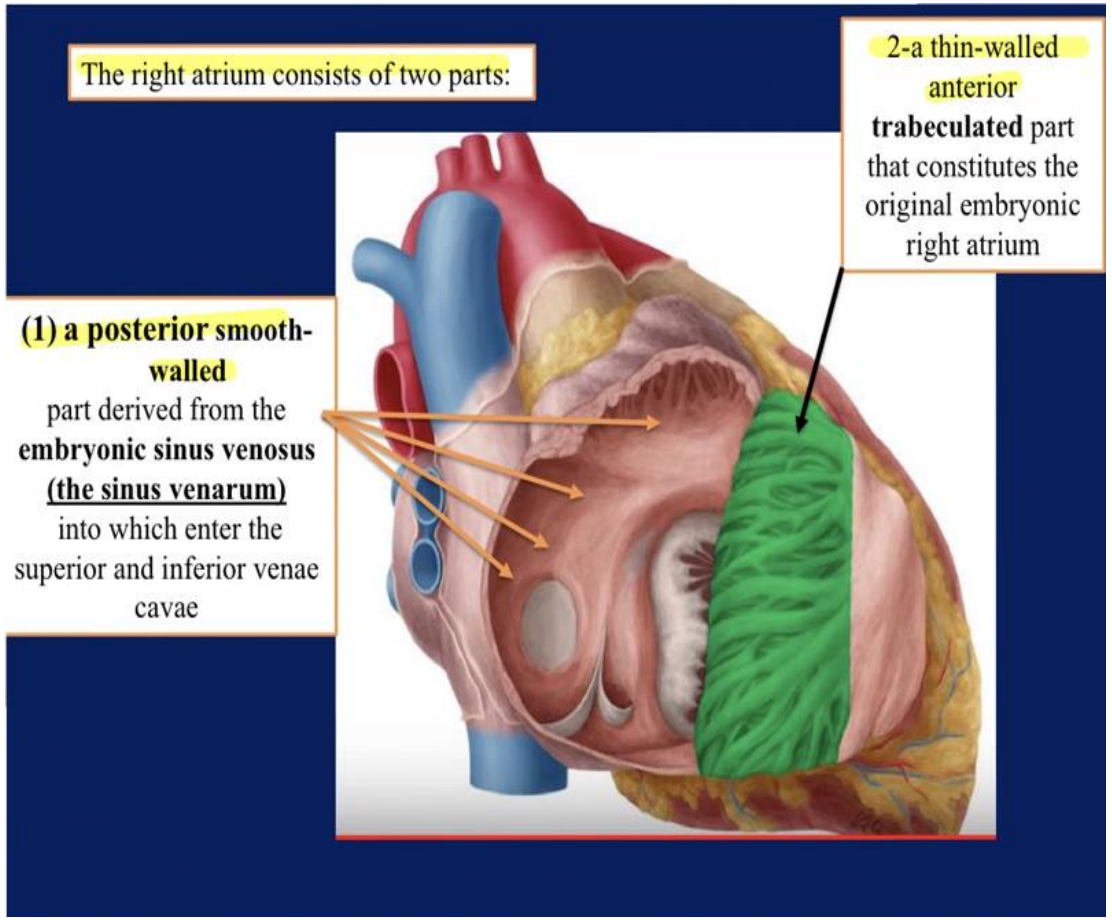
Size and Shape of the Heart



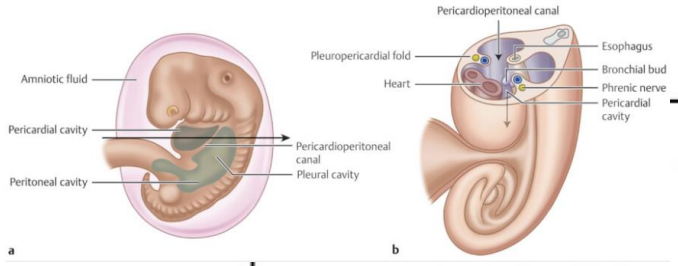
지방 조직(Adipose Tissue): 관상동맥 주위나 심장 표면에는 심장을 외부 충격으로부터 보호하고 에너지를 저장하는 지방층

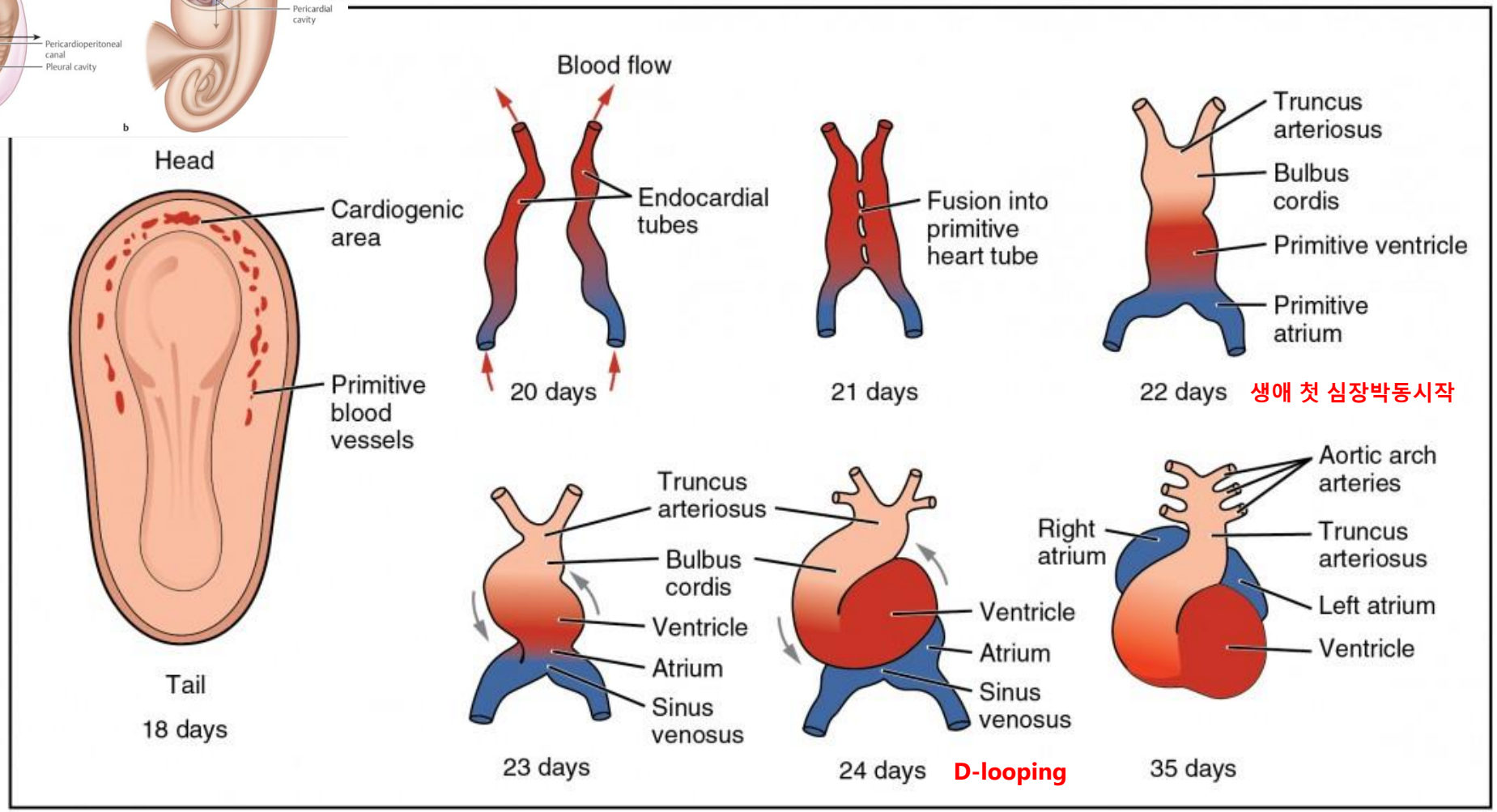
Right Atrium : smooth and rough part





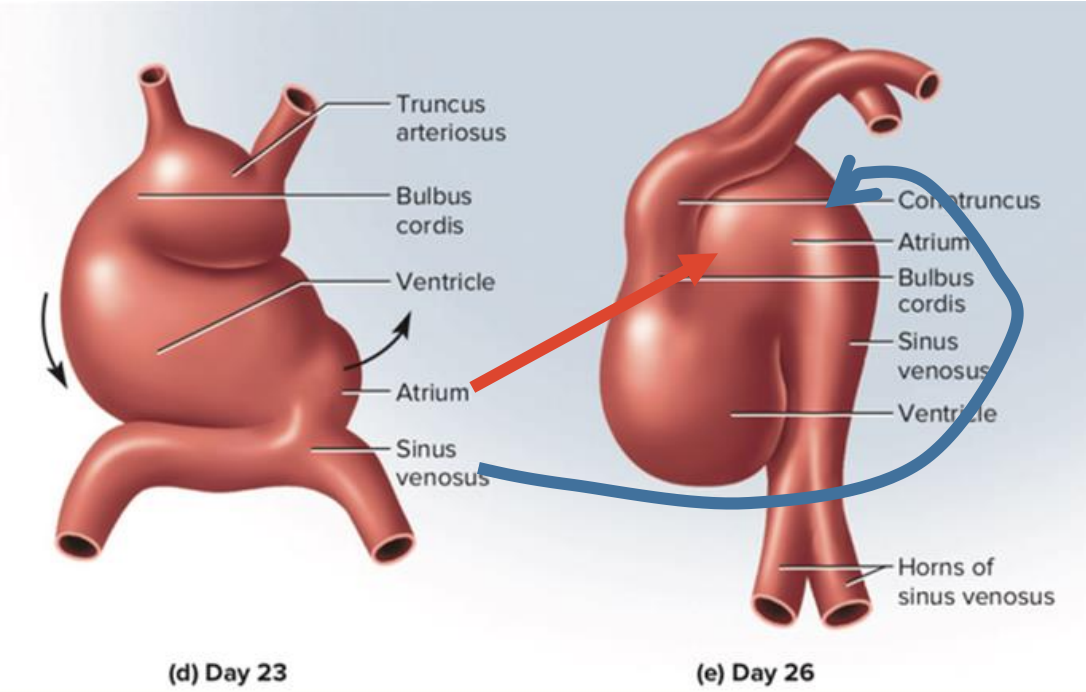
Embryology of the Heart





Embryology of the Heart

Atrial Architecture (Smooth vs. Pectinated Walls)



■ **Primitive atrium ---> 심방의 anterior wall 구성**

pectinated muscle

■ **Sinus venosus -----→ 심방의 posterior wall 구성**

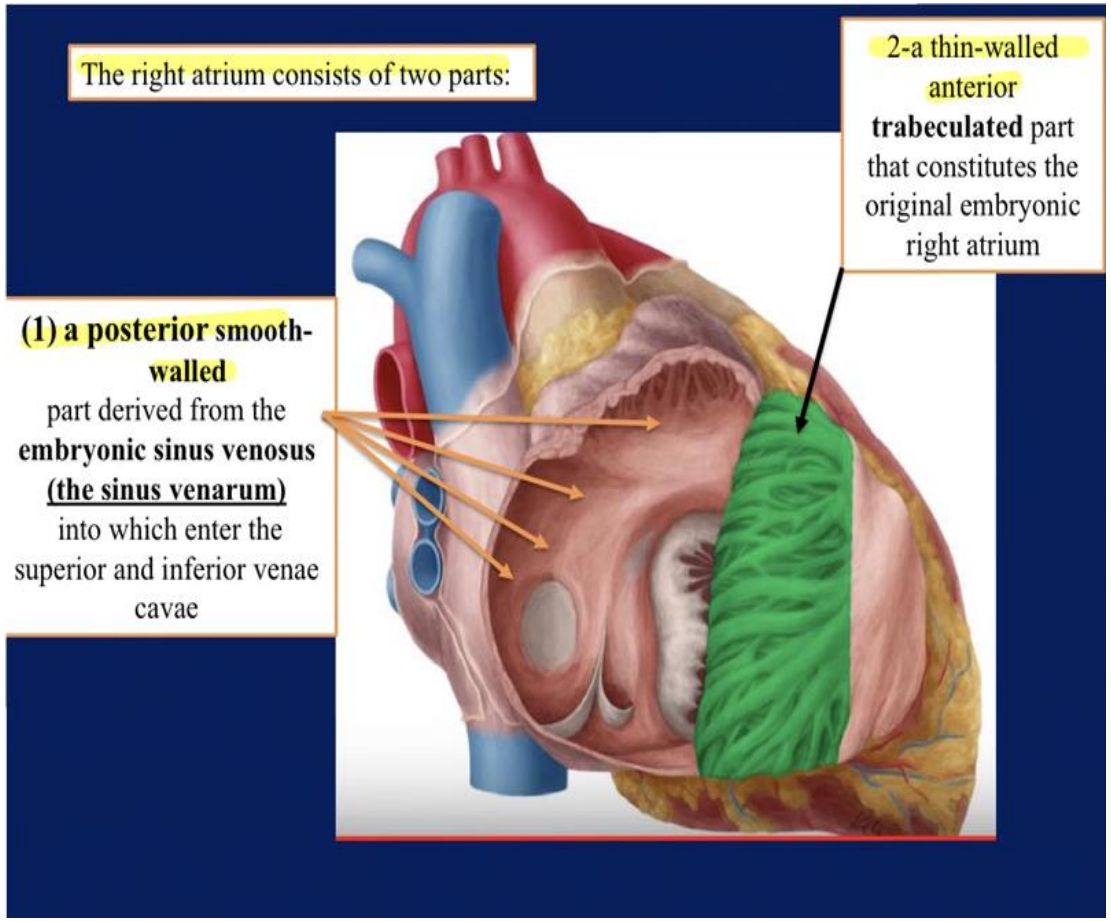
sinus venarum

Right Atrium : smooth and rough part

Sinus venosus

smooth wall

혈액이 원활히 들어오도록

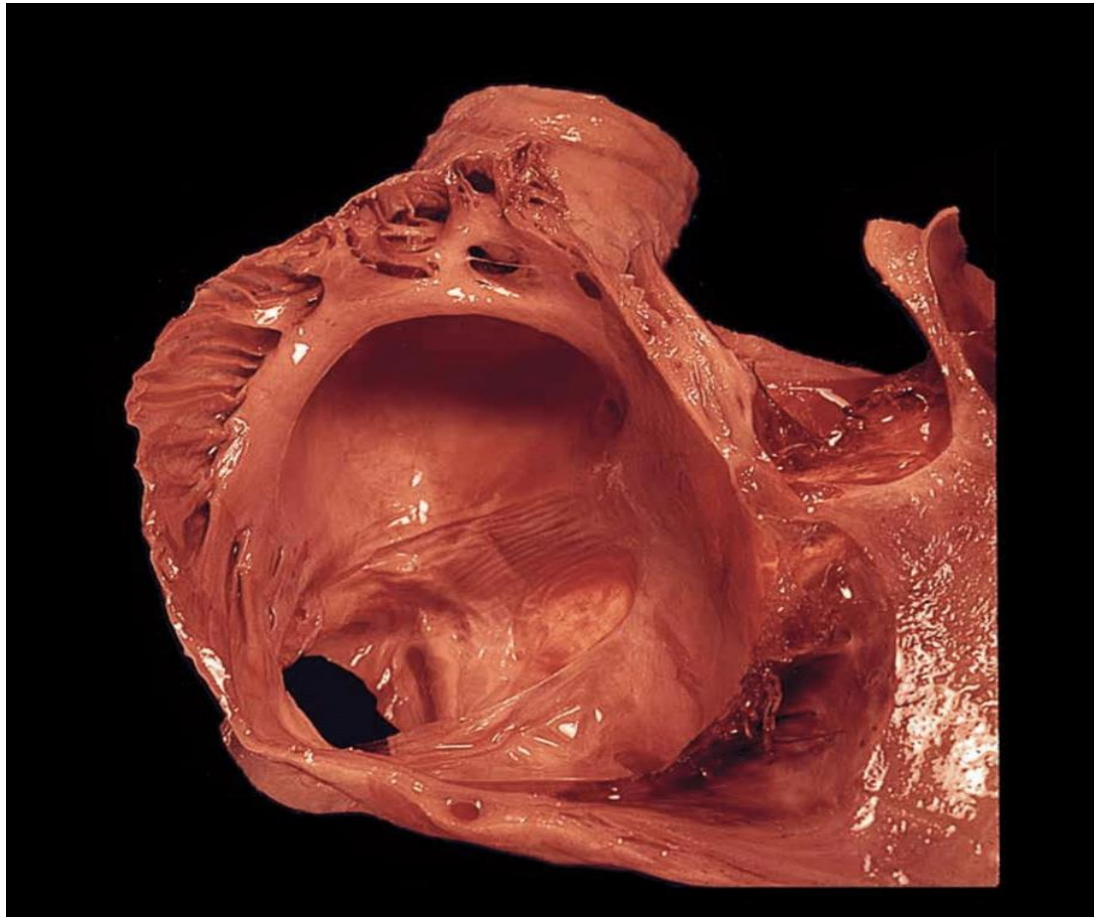


Primitive atrium

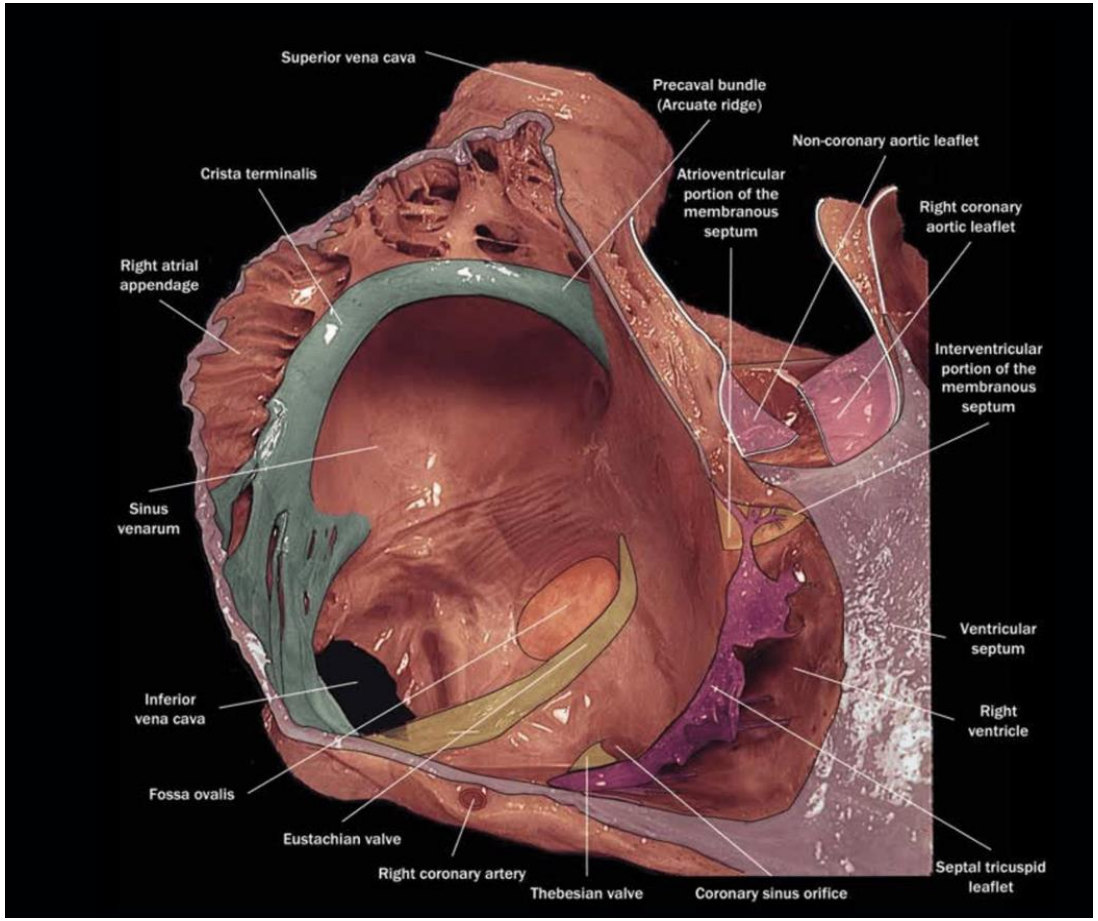
muscular wall

수축력 증가

Crista Terminalis

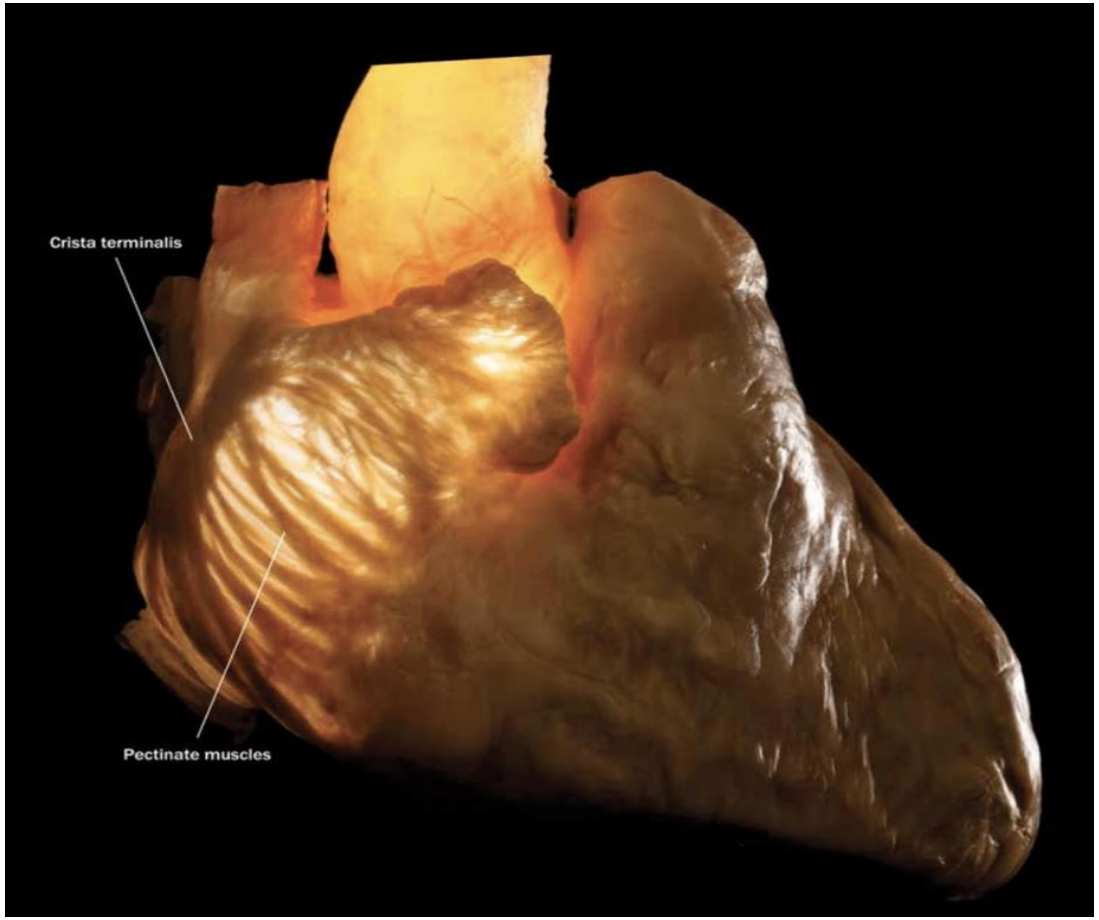


sinus venosus + primitive atrium = fusion line



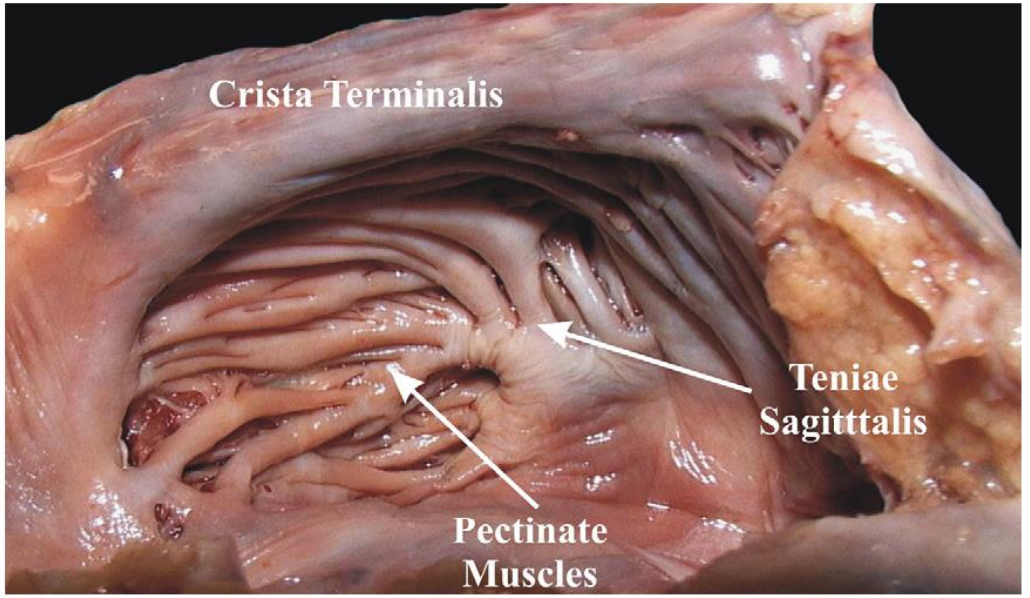
우심방의 “내부 경계선”

