

Mitral & Tricuspid valve surgery

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ESC GUIDELINES

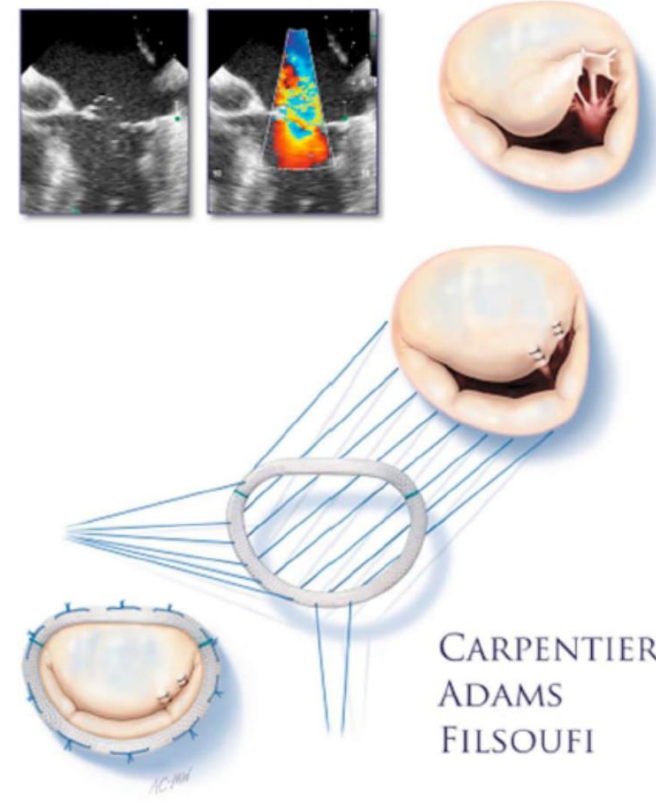
2025 ESC/EACTS Guidelines for the management of valvular heart disease

Developed by the task force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

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CARPENTIER'S RECONSTRUCTIVE VALVE SURGERY

From Valve Analysis to Valve Reconstruction



SAUNDERS
ELSEVIER

Part 4 Three question for every valve case

1 WHEN?

When is intervention indicated?

Symptoms • severity • LV/RV response • pulmonary pressure • AF • end-organ effects

Indication

2 WHAT?

What is the mechanism and surgical anatomy?

Leaflet • annulus • chordae • papillary muscle • ventricle • danger structures

Mechanism and Anatomy

3 HOW?

Which operation will give a durable result?

Repair vs replacement • prosthesis • concomitant procedures • technical risk

Surgical strategy

Contents

- ✓ Surgical Indications of Mitral and Tricuspid Valve
- ✓ Surgical Anatomy of Mitral and Tricuspid Valve
- ✓ Considering Factors for Mitral and Tricuspid Valve Surgery

Surgical Indications of Mitral and Tricuspid Valve

Mitral regurgitation - Pathophysiology

PRIMARY MR

Problem is primarily the valve

- Degenerative prolapse / flail
- Endocarditis
- Rheumatic disease

Surgical mindset:

“Can I achieve a durable repair?”

SECONDARY MR

Problem is primarily the ventricle or atrium

- Ischemic / ventricular remodeling
- Dilated cardiomyopathy
- Atrial functional MR

Surgical mindset:

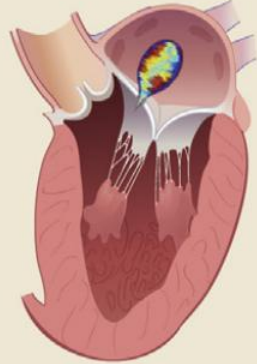
“Will valve treatment improve the disease trajectory?”

Carpentier's "Functional Classification"

Type I Normal Leaflet Motion		Type II Excessive Leaflet Motion		Type III Restricted Leaflet Motion	
Annular Dilation	Perforation	Prolapse	Flail	a Thickening/ Fusion	b LV/LA Dilation
					

PRIMARY MR

Carpentier Type I
(normal leaflet motion and position)



Leaflet Perforation
Cleft

Carpentier Type II
(excess leaflet motion)



Mitral Valve Prolapse

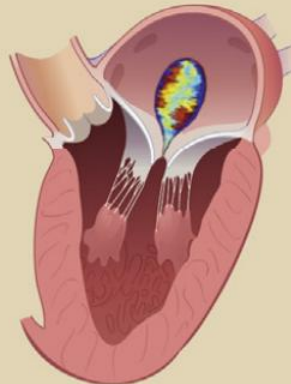
Carpentier Type IIIa
(restricted leaflet motion in systole and diastole)



Rheumatic Valve Disease
Mitral Annular Calcification
Drug Induced MR

Carpentier Type IIIb
(restricted leaflet motion in systole)