Pectinate Muscles



Crista terminalis를 따라서 심방내벽에 분포하는
빗살 모양의 근육다발

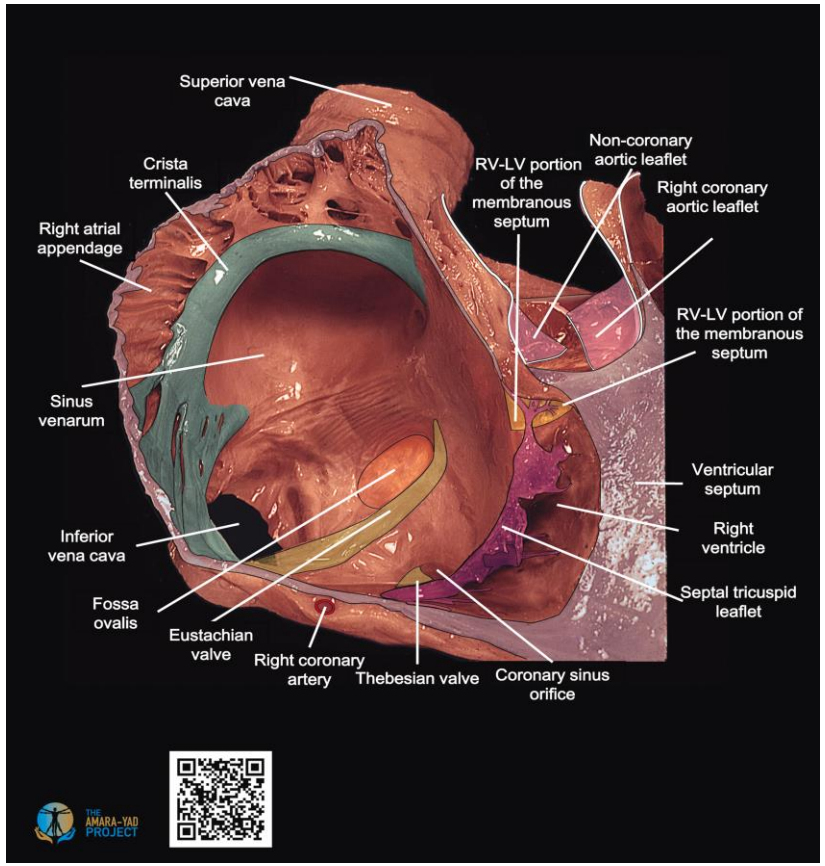
- ✓ 얇은 심방벽의 구조적 지지
- ✓ 심방의 수축력을 증강



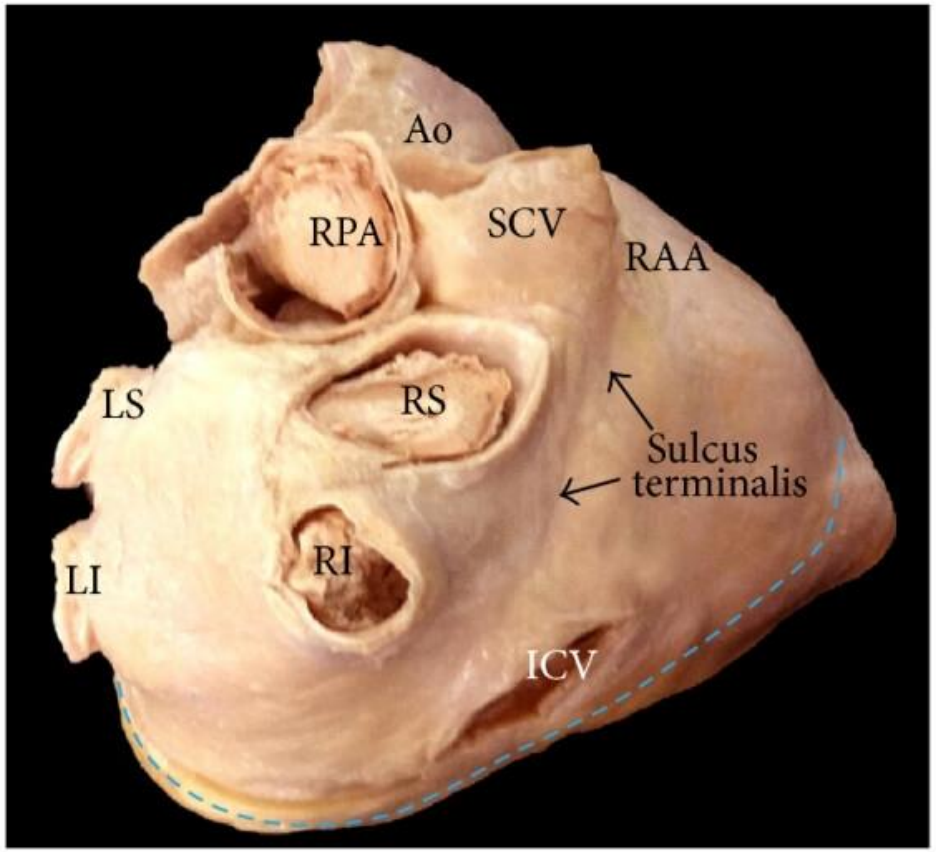
* Tenia sagittalis : pectinate muscle 다발

Sulcus Terminalis

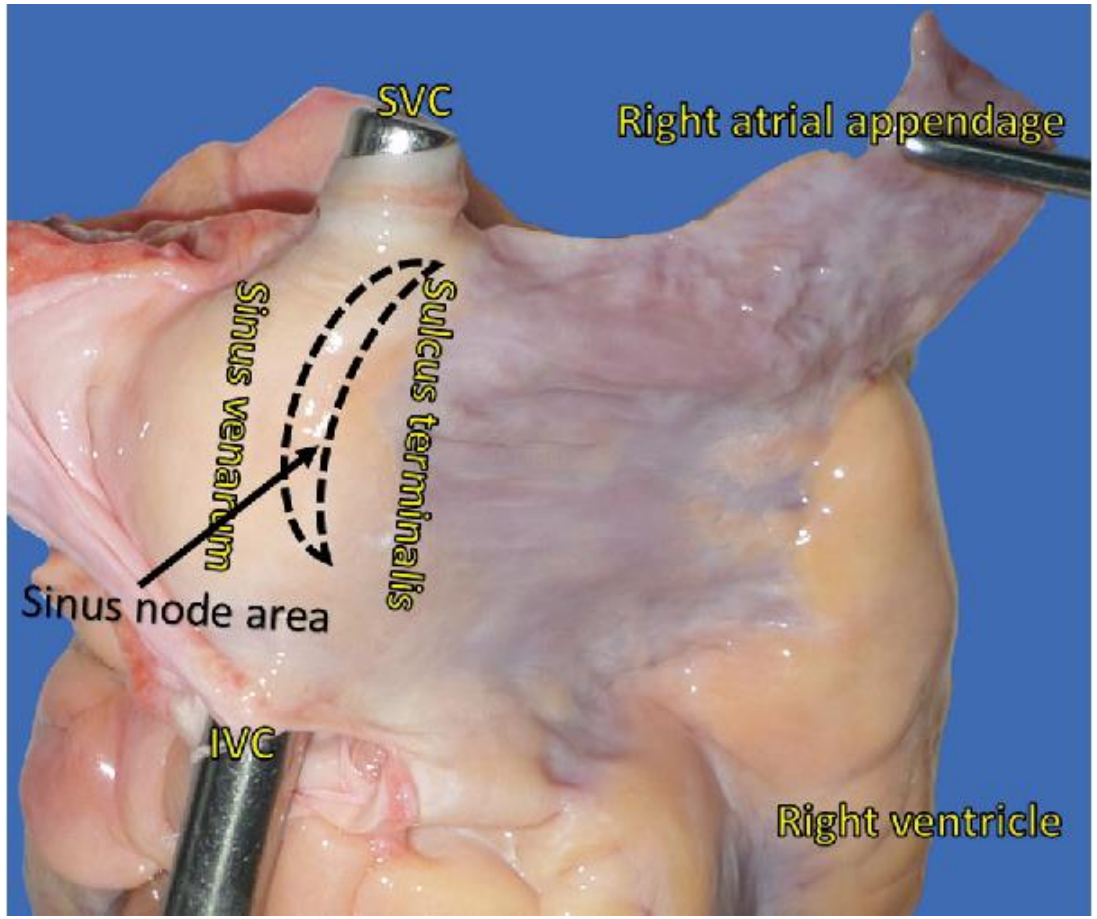
내측: cristal terminalis



외측 : 표면에서 **SVC–IVC를 연결하는 세로 방향의 홈**

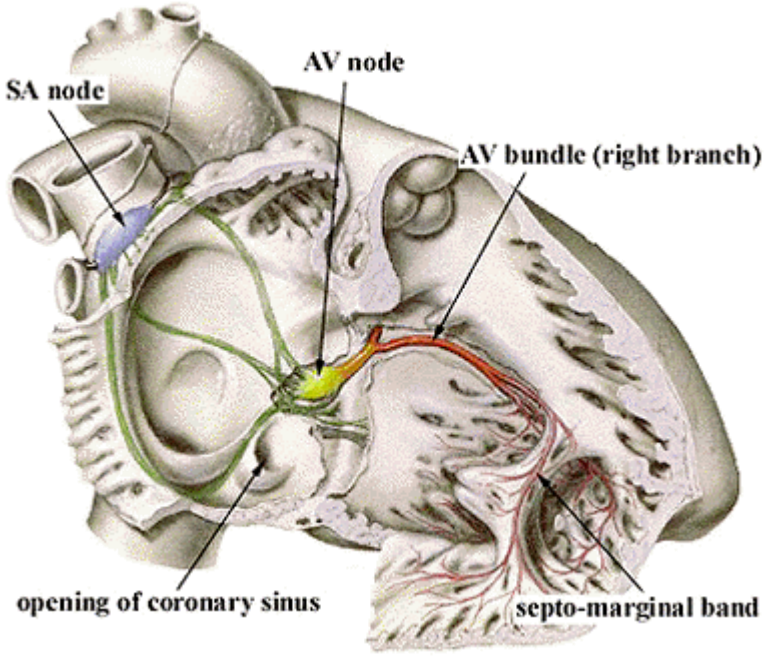


Sinoatrial (SA) Node : Anatomical Location

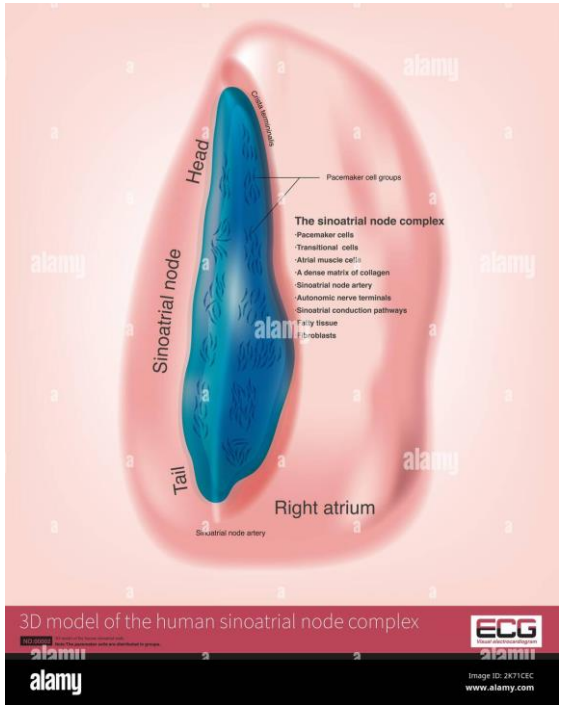


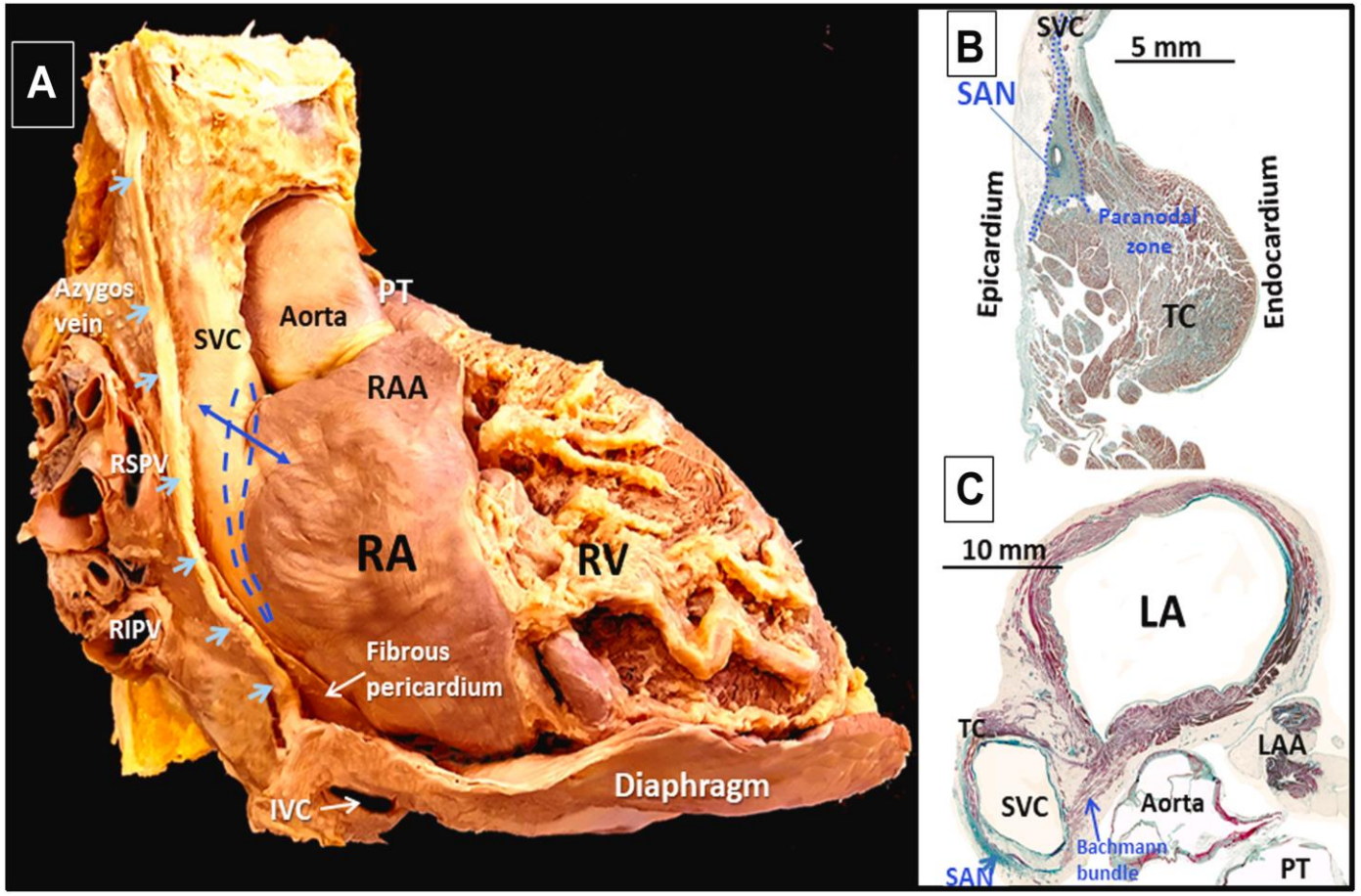
SVC-RA junction 부위에 위치

sulcus terminalis의 상부 안쪽면에 위치
(subepicardial)



Pacemaker complex of SA node





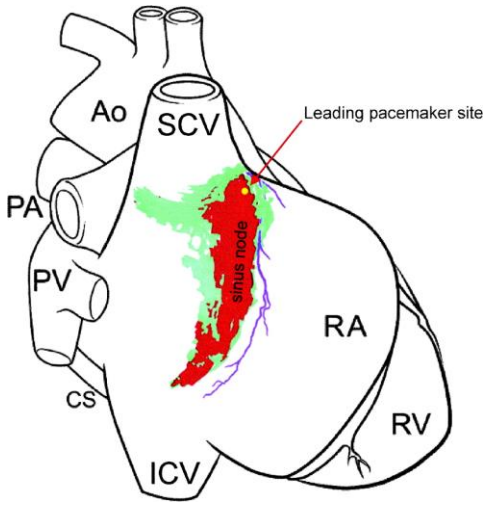
길이: 약 **10–20 mm**
폭: **2–3 mm**
두께: 약 **1 mm**
초승달 모양 또는 길쭉한 방추형
단일 점(point)이 아니라 **기능적으로 확장된 pacemaker complex**로 존재

SAN는 왜 Pacemaker complex로 이루어졌나?

기능적인 측면

하나의 점에서 모든 심방을 탈분극 시키기에는 전기적 부하가 너무 큼

따라서 여러 site가 동기화되어 집단적으로 작동 하기 위함



안정성 확보측면

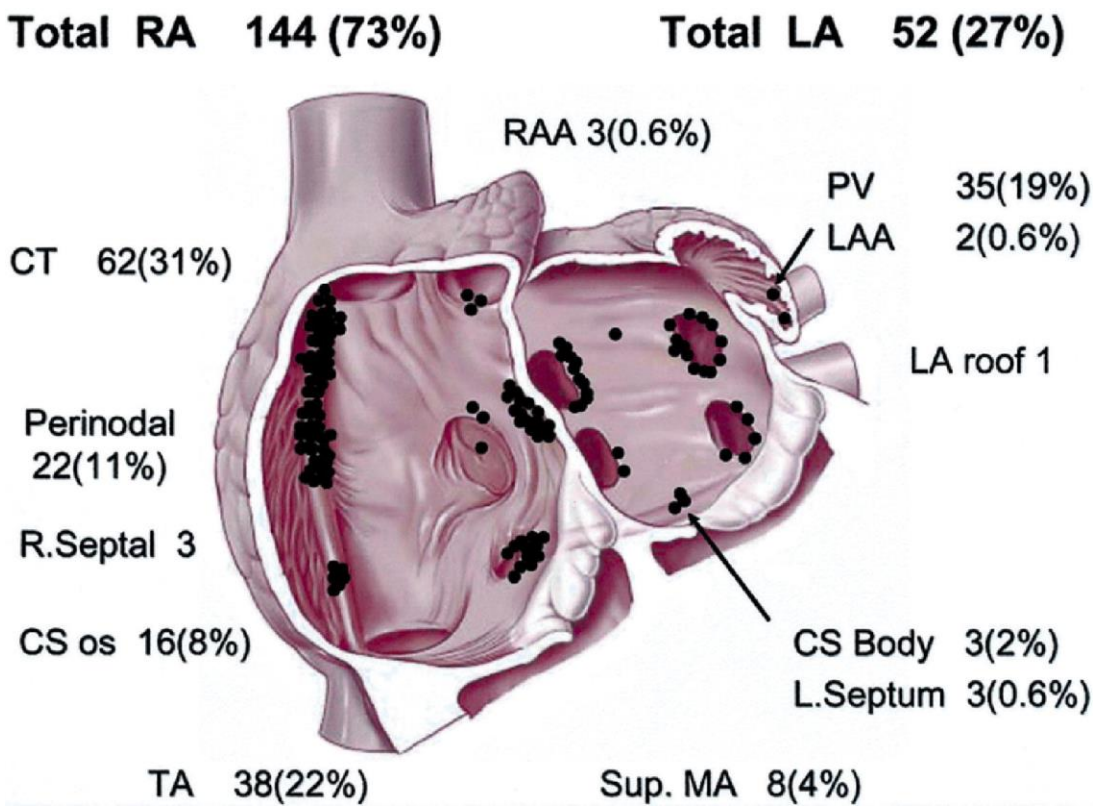
1) 단일 점 구조였다면? 주변의 국소 허혈에 매우 취약

2) 노화에 따른 조직의 섬유화 시 즉시 기능 상실

☞ 어느 일부분이 고장이 나도 나머지 부위가 기능을 유지 하기 위함

즉, 생존을 위한 안정성과 유연성을 확보하기 위한 구조적 전략이다

(Crista Terminalis)는 우심방 부정맥의 주요 발생지



심방빈맥(Atrial Tachycardia)

1) 근섬유 배열의 이질성 (Anisotropy)

smooth posterior RA와 **pectinated anterior RA**

→ 전도 속도와 방향성이 달라짐

→ **conduction heterogeneity 발생**

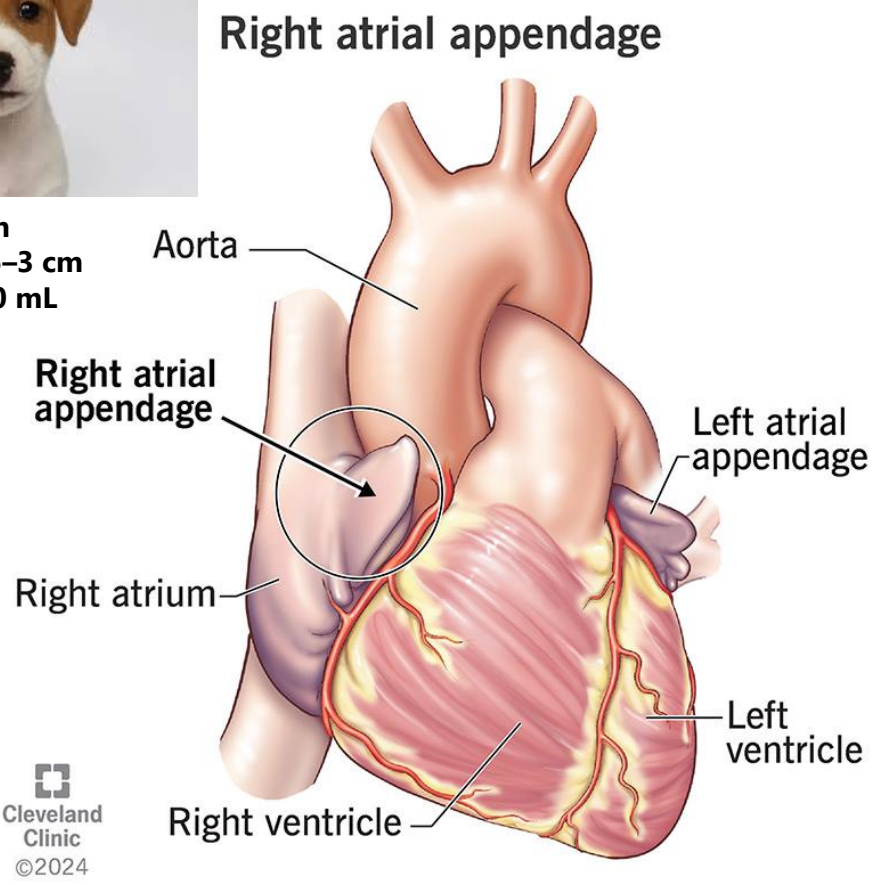
2) Pacemaker complex 근처

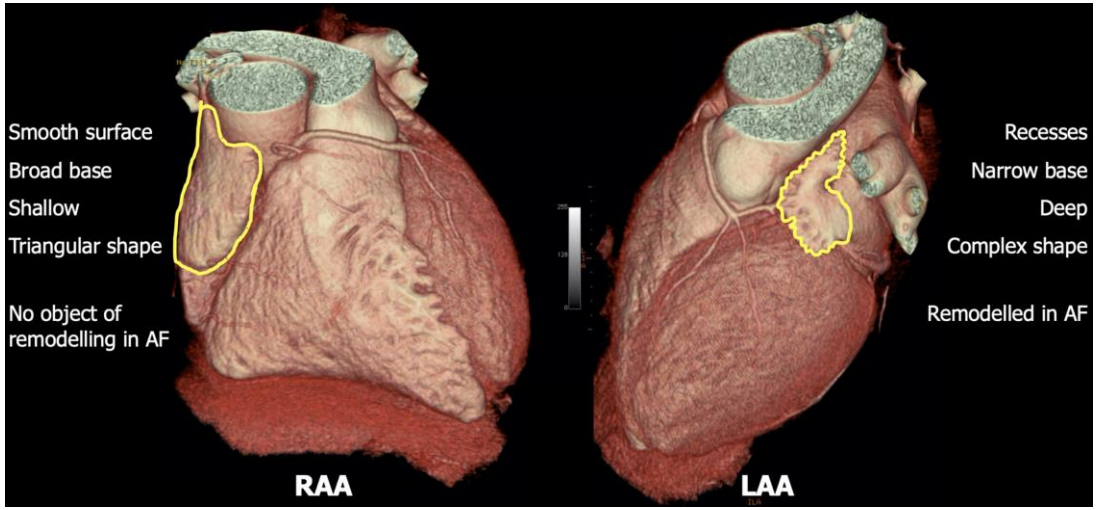
central pacemaker cells + 주변 transitional cells

→ **focal atrial tachycardia**

RA Appendage

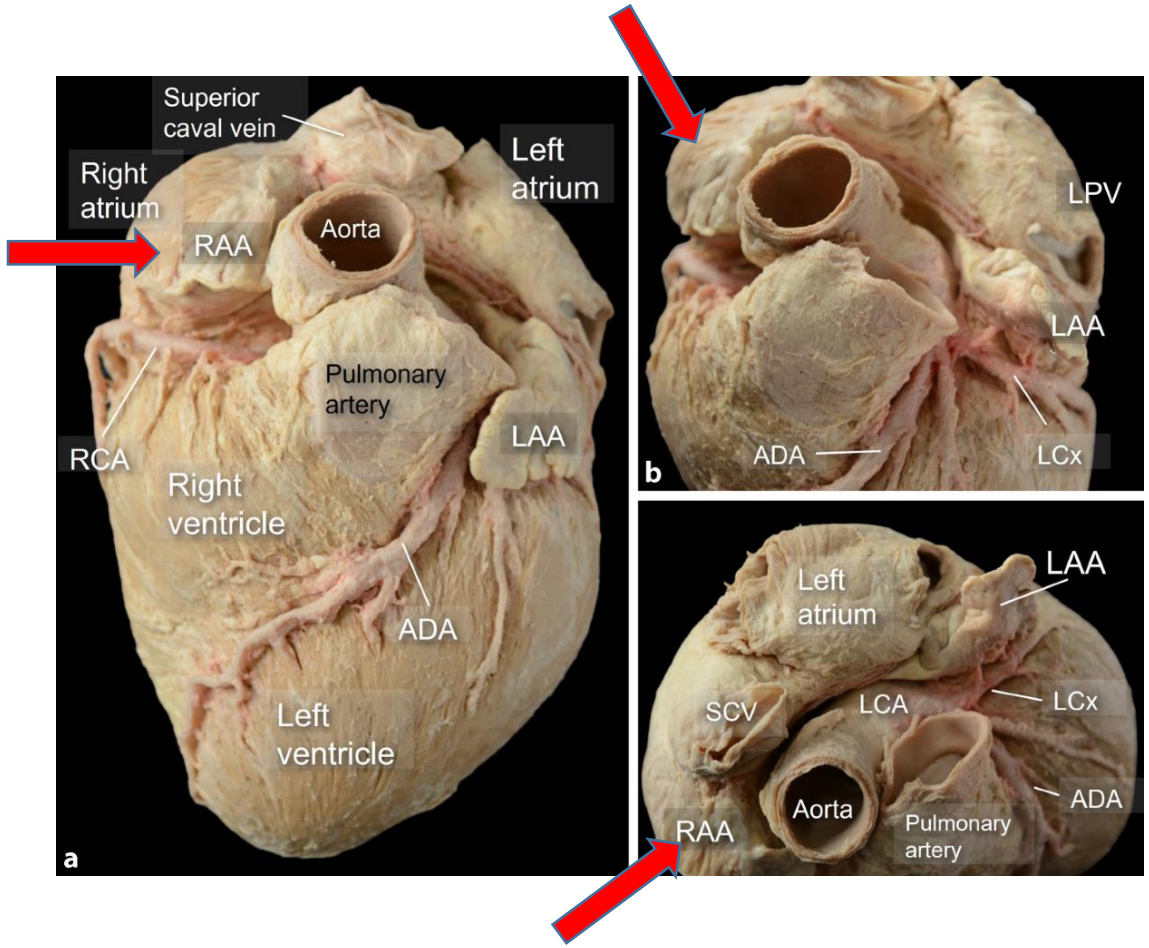
•길이: 약 **2–4 cm**
•(ostium): 약 **1.5–3 cm**
•용적: 대략 **5–10 mL**

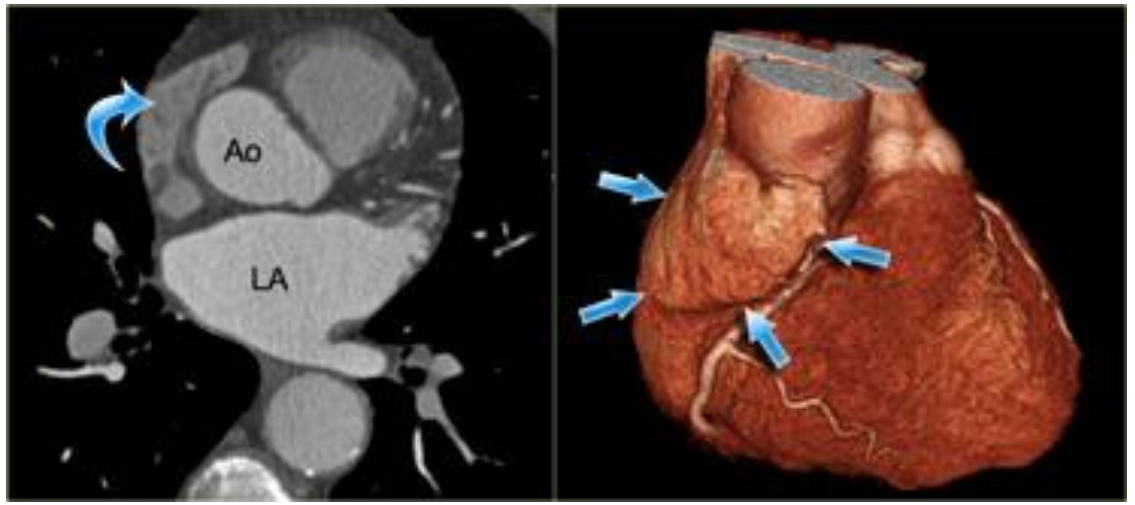




구분	RAA	LAA
형태	비교적 단순	매우 다양
근육 구조	pectinate muscle 풍부	불규칙 trabeculation
혈전 위험	낮음	매우 높음 (AF에서)
임상적 중요성	상대적으로 낮음	LAA closure 대상

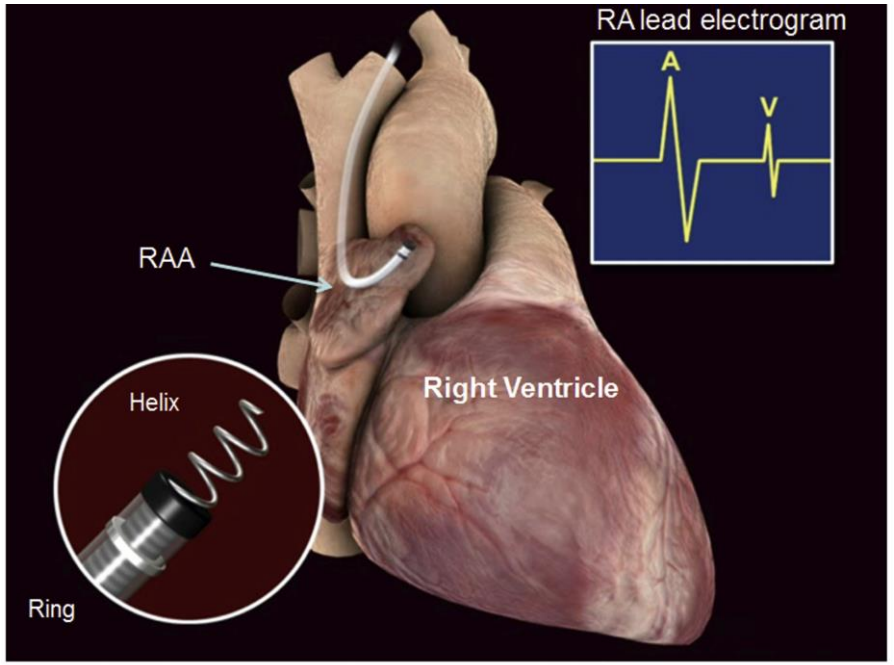
Right Atrial Appendage : Surrounding Anatomical Structures

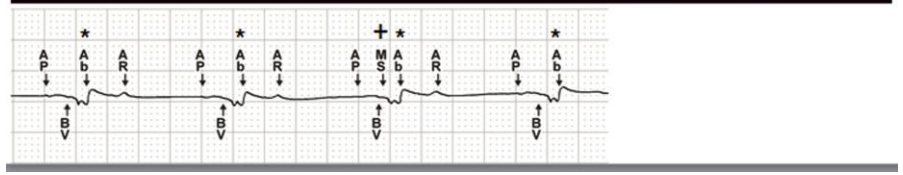




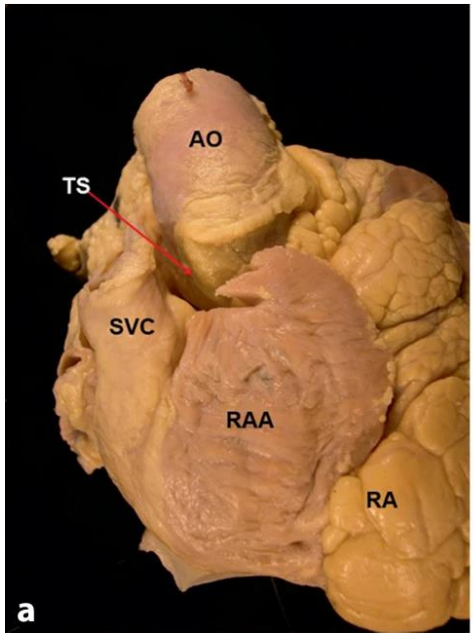
1. SVC
2. SA node
3. Crista terminalis
4. Right coronary artery (atrioventricular groove)
5. RVOT
6. Right phrenic nerve

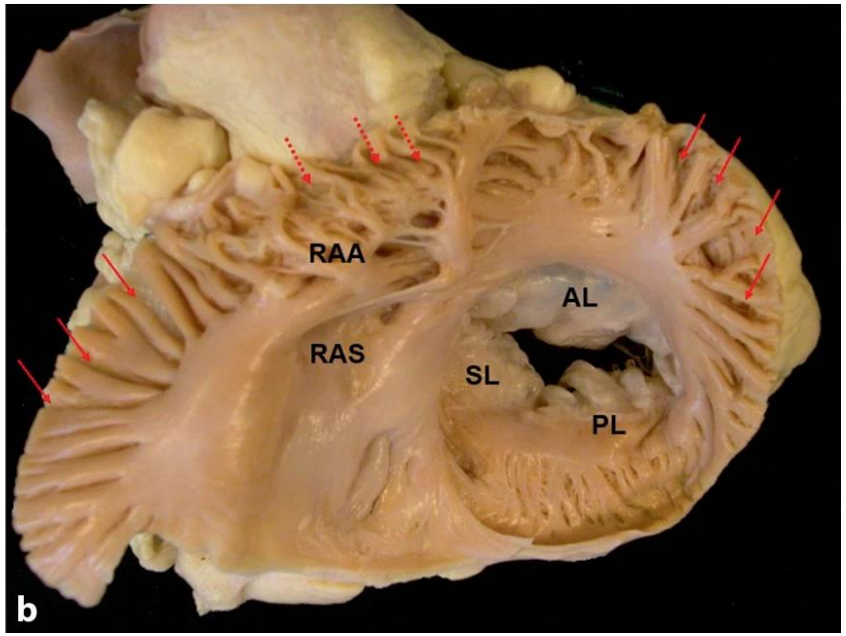
pacemaker lead placement in the RAA





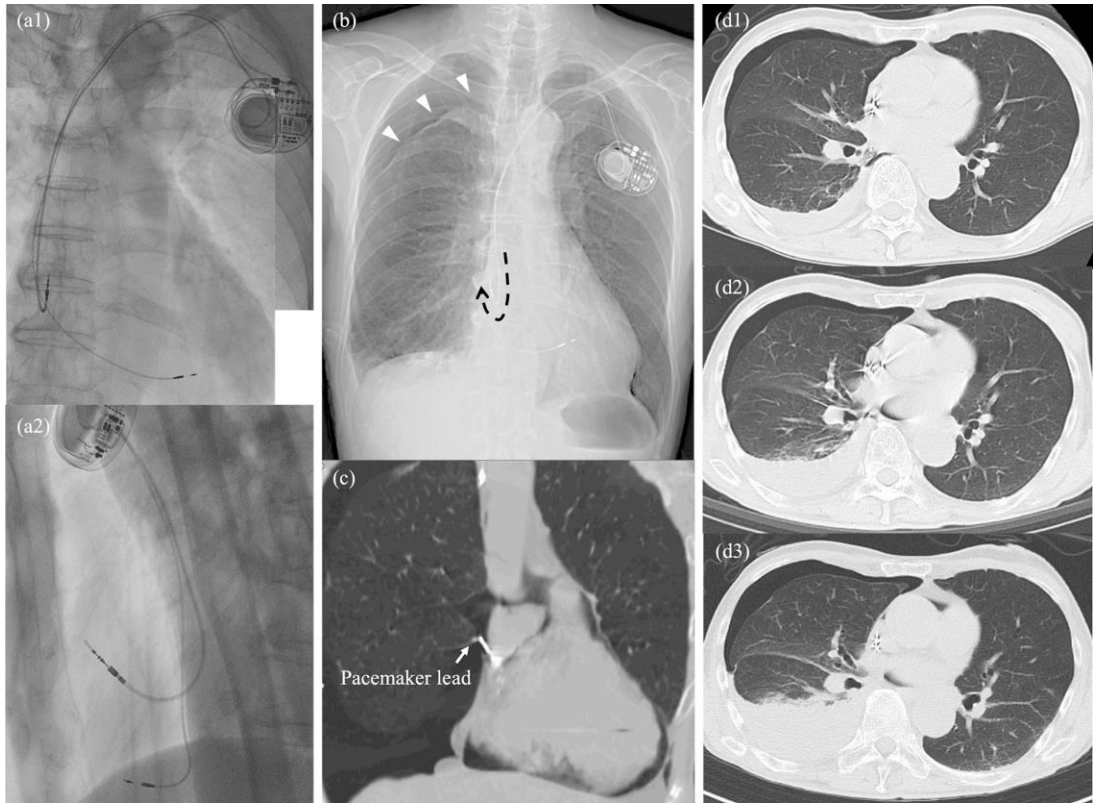
fixation screw 1.5mm, perforate the wall주의

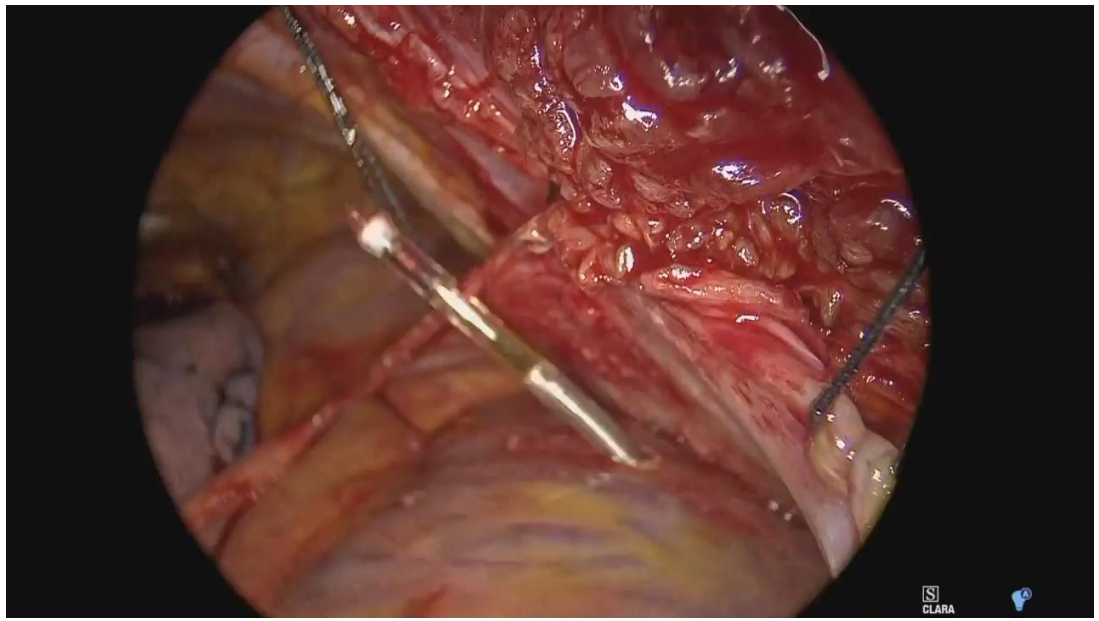




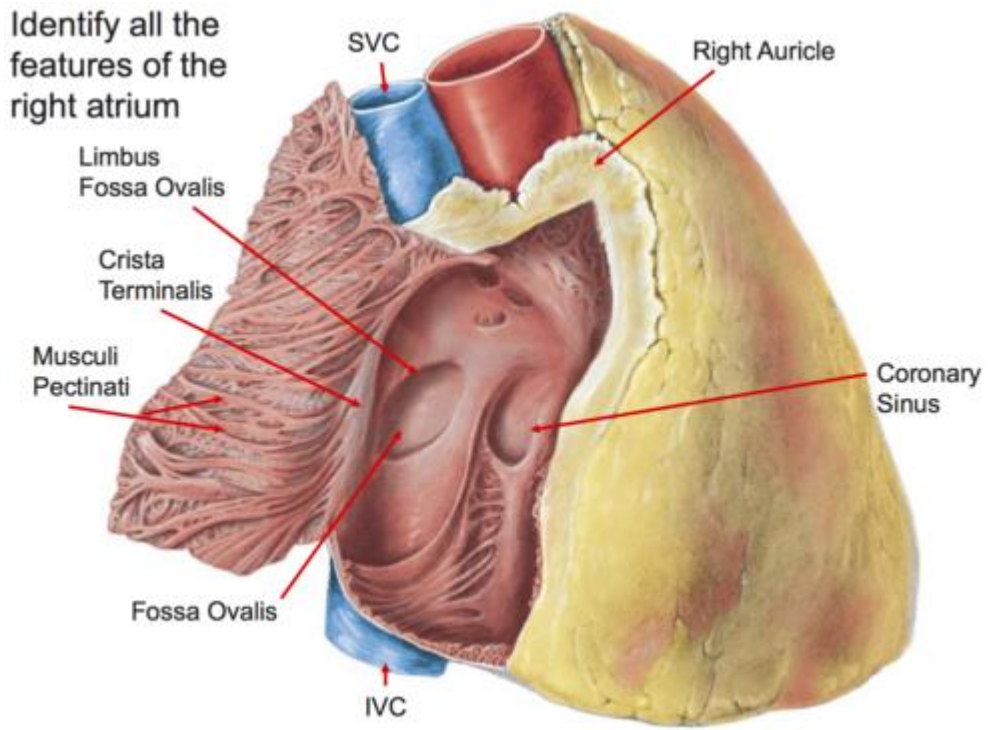
Right atrial appendage 1–2 mm
자유벽 (RA free wall)2–3 mm

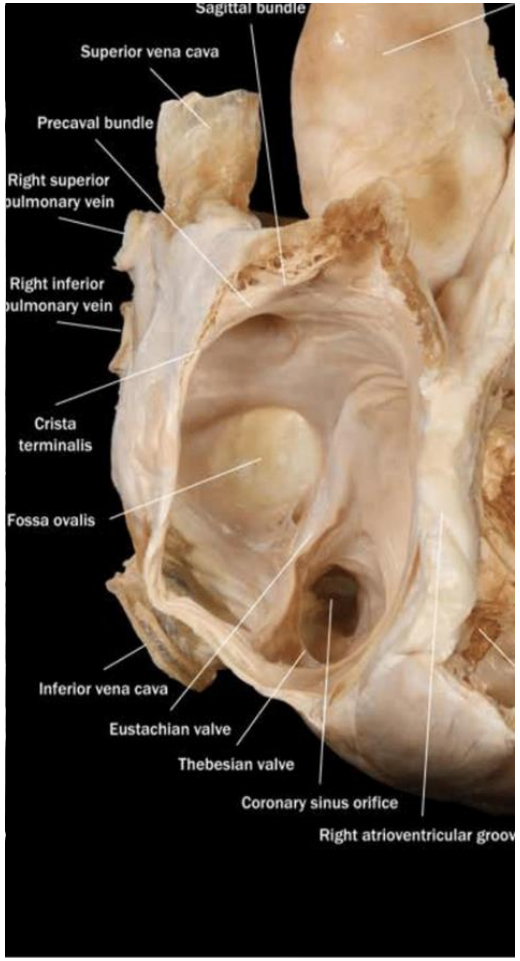
우심방(right atrium) 벽은 심장 구조 중에서도 가장 얇은 부위 중 하나입니다

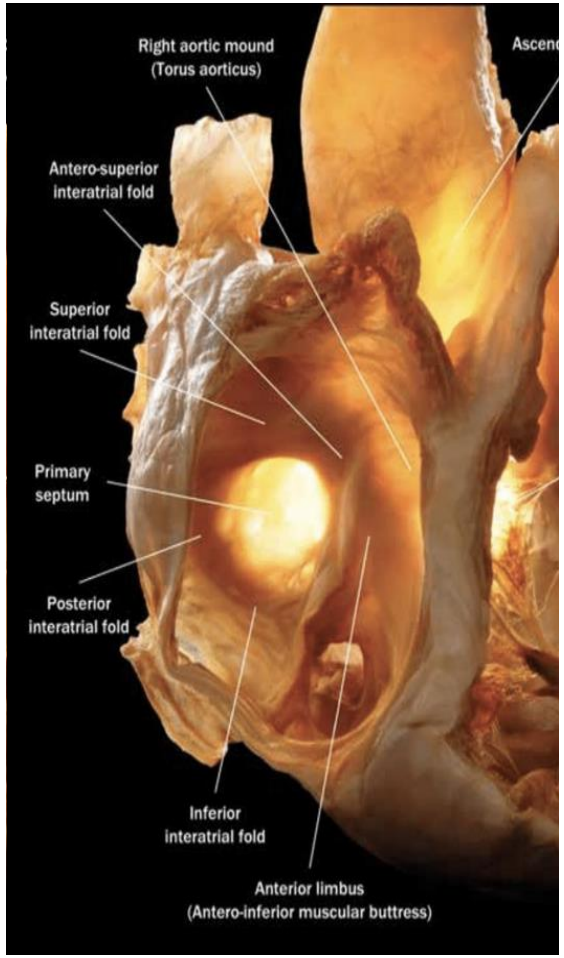




Septal Structures : Fossa Ovalis



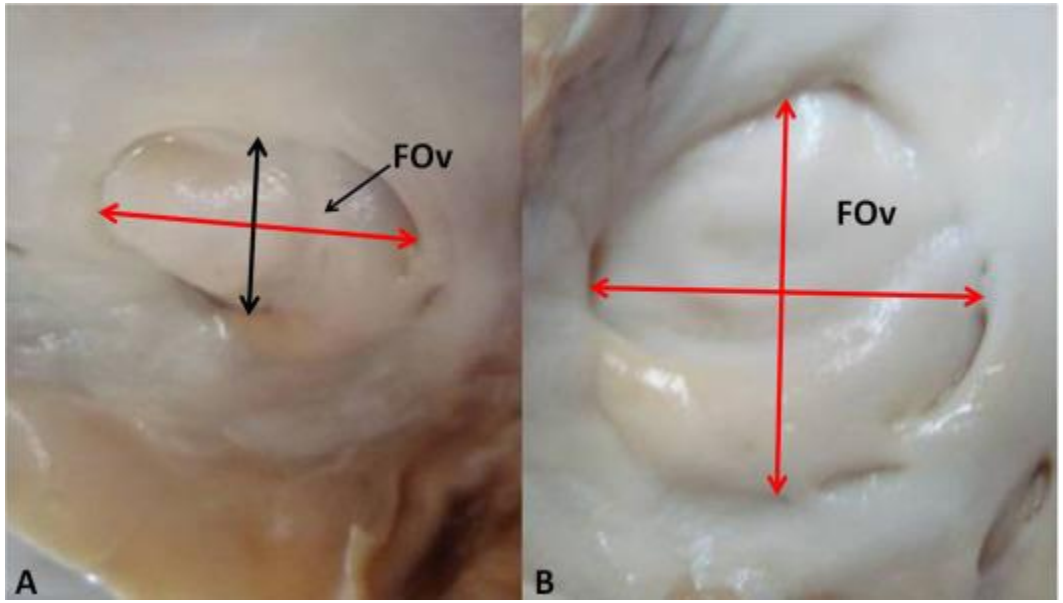




- ✓ 태아기의 **foramen ovale**가 닫히면서 남는 흔적
- ✓ 좌심방과 직접 맞닿는 가장 얇은 부위 1-2mm

Septal Structures : Fossa Ovalis

Shapes of fossa ovalis (FOv)



(A) Oval 81% (B) circular 14%

일반적인 성인의 평균 크기

- **길이 (superior–inferior)** : 약 **15–25 mm**
- **폭 (anterior–posterior)** : 약 **10–15 mm**

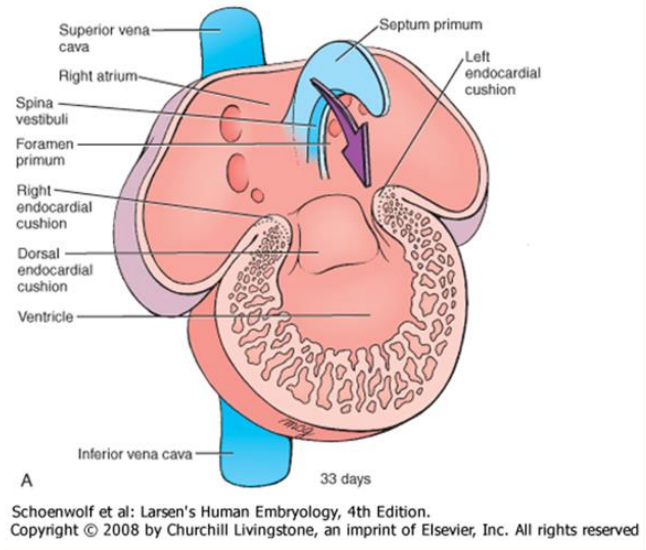
구조적으로는

- 중앙의 **fossa floor : 0.5-1.5mm**
- 주변의 두꺼운 **limbus (rim) : 3-5mm**

태아기의 **foramen ovale**가 닫히면서 남는 흔적

Embryology of the Interatrial Septum

대략 **배아 4주~6주 사이**에 형성



(common atrium) 4주(roof)

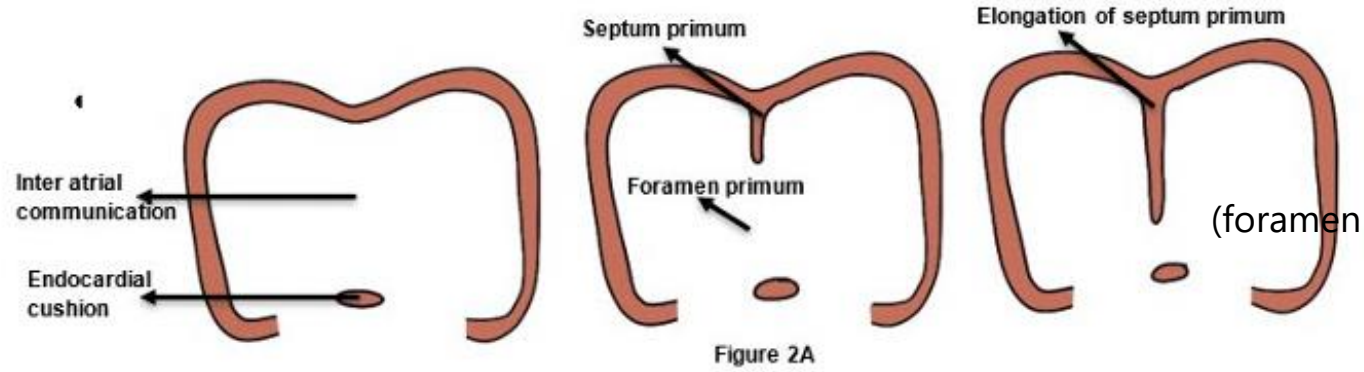


Figure 2A

(foramen primum)

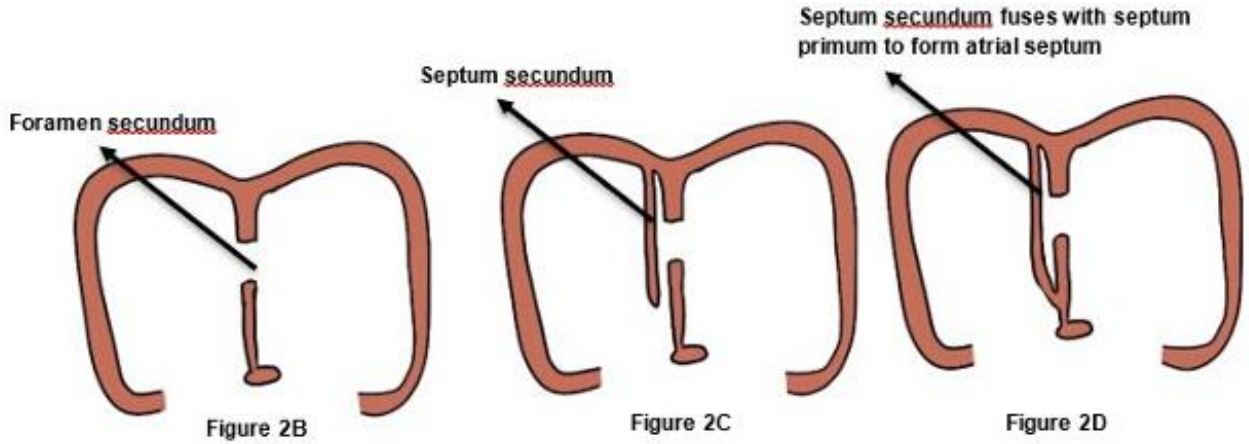
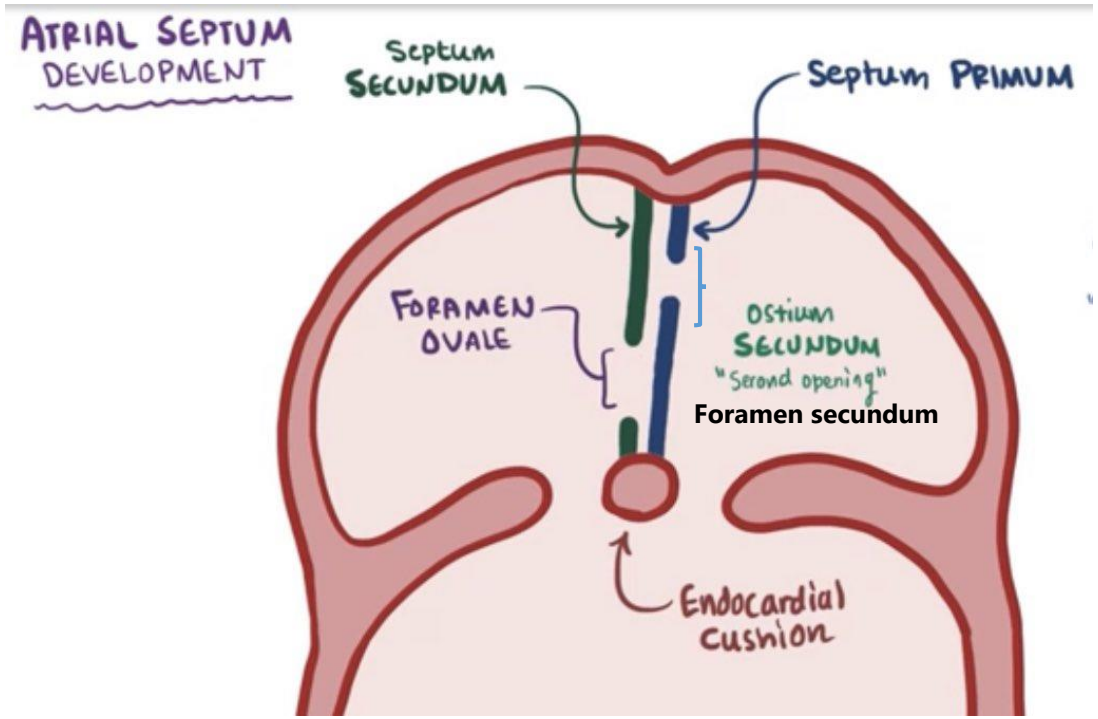


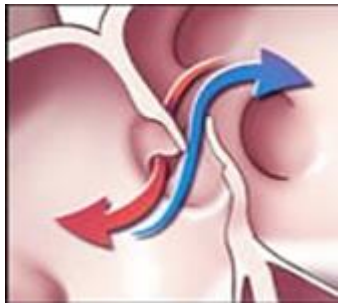
Figure 2B Figure 2C Figure 2D

(foramen secundum)

5주
(septum secundum)
(foramen ovale)

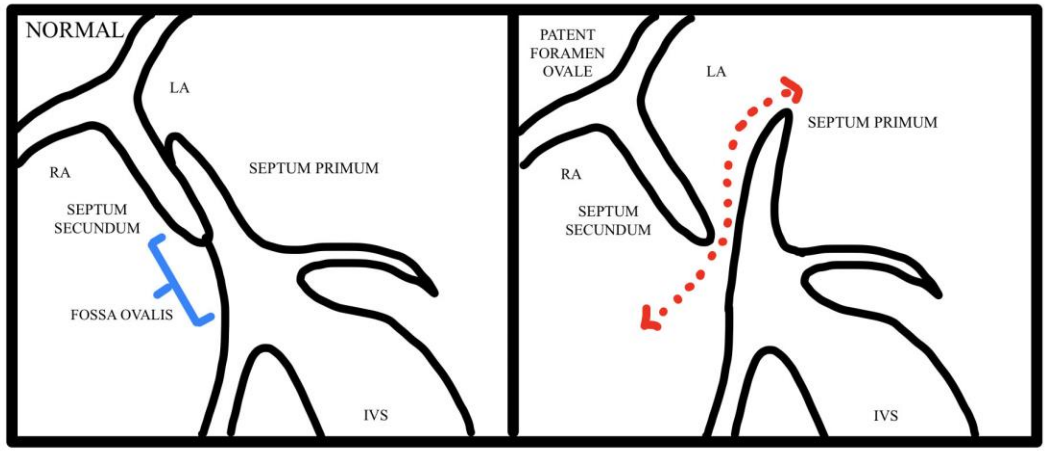
Embryology of the Interatrial Septum





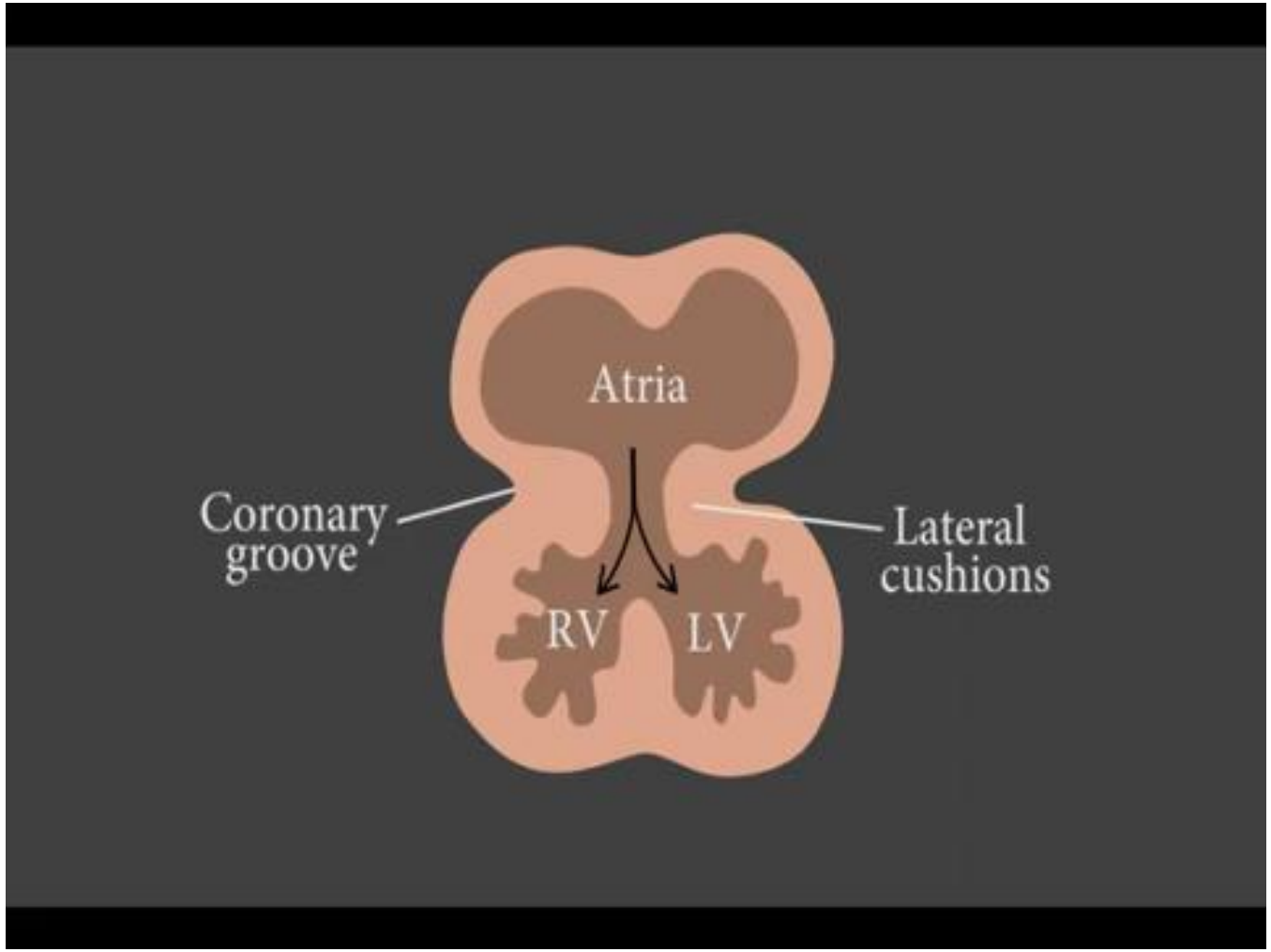
Septum primum : 매우 얇고 막성(membranous)

Septum secundum : 두껍고 근육성(muscular)

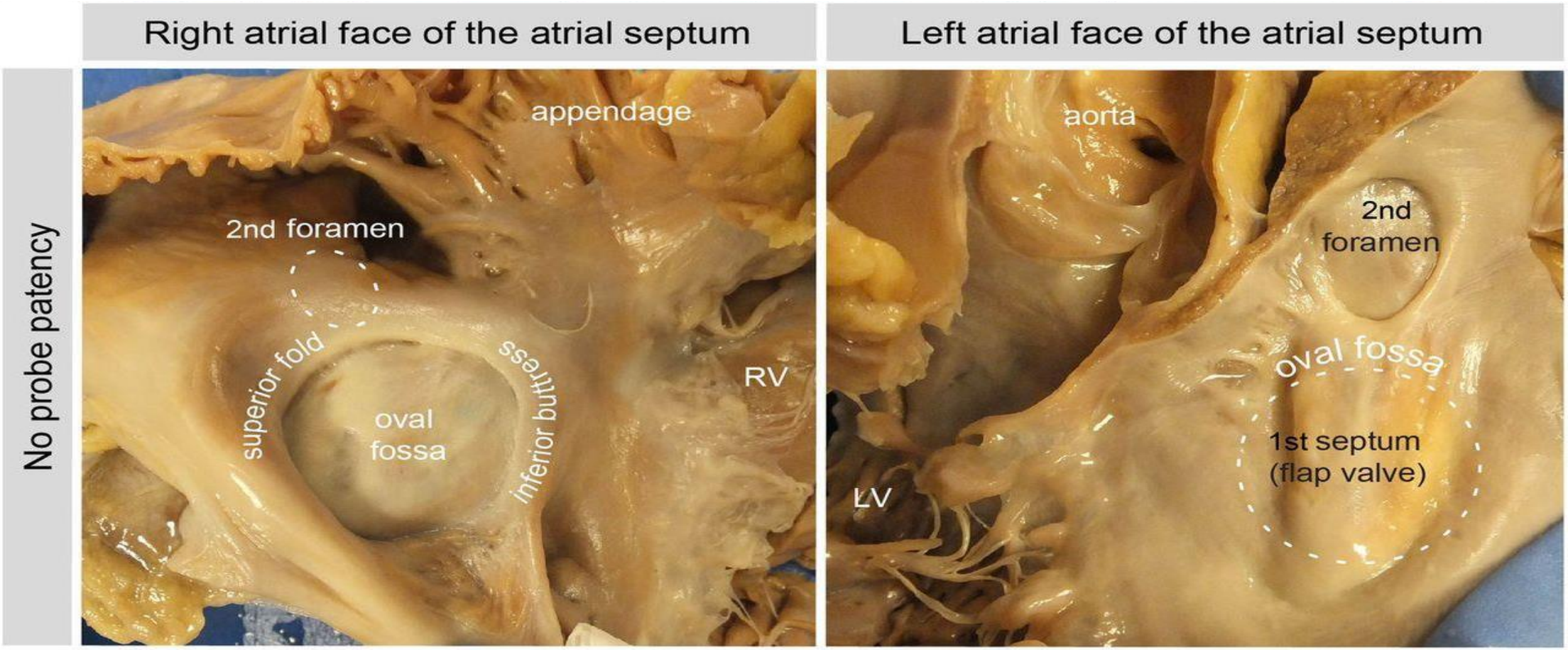


fossa ovalis **foramen ovale**

Embryology of the Interatrial Septum



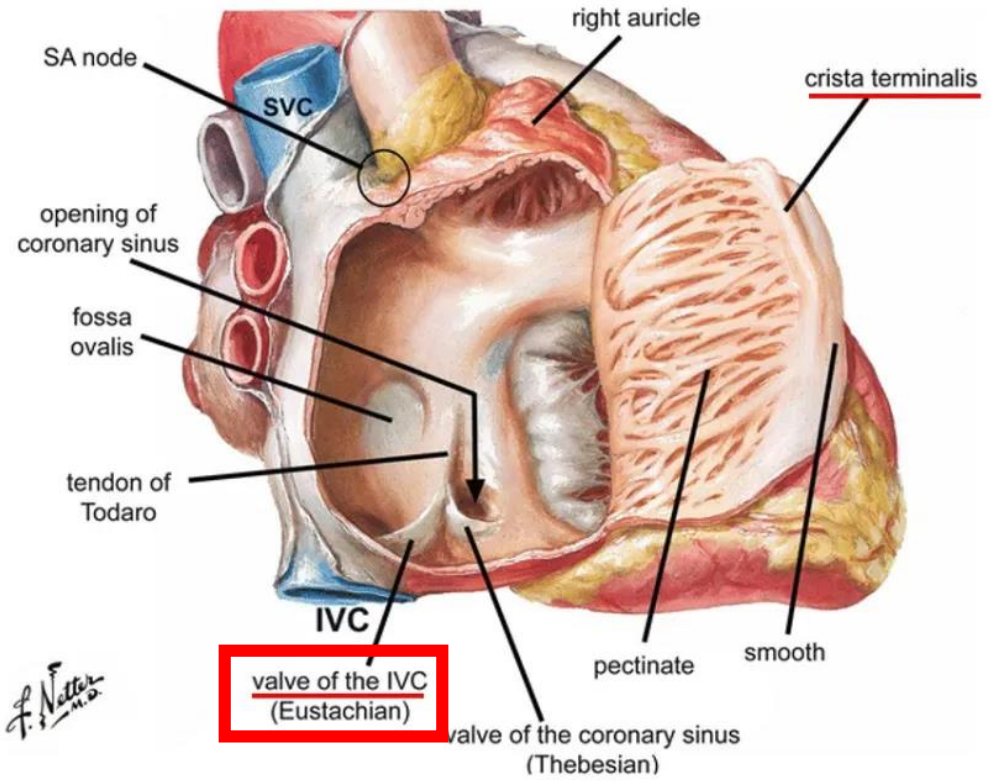
Septal Structures : Fossa Ovalis



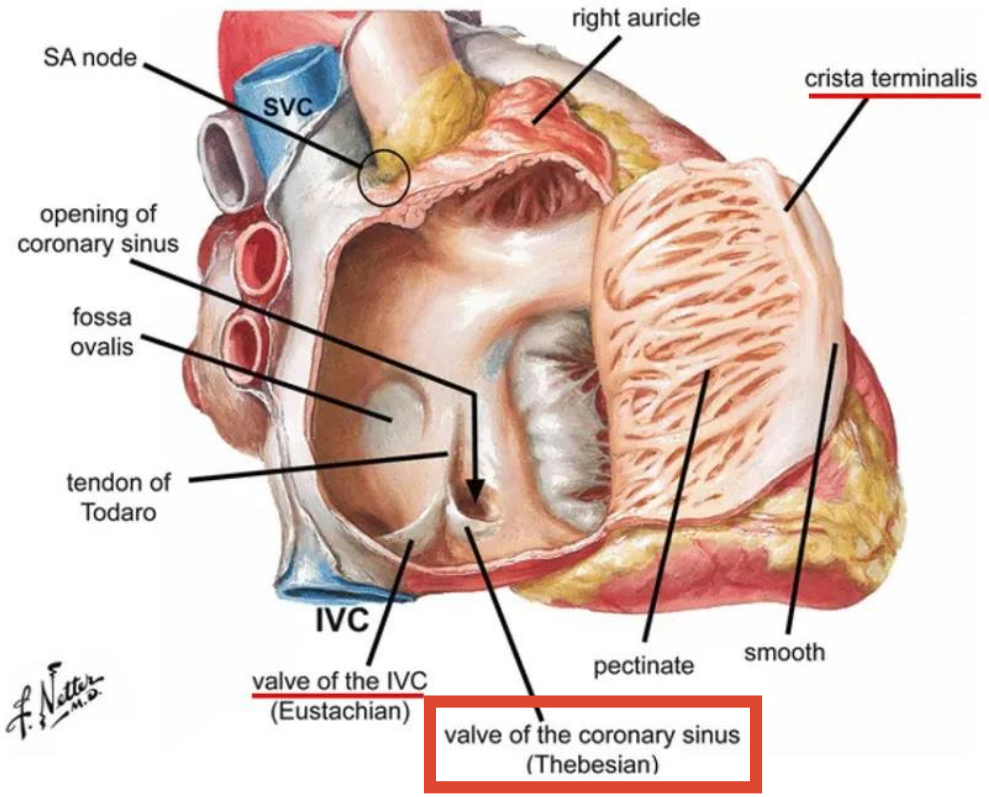
- Fossa ovalis floor → septum primum
- fossa ovalis rim (limbus) → septum secundum

Right venous valve of the sinus venosus

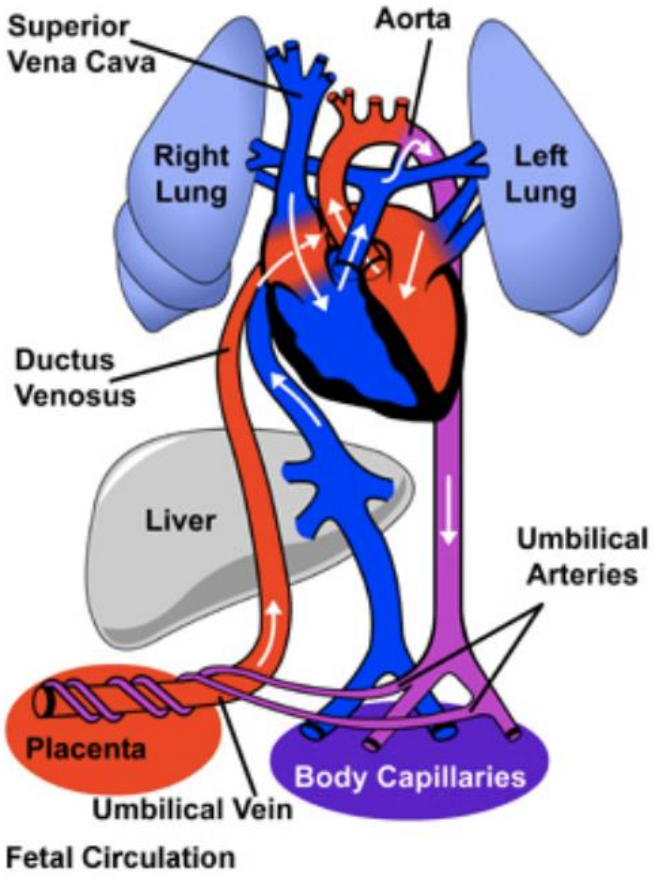
Eustachian valve



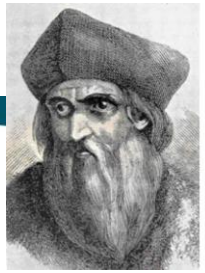
Thebesian valve



Eustachian valve of Right venous valve



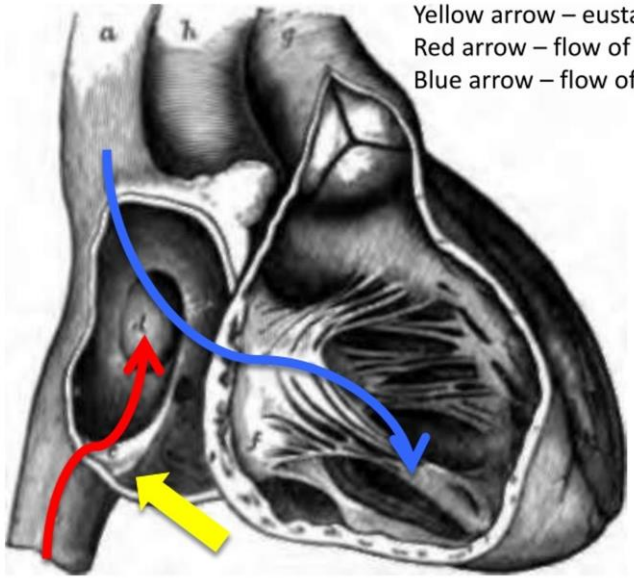
Fetal Circulation



Bartolomeo Eustachio

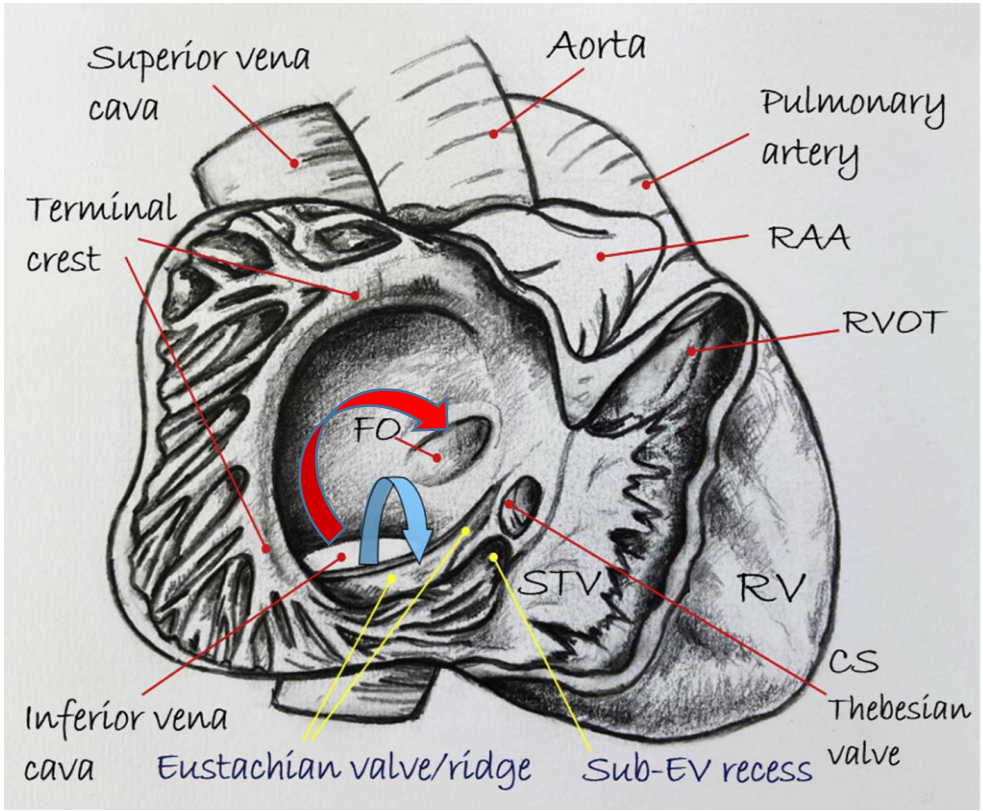
San Severino Marche (Macerata), 1507? – Fossato di Vico (Perugia), August 27 1574

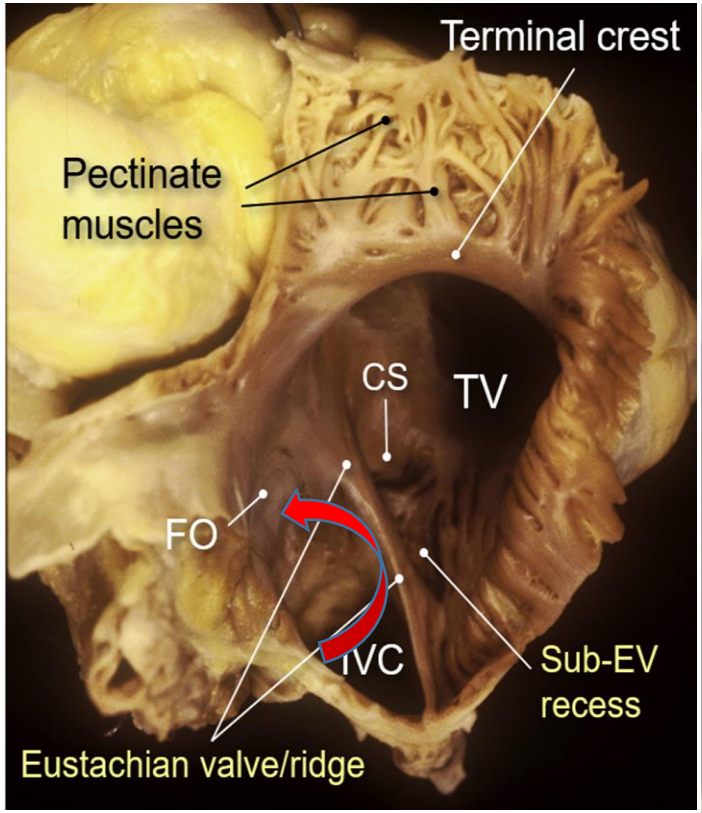
Yellow arrow – eustachian valve
Red arrow – flow of umbilical blood
Blue arrow – flow of desaturated blood

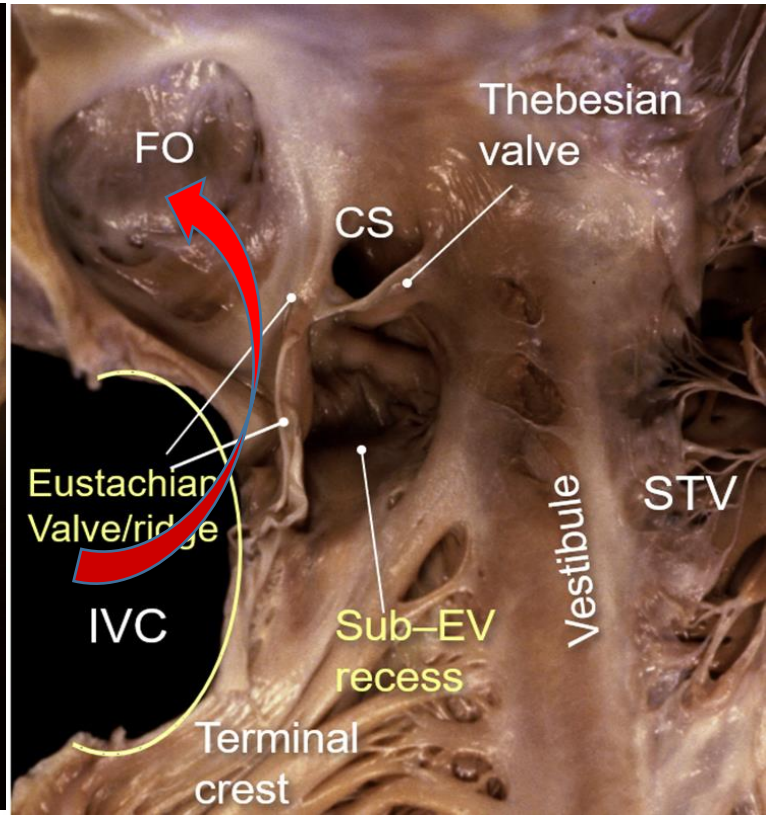


태아기 umbilical blood flow를
foramen ovale로 유도하는 역할

Eustachian valve of Right venous valve







출생시 퇴화되어 성인에서는 작은 주름 형태로 남아있음

Eustachian valve of Right venous valve

◆ **위치**

IVC–RA junction
Eustachian ridge와 연결
Coronary sinus 입구 방향으로 이어짐
Tendon of Todaro와 연결되어 **Triangle of Koch**

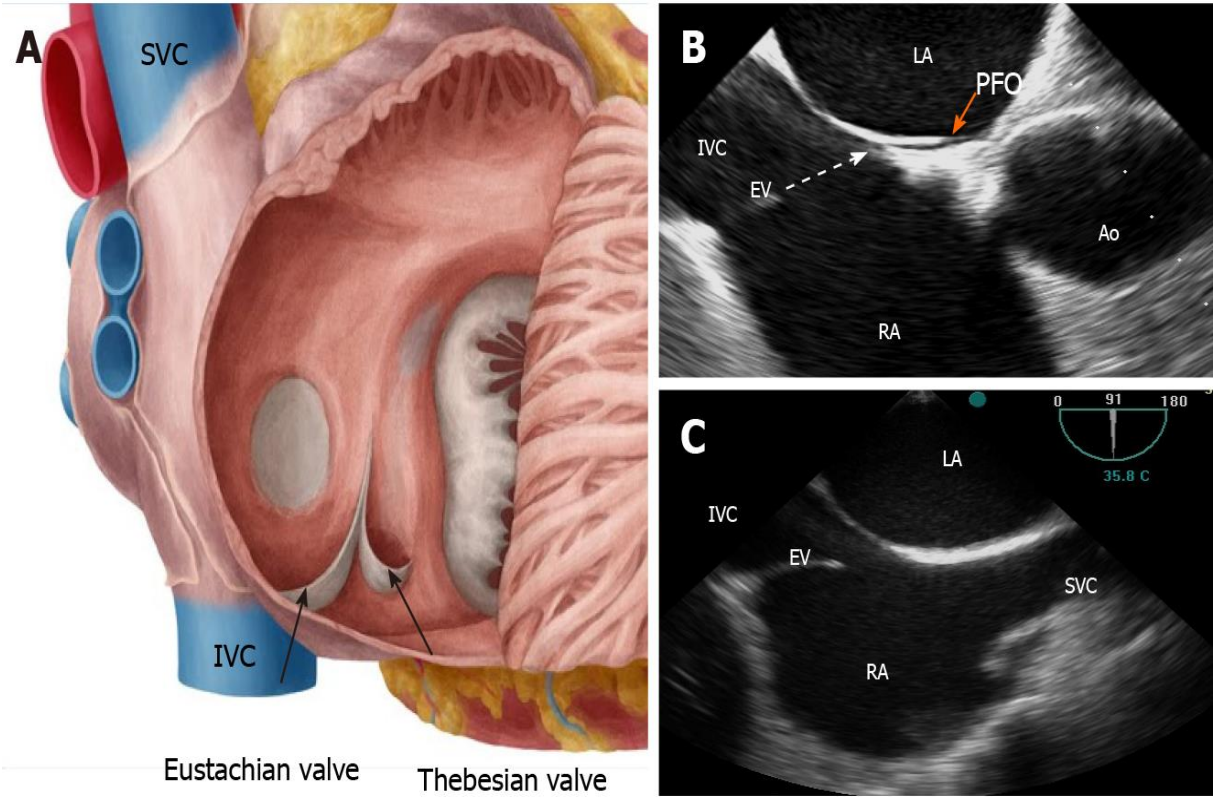
◆ **형태**

사람마다 매우 다양

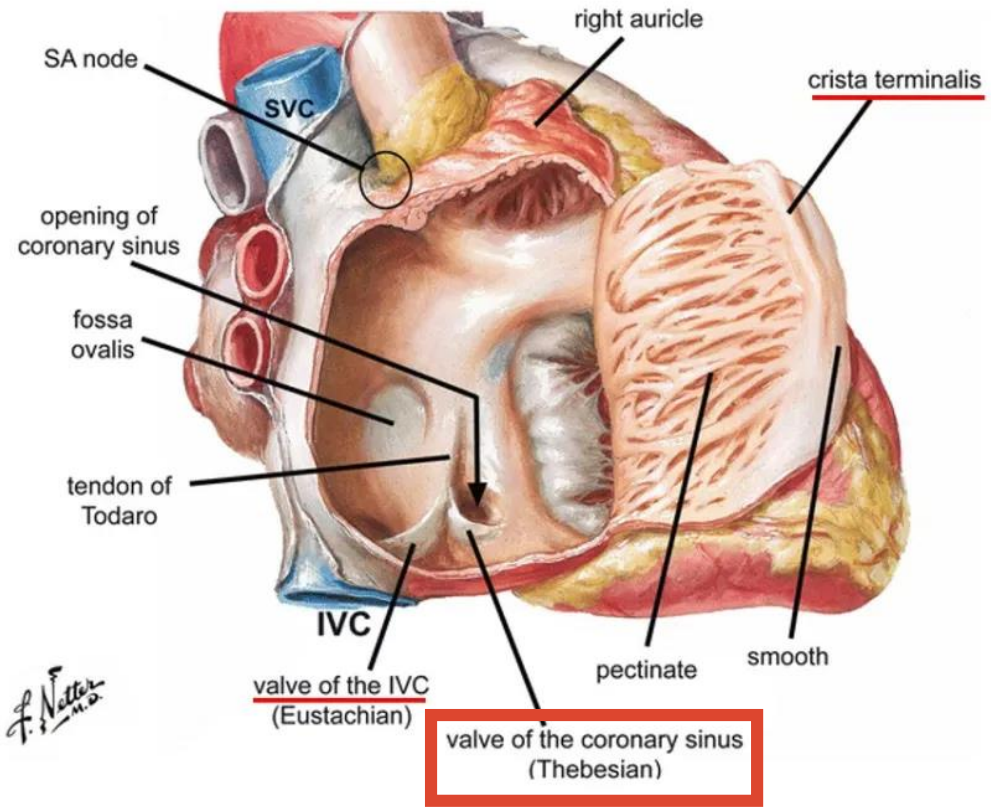
◆ **크기**

보통 **몇 mm 정도의 작은 endocardial fold**

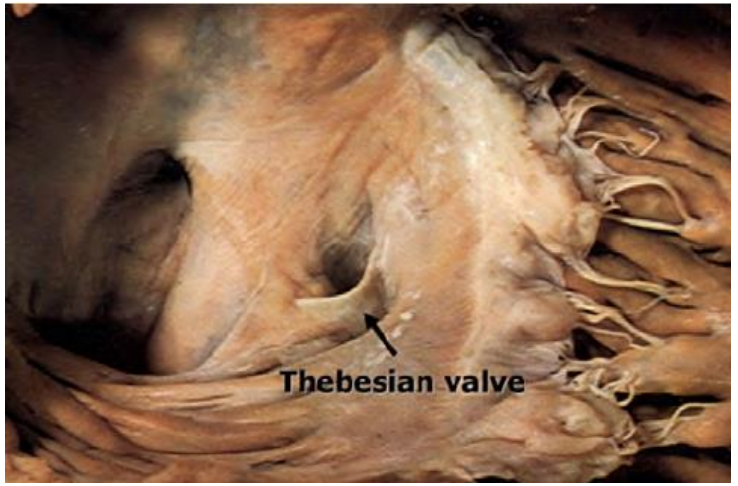
- 높이(height): 약 3–8 mm
- 길이(length): 약 5–15 mm
- 두께(thickness): 약 1 mm 이하 (얇은 막)



Thebesian valve of Right venous valve



- 위치 : **coronary sinus ostium anterior-inferior**
- 크기 : **5–15 mm**
- 두께 : **0.5–1 mm**
- 기능 : **태아 circulation 잔여 구조**
- 임상 : **CS catheterization difficulty**

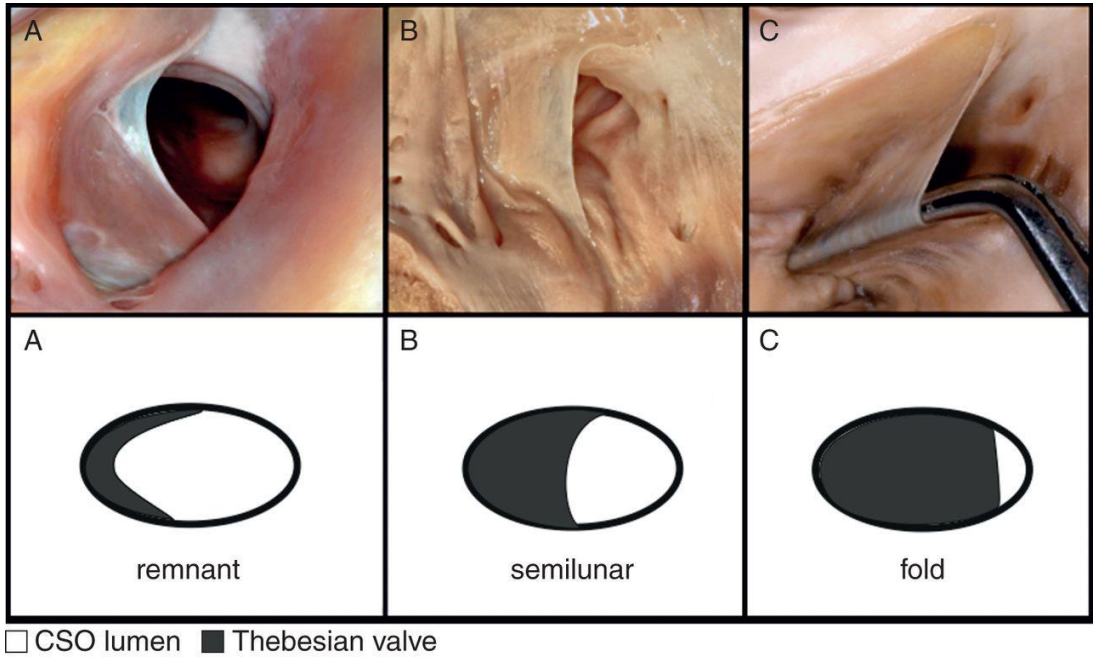


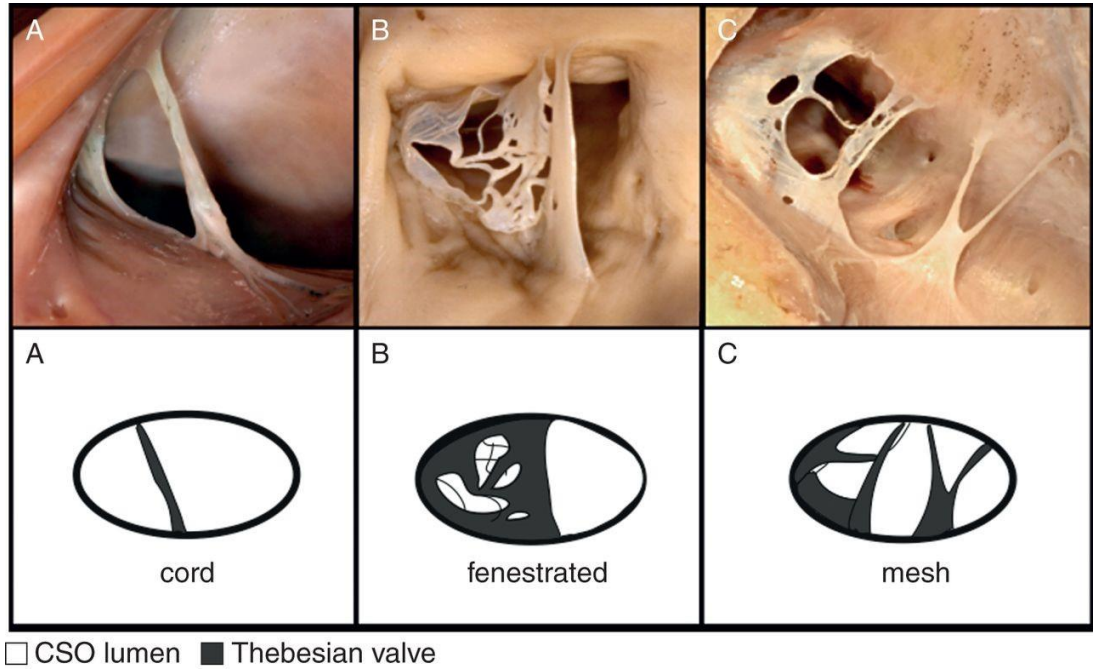
Anatomical variations of Thebesian valve

the TV was present in 82.1% of the examined hearts

(Absence): ~12%~35%

(Obstructive): ~ 2.6%



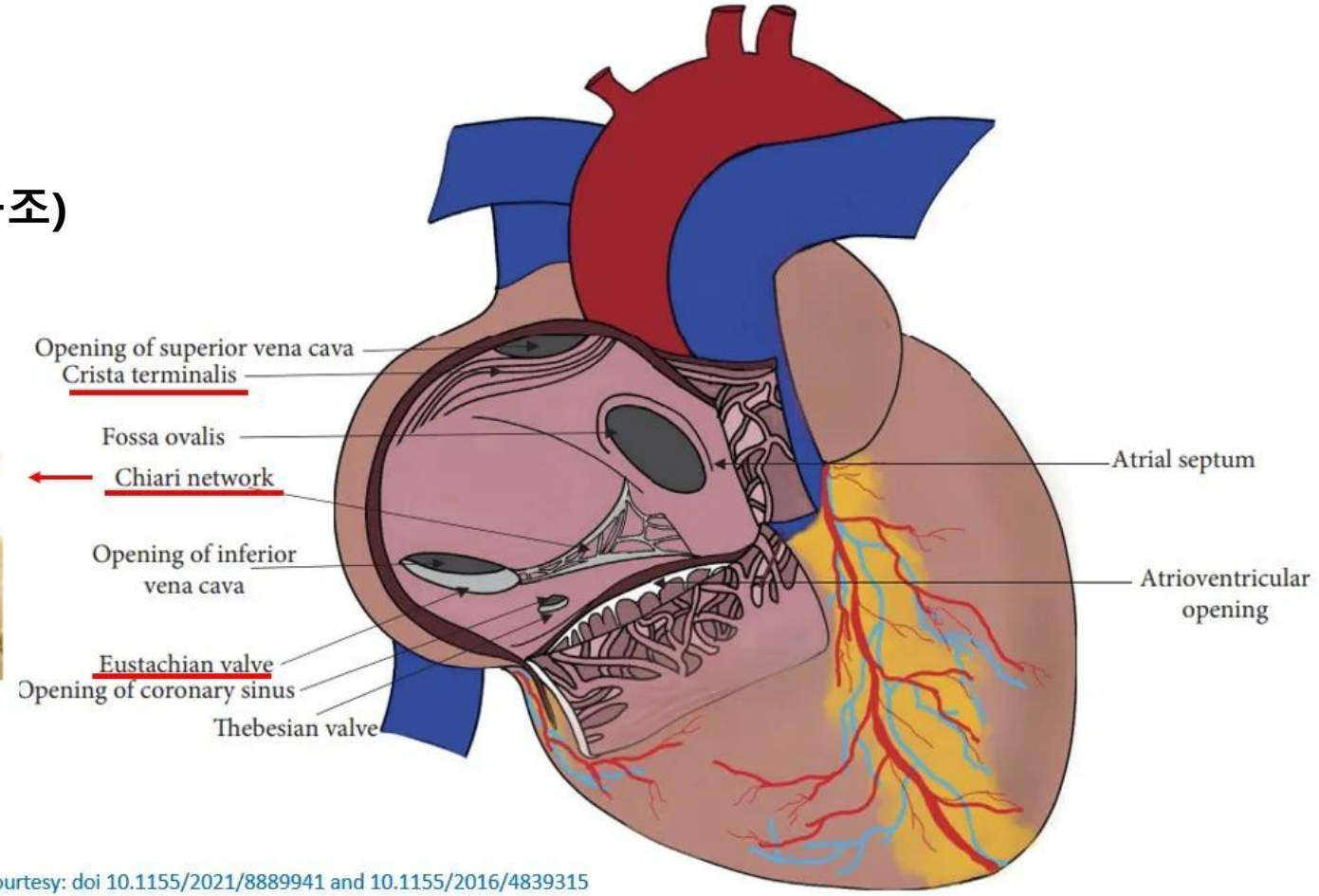


EP Europace, Volume 17, Issue 6, June 2015, Pages 921–927

RA Chiari Network of Right venous valve

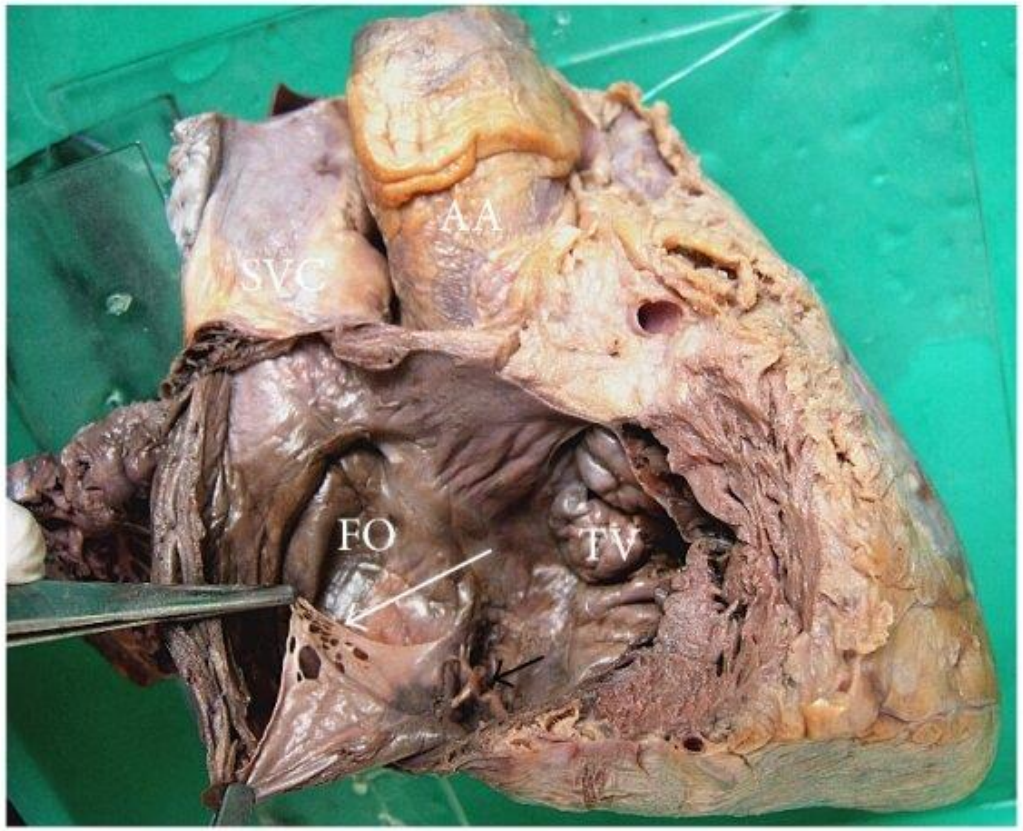
right venous valve

1.Eustachian valve
2.Thebesian valve
3.Chiari network (잔존 구조)



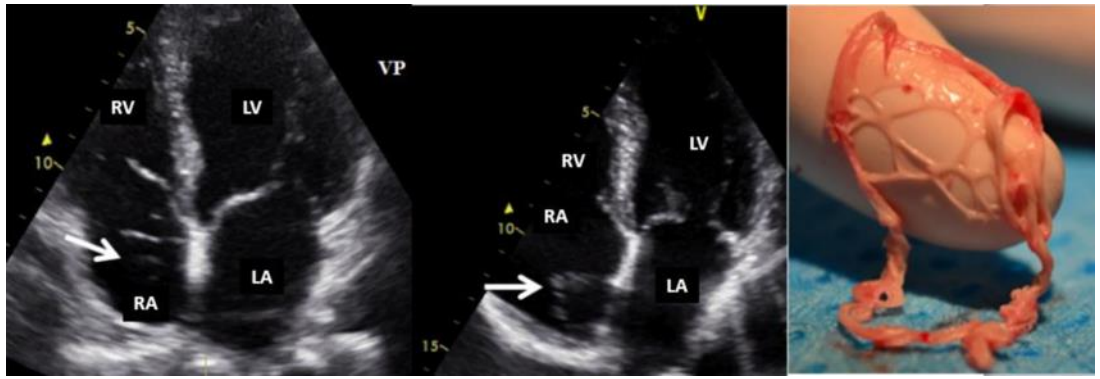
Courtesy: doi 10.1155/2021/8889941 and 10.1155/2016/4839315

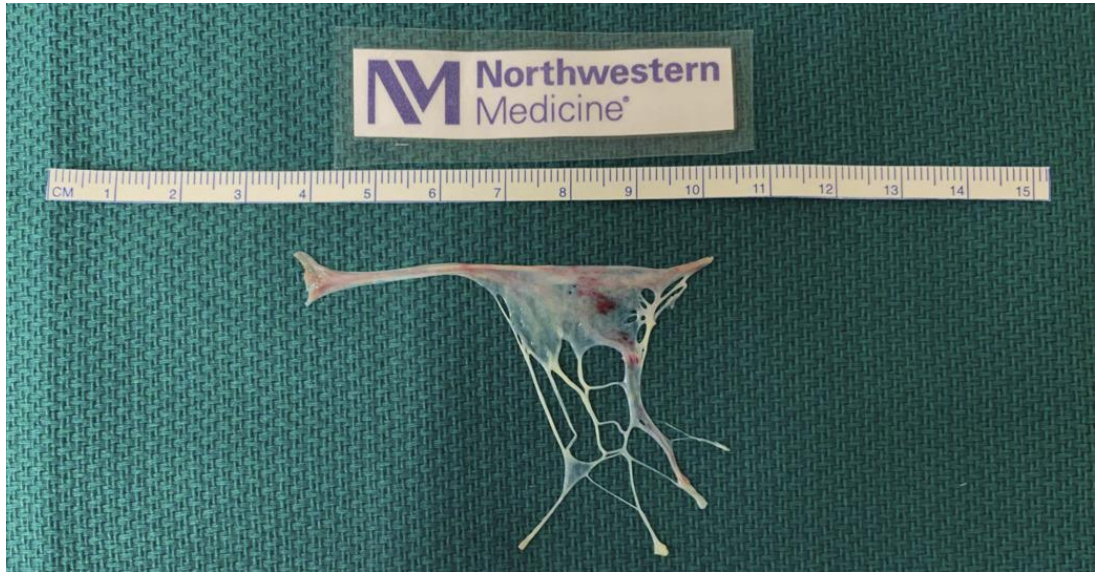
RA Chiari Network of Right venous valve

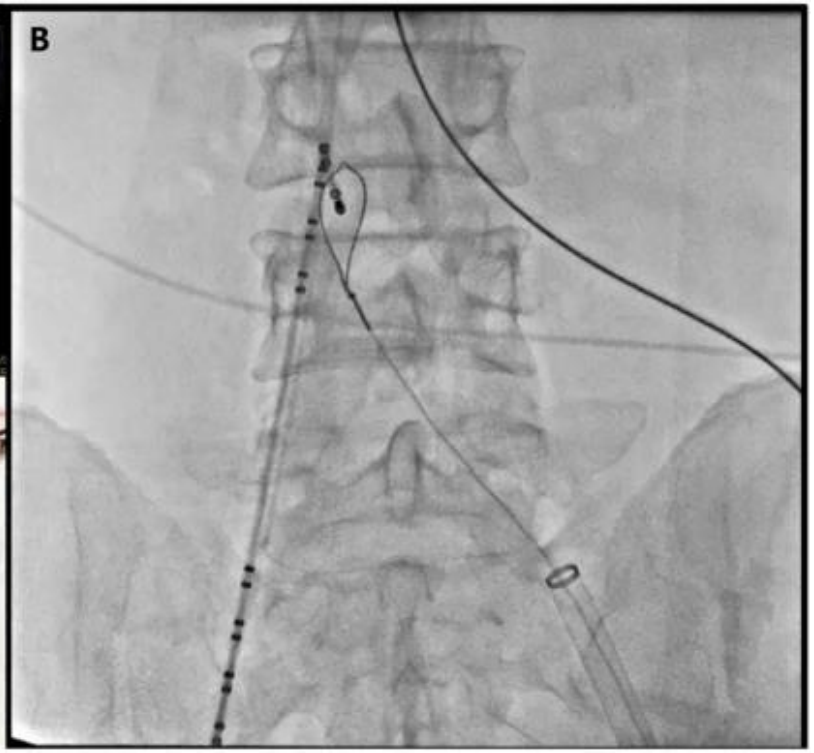


right venous valve의 불완전 퇴화
발생률: 약 **2~3%,** 대개는 benign

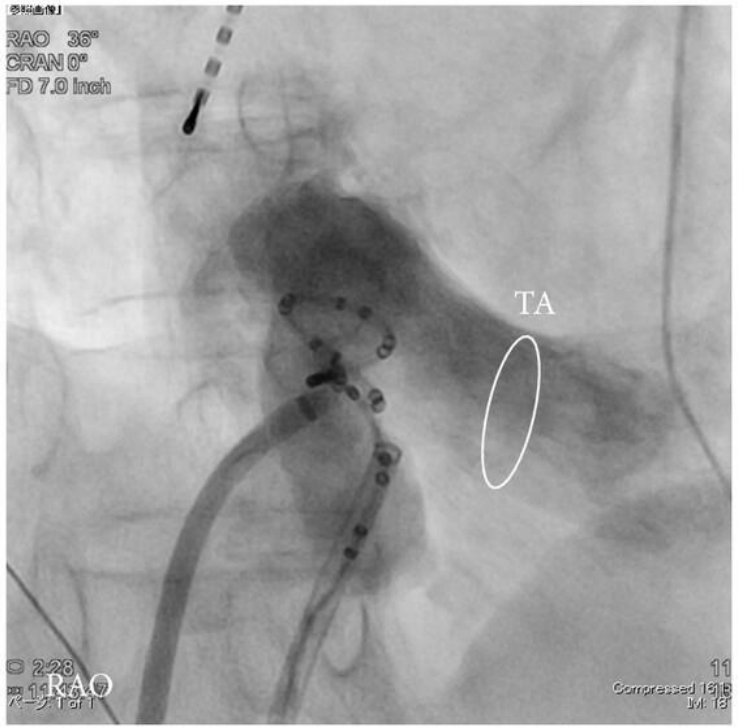
RA Chiari Network

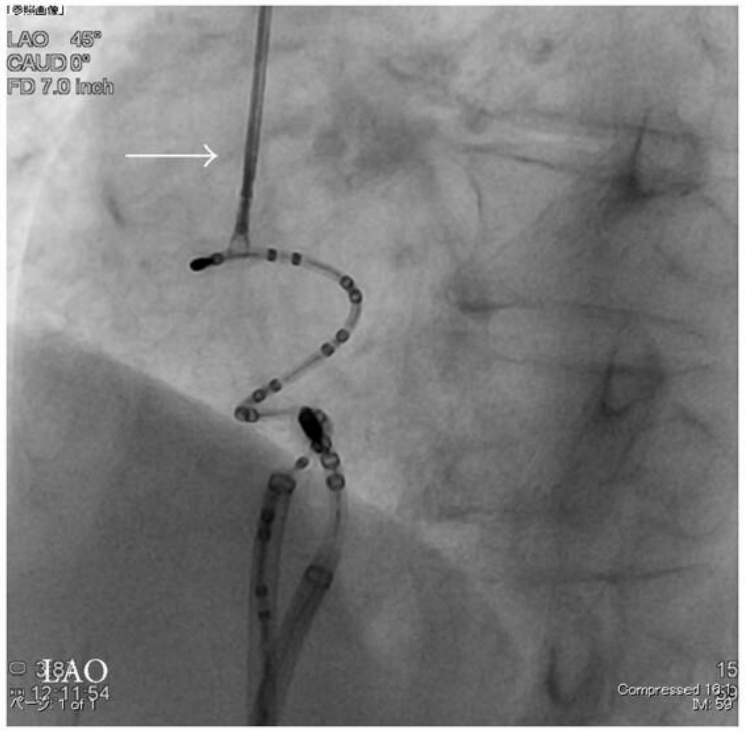






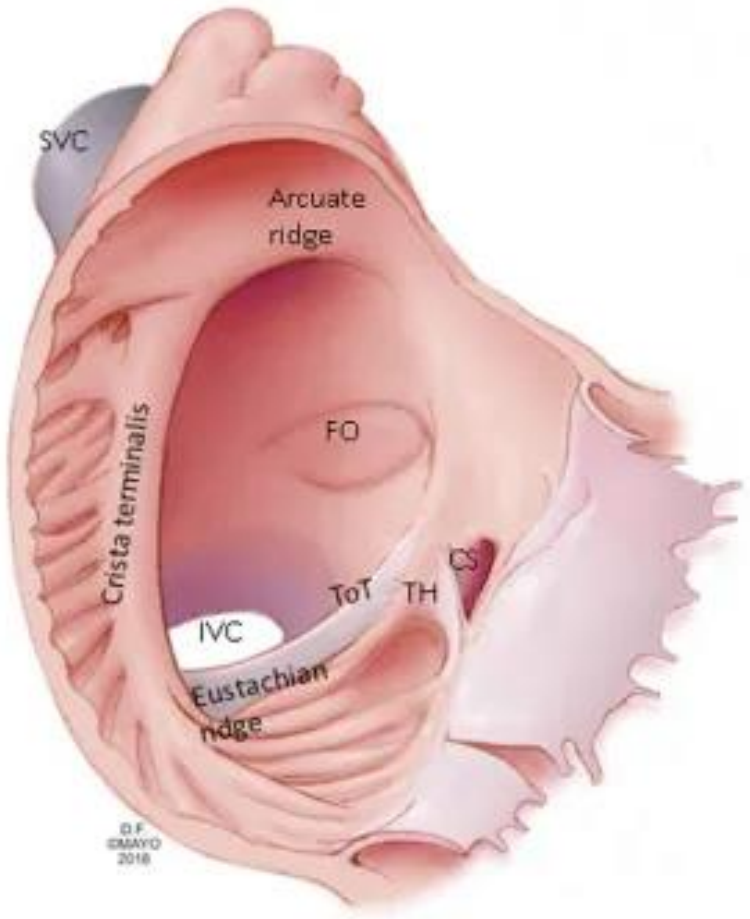
RA Chiari Network





☞ catheter entrapment

Cavotricuspid Isthmus (CTI) Anatomy



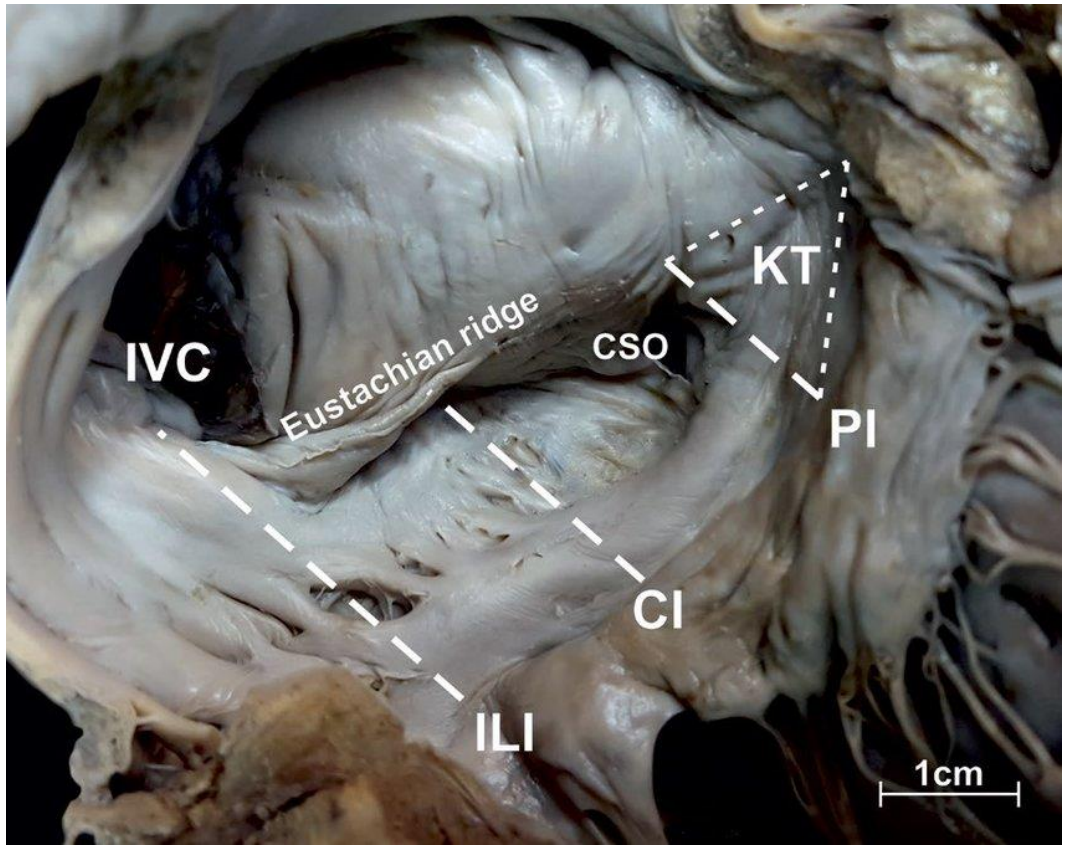
Cavo + Tricuspid + Isthmus

IVC + 삼첨판 + 협부

IVC와 tricuspid valve annulus사이에 존재하는 우심방 하부의 근육성(pectinate muscles) 통로

The CTI forms the “floor” of the right atrium.

Cavotricuspid Isthmus (CTI)



① **Septal CTI**
가장 짧음 (≈20–25 mm)

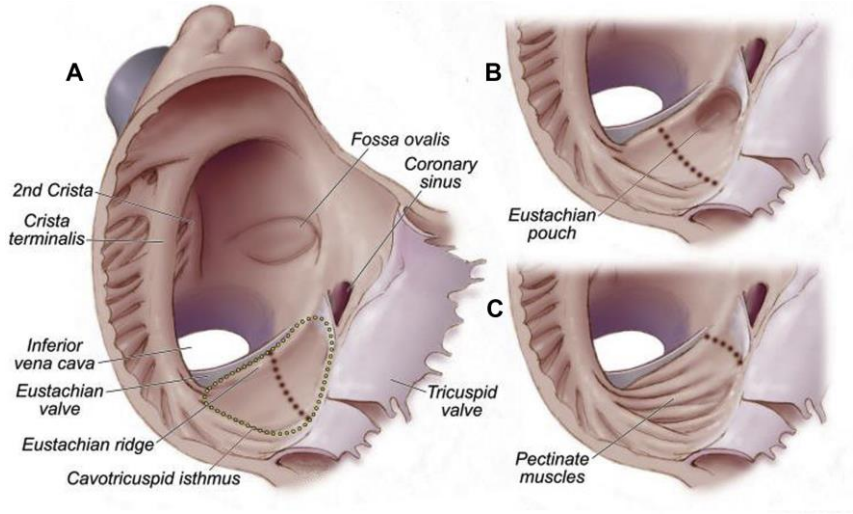
② **Central CTI**
평균 25–30 mm

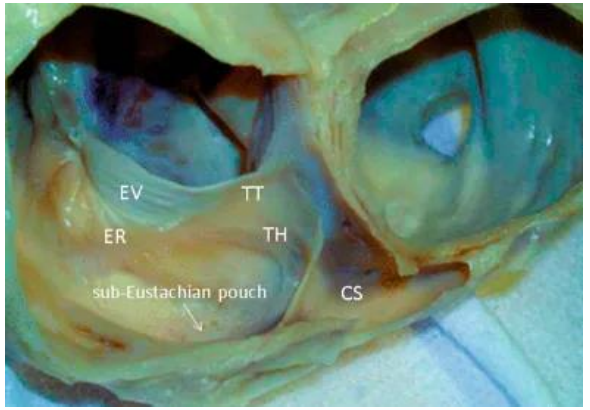
③ **Lateral CTI**
가장 길고 두꺼움 (≈30–35 mm 이상 가능)

- **Length:** 약 **20–35 mm**
- **Depth (pouch):** 최대 **5–10 mm**
- **Thickness:** 약 **3–7 mm**

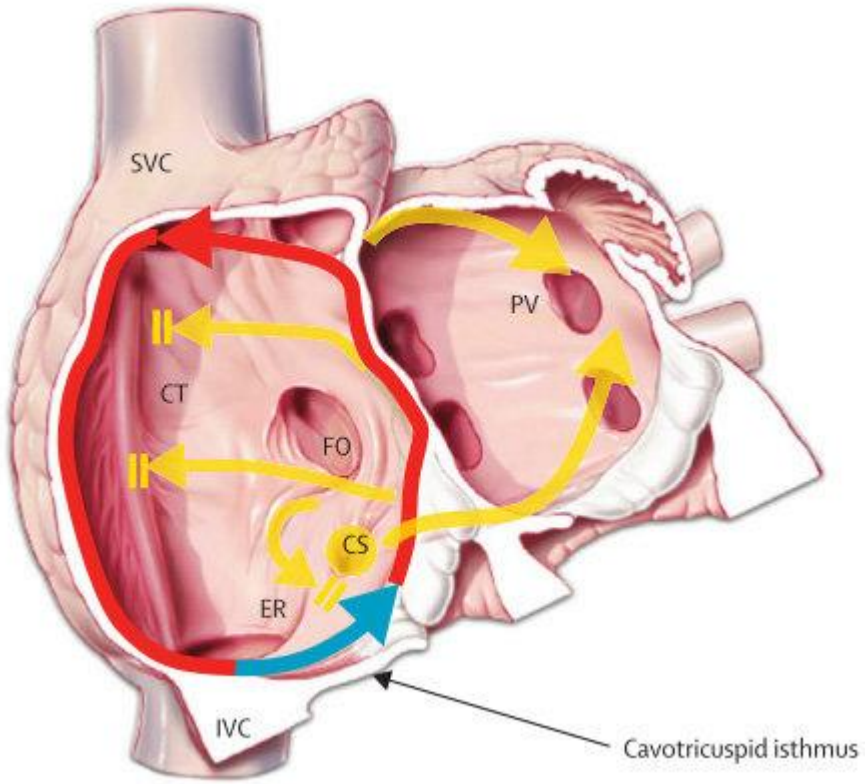
CTI : Morphologic Types

CTI 형태	발생 빈도
1. Straight / Flat	**35–40%**
2. Concave	**20–25%**
3. Pouch (Sub-Eustachian pouch)	**25–30%**
4. Prominent Eustachian ridge	**10–15%**



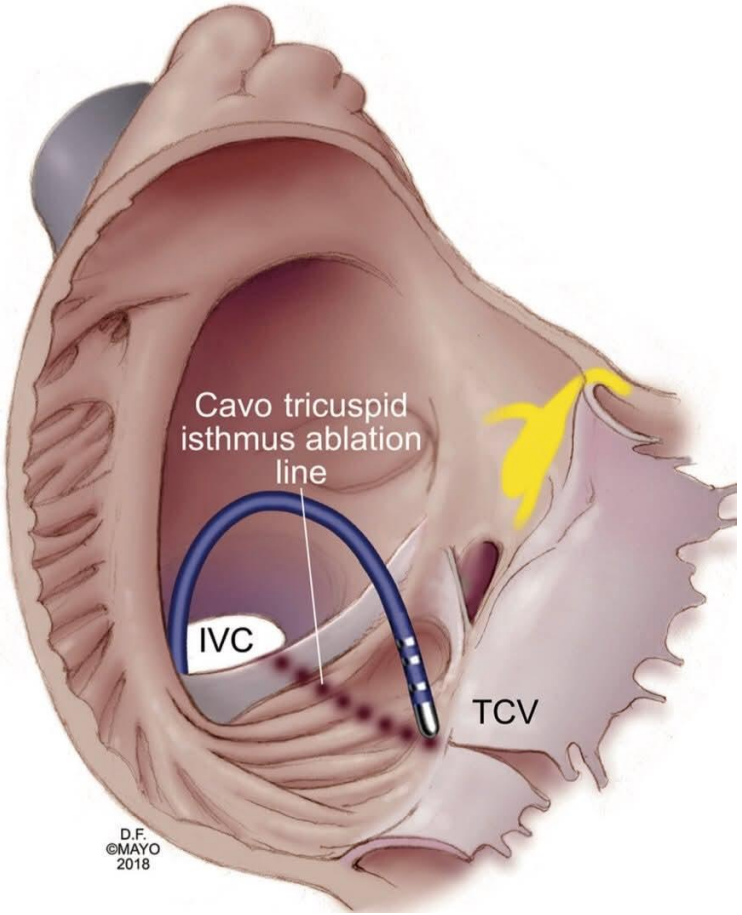


CTI : critical isthmus of typical AFL

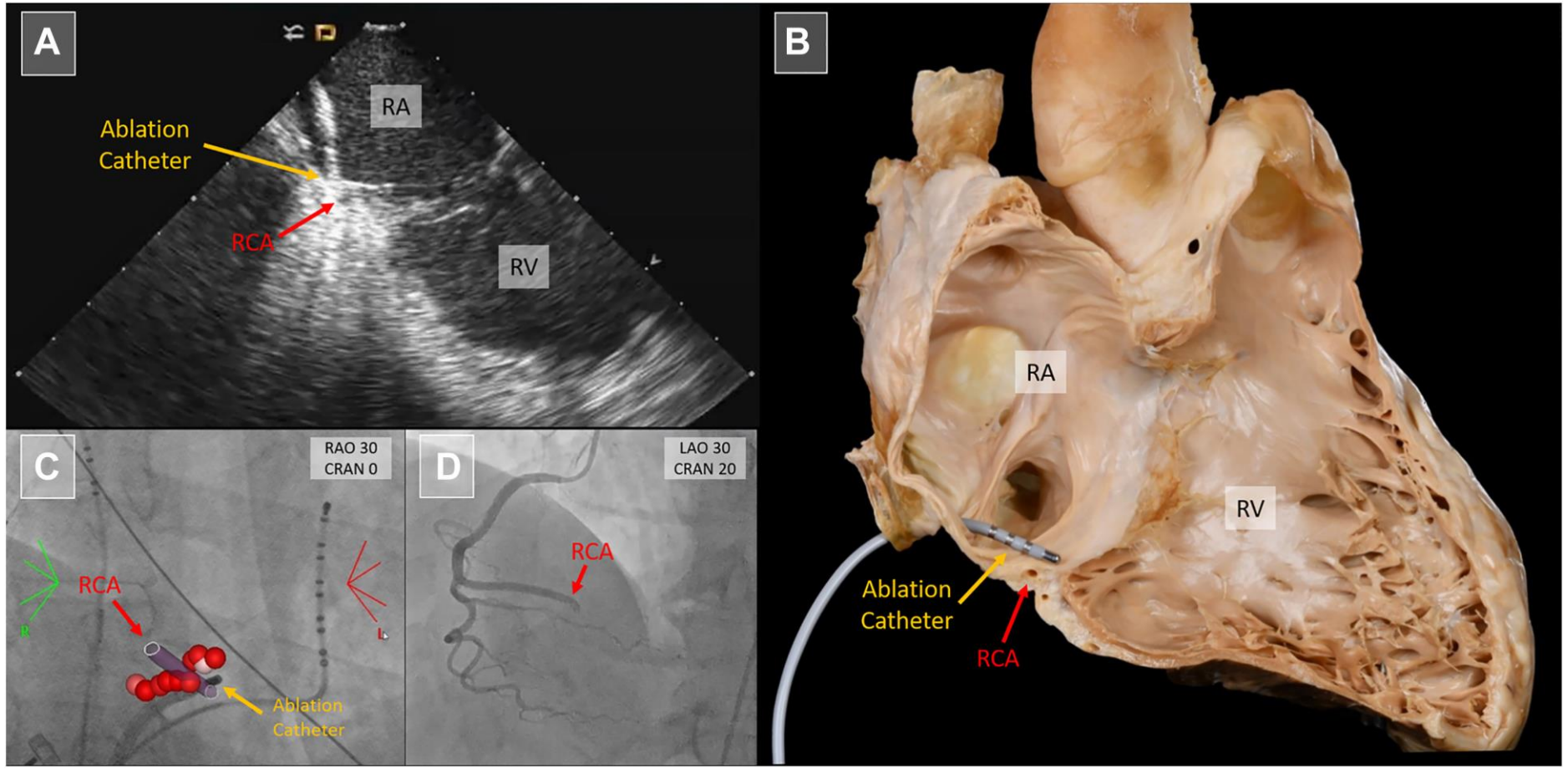


☞ **macro-reentry circuit :** critical isthmus

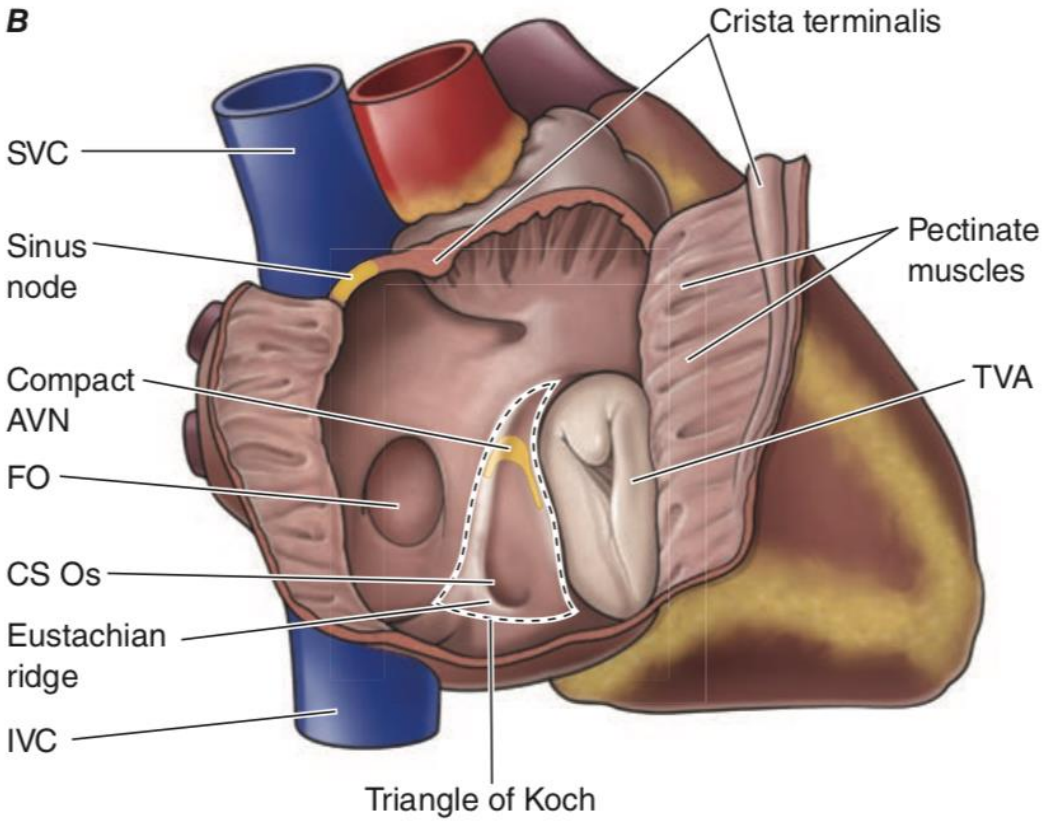
느린 전도 특성, 길고 좁은 구조
→ reentry가 유지되기 좋은 조건

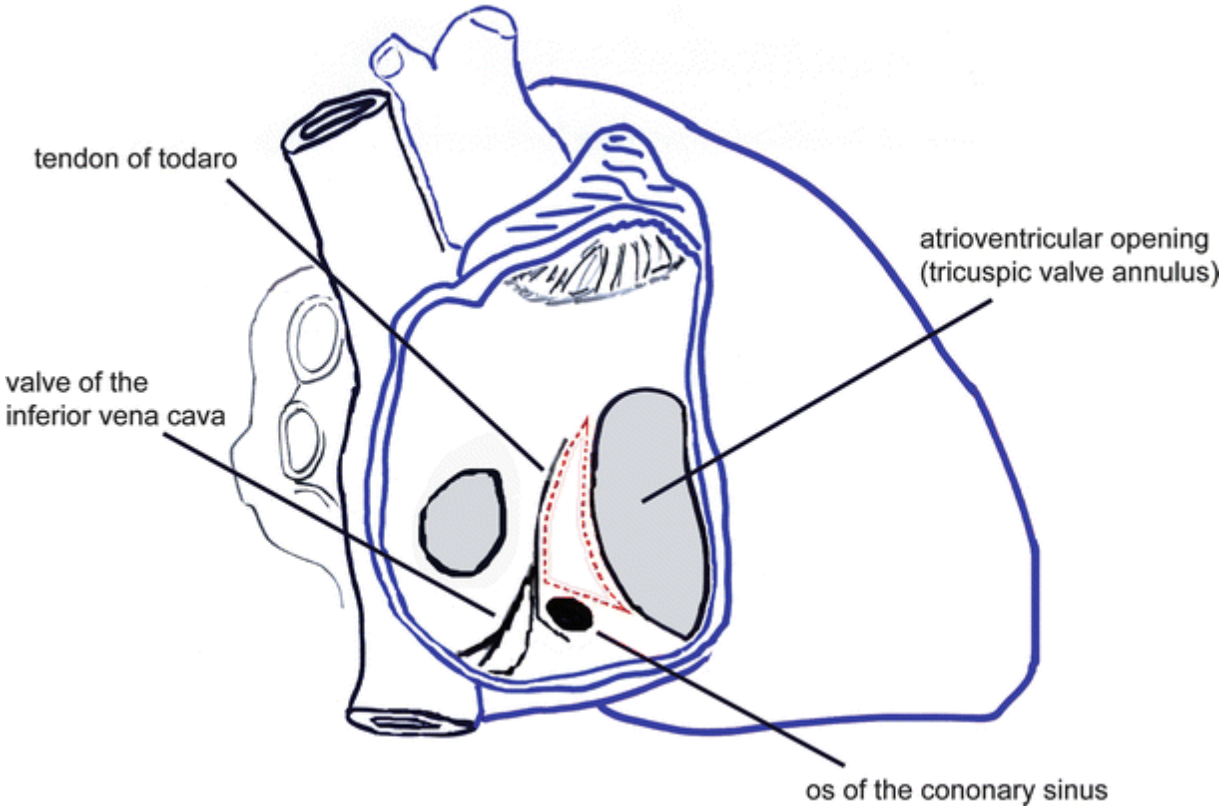


Cavotricuspid Isthmus Ablation and the Risk of Right Coronary Artery Injury

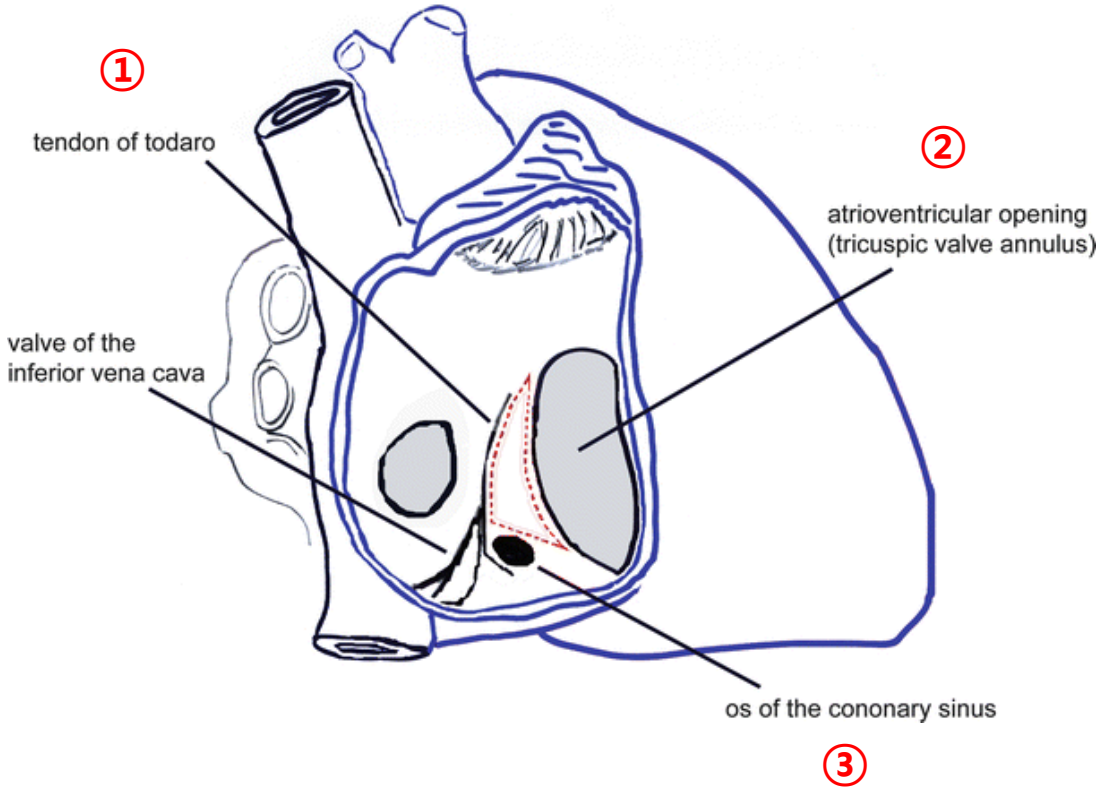


Triangle of Koch





The triangle is defined by three anatomical structures:



1. Tendon of Todaro

- Eustachian valve의 섬유성 연장
- 삼각형의 posterior boundary

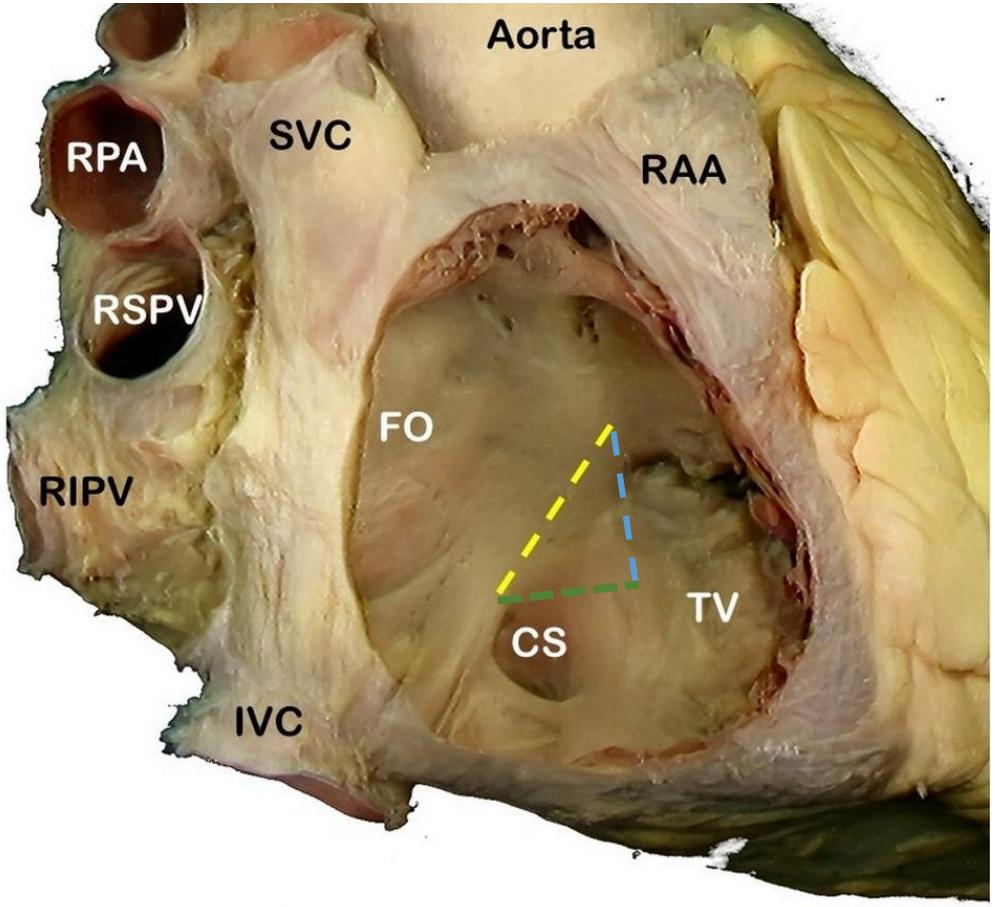
2. Tricuspid valve annulus

- 삼각형의 Anterior boundary

3. Coronary sinus ostium

- 삼각형의 Inferior boundary

Triangle of Koch 같이 외워봅시다

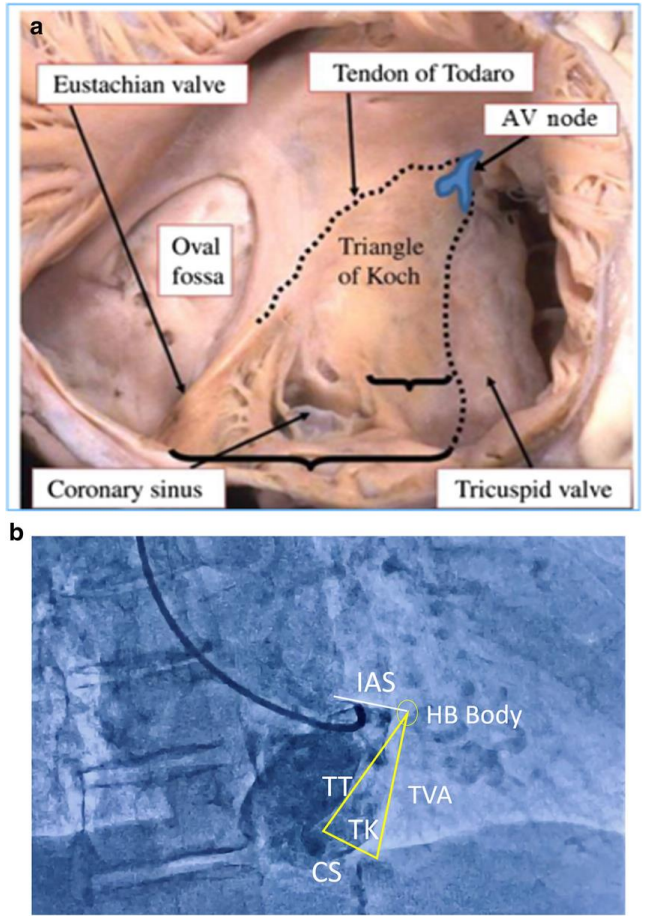


1. Tendon of Todaro

2. Tricuspid valve annulus

3. Coronary sinus ostium

Triangle of Koch: Contents

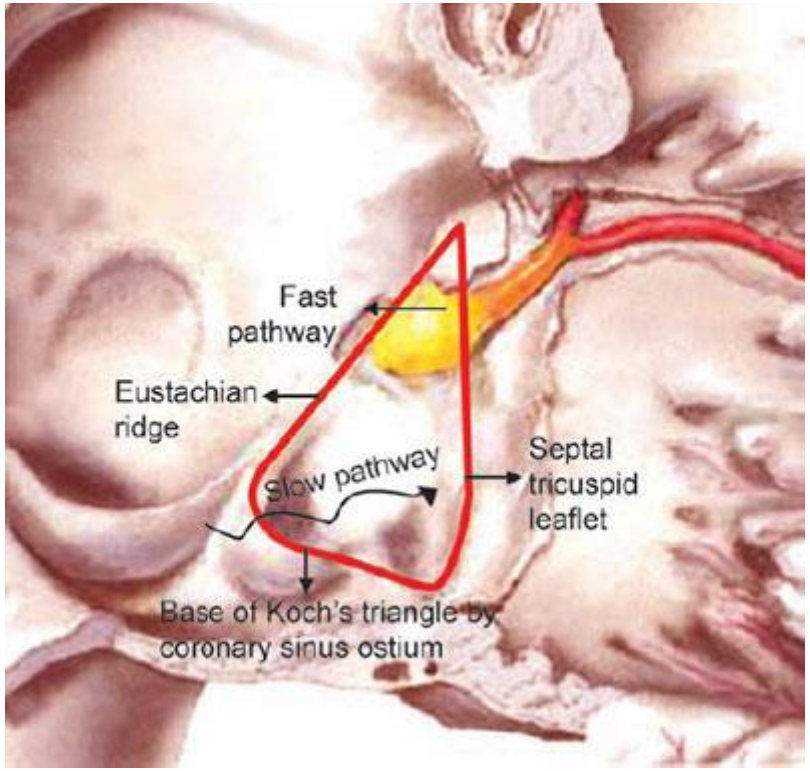


AV node

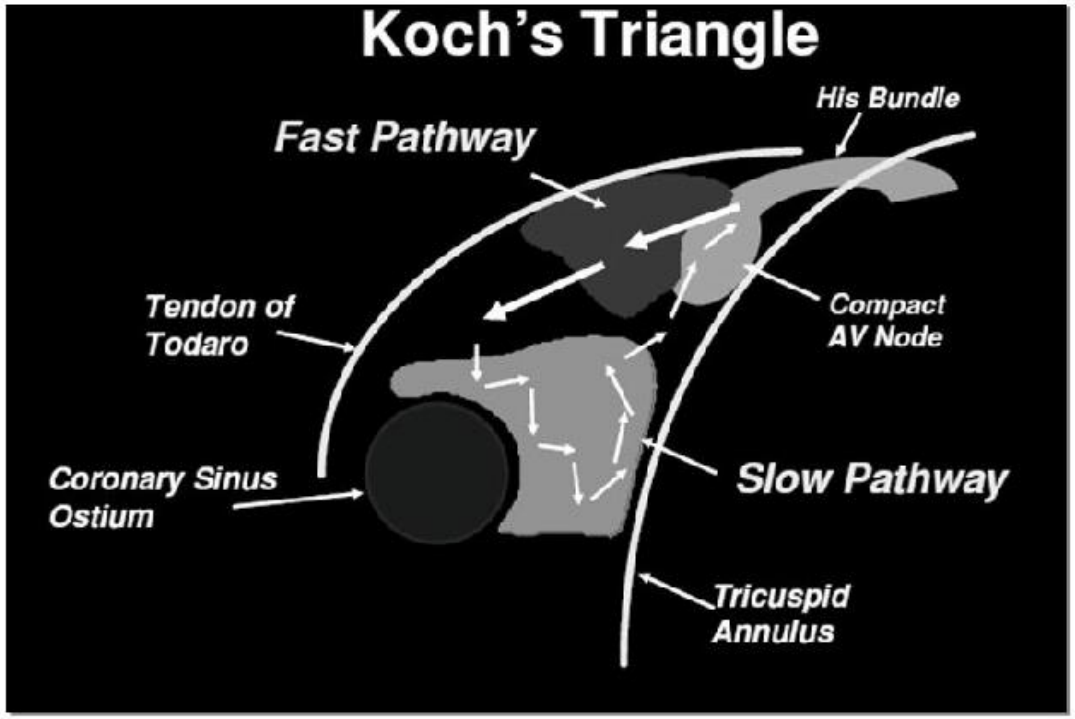
Proximal His bundle

AV nodal artery

Dual AVN pathway
→AVNRT 가능



Triangle of Koch : Dual AV nodal physiology

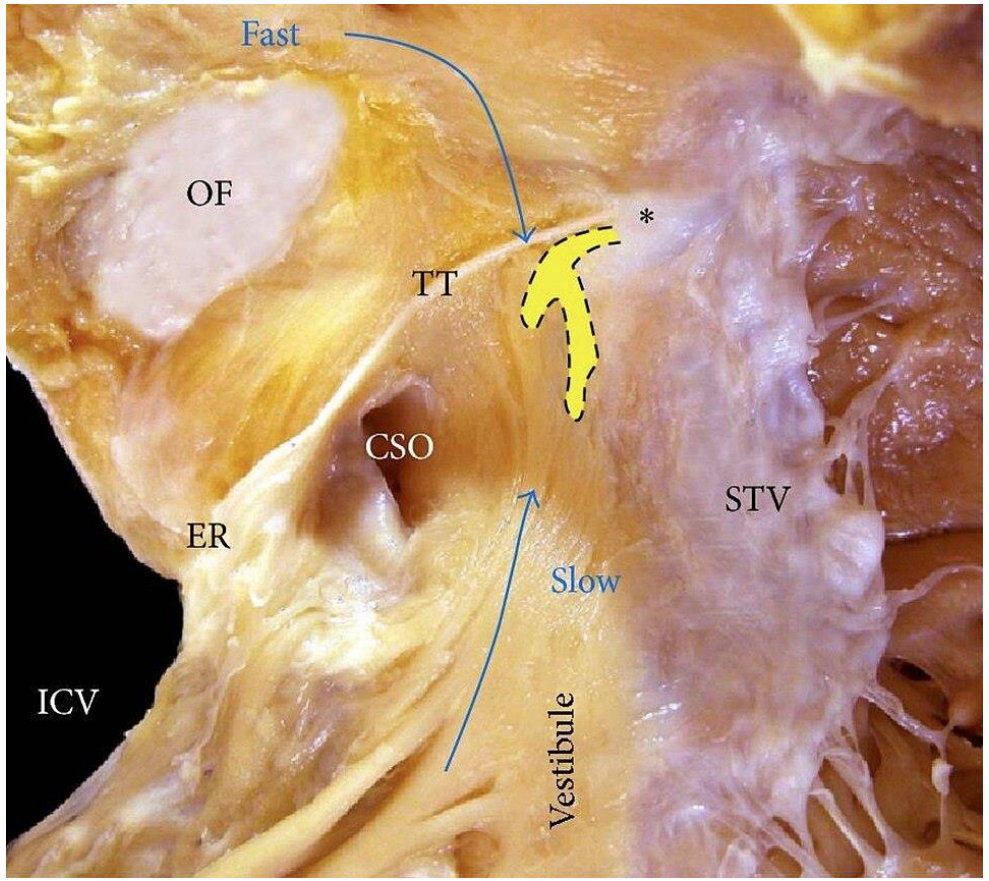


전도 특성이 다른 두 개의 입력 경로가 존재하는 상태

Dual AV nodal physiology 존재 **20–35%**

실제 AVNRT 발생 **1–2%**

Triangle of Koch : Dual AV nodal physiology



◆ **Fast pathway**

- 위치: **Koch triangle의 superior part**
- 구조 관계

  Tendon of Todaro

  Interatrial septum

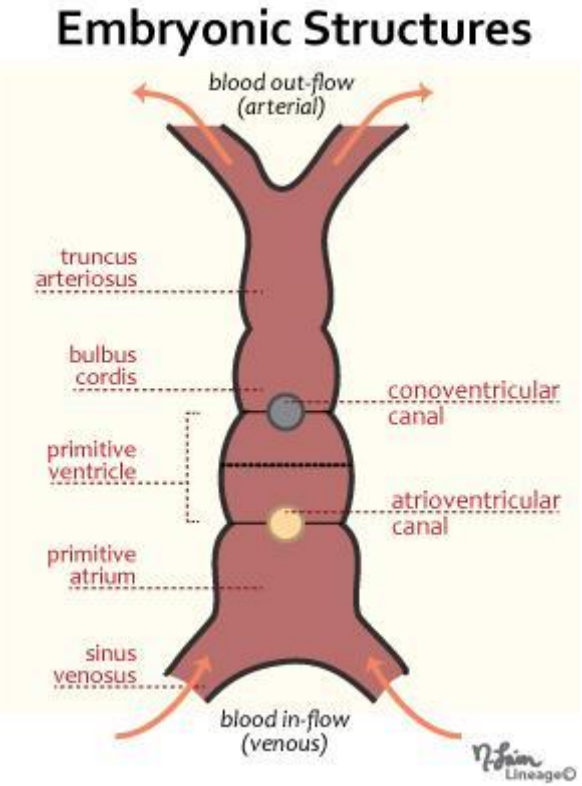
◆ **Slow pathway**

- 위치: **posterior-inferior Koch triangle**
- 구조 관계

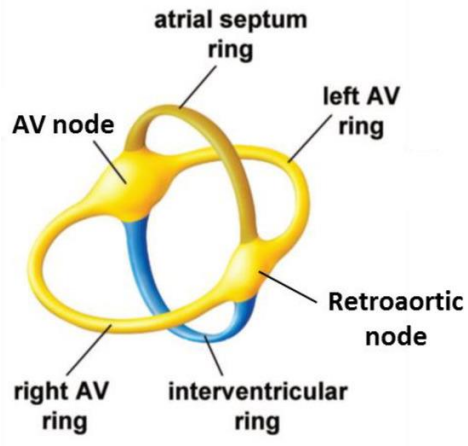
  Coronary sinus ostium

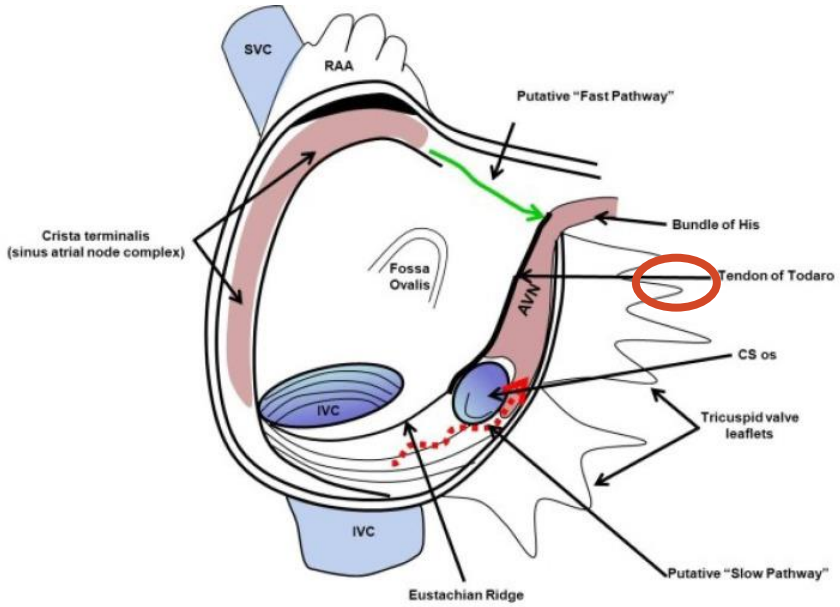
  Tricuspid valve

Dual AV nodal pathways는 왜 생길까?



specialized conduction tissue

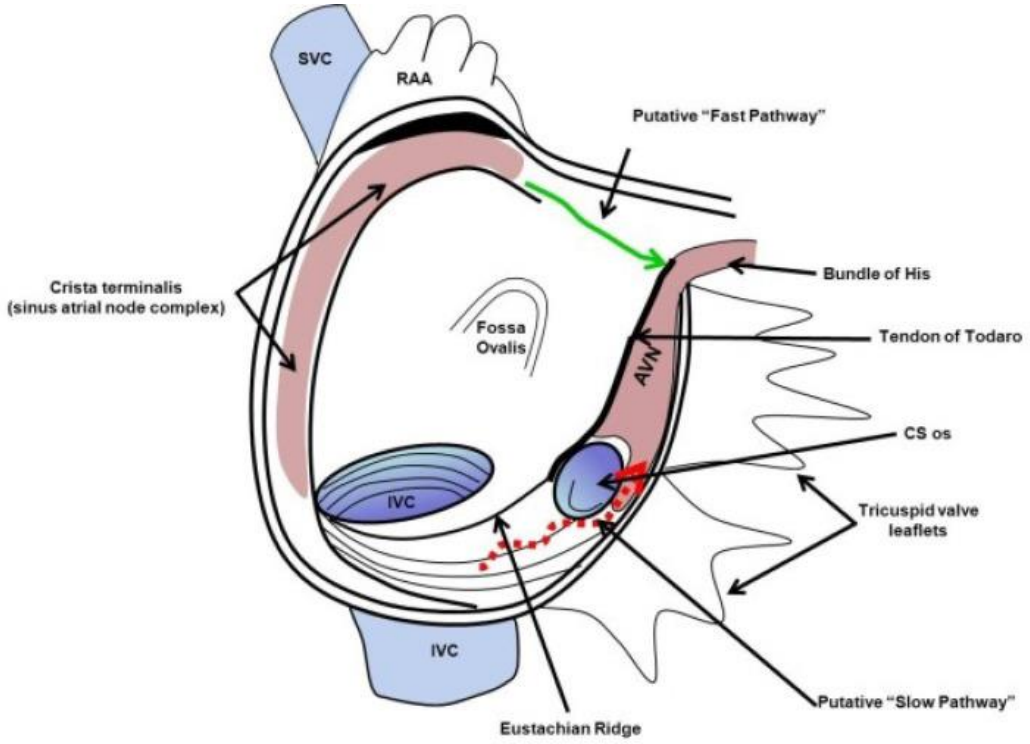




■ 발생학적으로 다른 조직의 결합

→ fast or slow pathway

Dual AV nodal pathways는 왜 생길까?



Atrial myocardium (septal RA)

+

AV nodal transitional cells

} FAST pathway

+

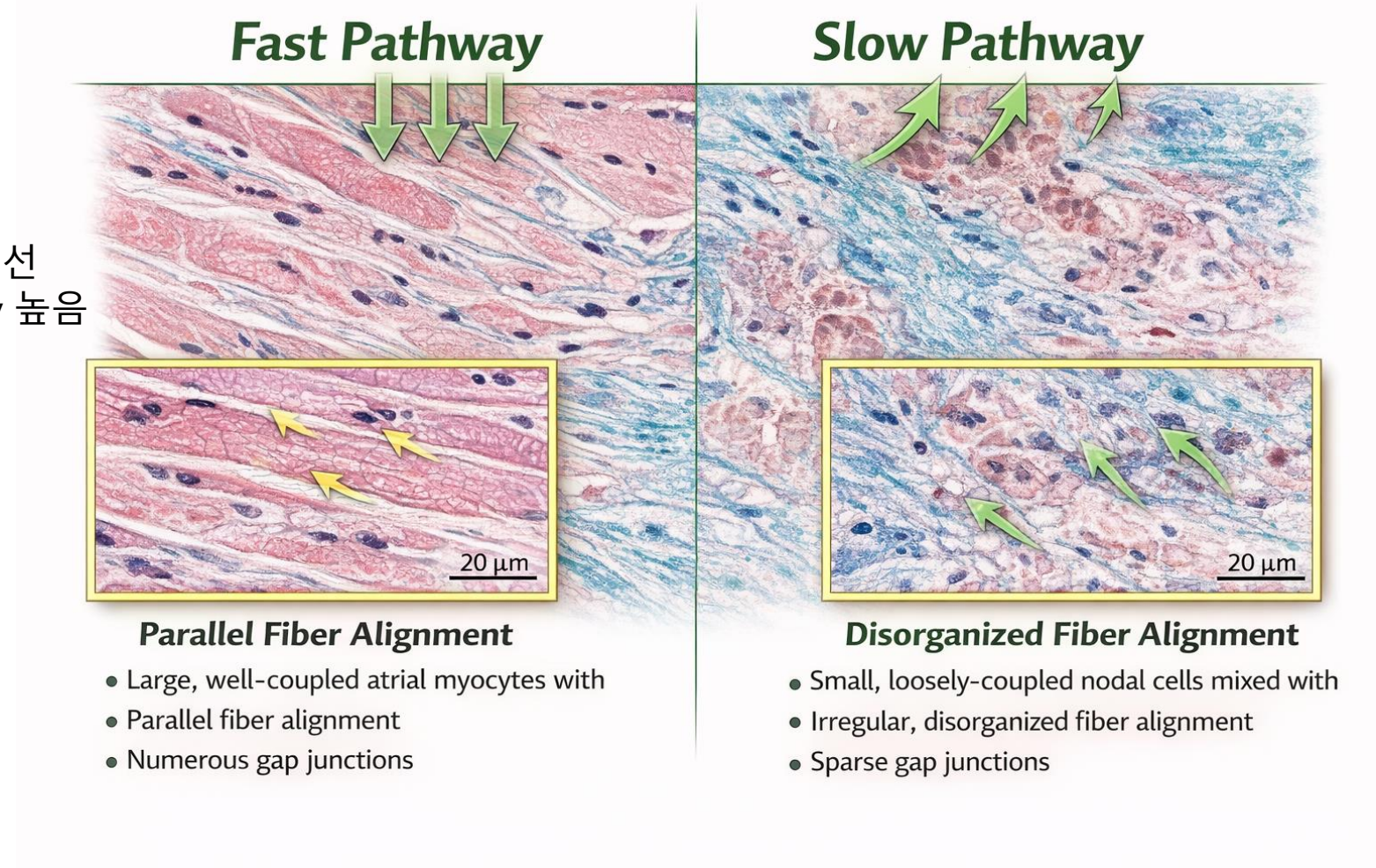
Coronary sinus myocardial sleeve
(Sinus venosus derived atrial tissue)

} SLOW pathway

세포구조의 차이에 따른 전도속도의 차이

fiber alignment가 직선
Gap junction density 높음

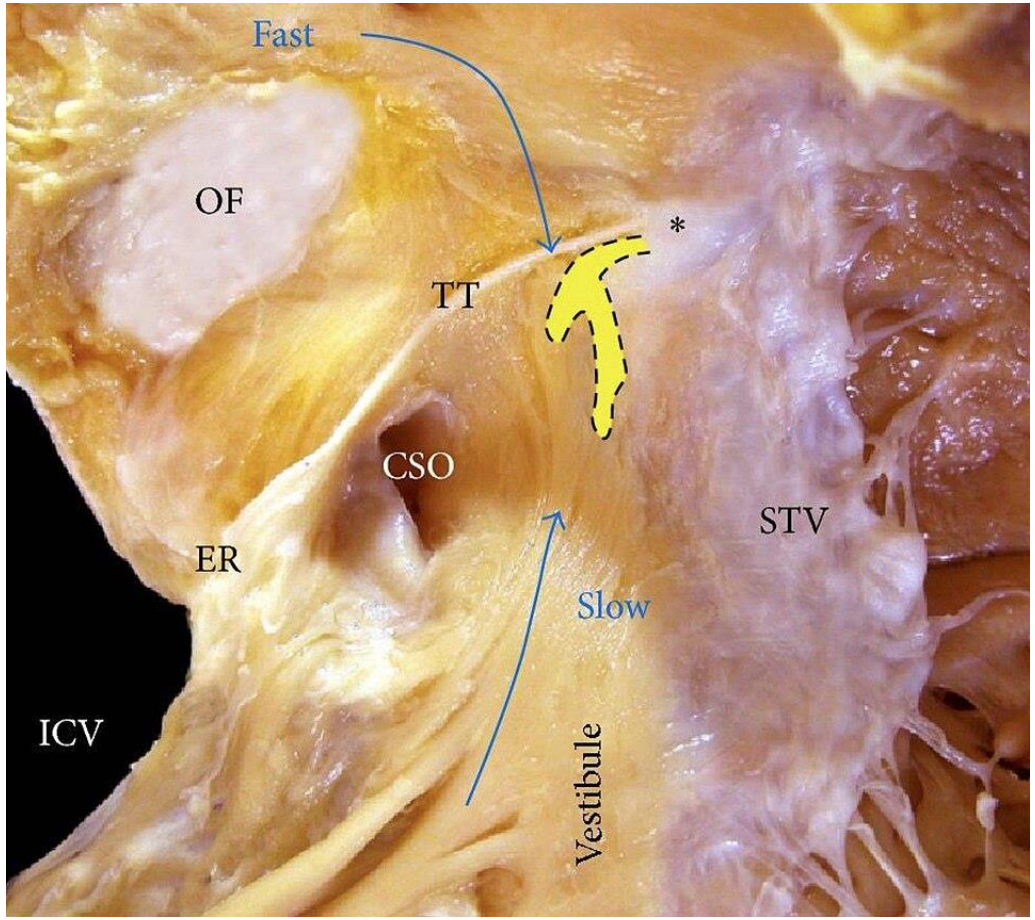
전도 속도
0.5 – 1.0 m/s

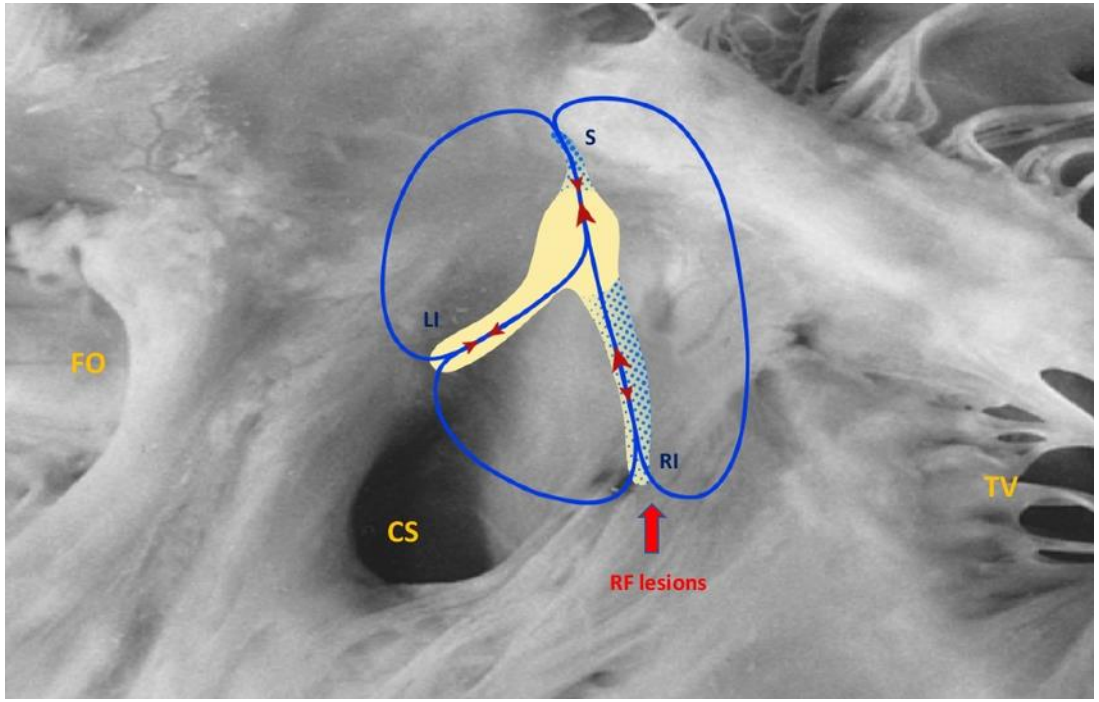


fiber orientation 불규칙
gap junction density 감소
fibrous tissue 많음

전도 속도
0.2 – 0.5 m/s

Dual AV nodal pathways





♨ **Ablation site : Slow pathway**
CS ostium 근처

Thank you for listening

INJE
UNIVERSITY
SANGGYE
PAIK
HOSPITAL

인제대학교상계백병원