SECONDARY MR



Atrial MR

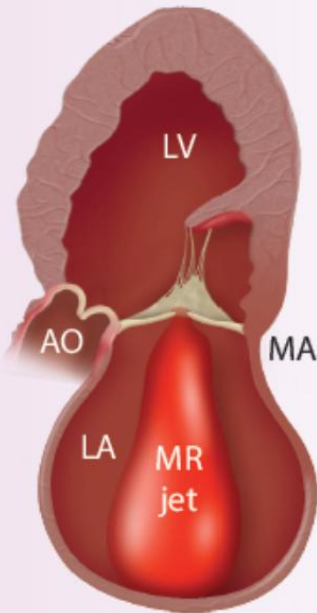


Nonischemic
Cardiomyopathy



Ischemic
Cardiomyopathy

Atrial SMR



Key criteria

LVEF $\geq 50\%$ without regional wall motion abnormalities

No or mildly dilated LV cavity^a without leaflet tethering

Mitral annulus dilatation (AP > 35 mm)

Enlarged LA (LAVI > 34 mL/m²)

LVEF $< 50\%$ with or without regional wall abnormalities

Restrictive leaflet motion with tethering

Normal leaflet morphology

Central or eccentric jet

Additional echocardiographic criteria^b

Normal leaflet motion

Normal leaflet morphology

Usually central jet

Dilated LV

Dilated LA

Dilated MV annulus

Additional clinical criteria

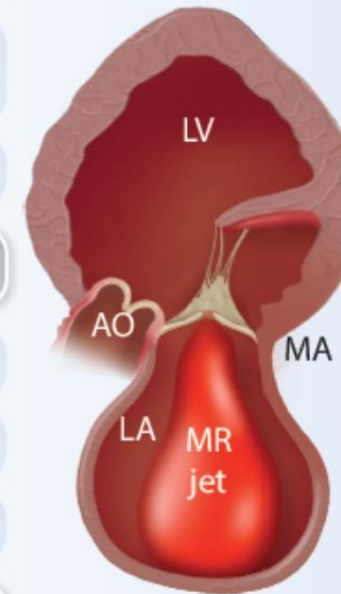
Atrial fibrillation

HFpEF

Ischaemic heart disease

Dilated cardiomyopathy

Ventricular SMR



Indications for primary MR

Recommendation	Class	LOE	vs 2021
<u>MV repair</u> is the recommended surgical technique to treat patients with severe PMR when the result is expected to be durable.	I	B	
MV surgery is recommended in <u>symptomatic</u> patients with severe PMR considered operable by the Heart Team.	I	B	
MV surgery is recommended in <u>asymptomatic</u> patients with severe PMR and <u>LV dysfunction</u> (LVESD ≥ 40 mm or LVESDi ≥ 20 mm/m ² or LVEF $\leq 60\%$).	I	B	
NEW Surgical MV repair is recommended in low-risk <u>asymptomatic</u> patients with severe PMR <u>without LV dysfunction</u> (LVESD < 40 mm, LVESDi < 20 mm/m ² , and LVEF $> 60\%$) when a durable result is likely, if at least three of the following are fulfilled: AF; SPAP at rest > 50 mmHg; LA dilatation (LAVI ≥ 60 mL/m ² or diameter ≥ 55 mm); concomitant secondary TR $\geq$ moderate.	I	B	New Class I row

Asymptomatic patients: LV dysfunction, or at least 3 of AF, SPAP > 50 mmHg, LA dilatation, secondary TR, already justify surgery (Class I).

Why is LVEF 60% important in chronic MR?



Because the LV ejects into both the aorta and the low-pressure LA, EF can look “normal” despite developing myocardial dysfunction.

**Severe MR + LVEF 60%
≠ reassuring normal LV function**

Indications for secondary MR (ventricular)

No CAD

Recommendation	Class	LOE	vs 2021
UPGRADED <u>TEER is recommended to reduce HF hospitalizations and improve quality of life in haemodynamically stable, symptomatic patients with impaired LVEF (<50%) and persistent severe ventricular SMR, despite optimized GDMT and CRT (if indicated), fulfilling specific clinical and echocardiographic criteria (Table 7).</u>	I	A	Ila B → I A
MV surgery may be considered in symptomatic patients with severe ventricular SMR without advanced HF who are not suitable for TEER.	IIb	C	Reworded

CAD

Recommendation	Class	LOE	vs 2021
MV surgery is recommended in patients with <u>severe ventricular SMR</u> undergoing CABG.	I	B	

Part 4

Indications for secondary MR (atrial)

Recommendation	Class	LOE	vs 2021
NEW <u>MV surgery, surgical AF ablation, if indicated, and LAAO should be considered in symptomatic patients with severe atrial SMR under optimal medical therapy.</u>	IIa	B	New row
NEW <u>TEER may be considered in symptomatic patients with severe atrial SMR not eligible for surgery after optimization of medical therapy including rhythm control, when appropriate.</u>	IIb	B	New row



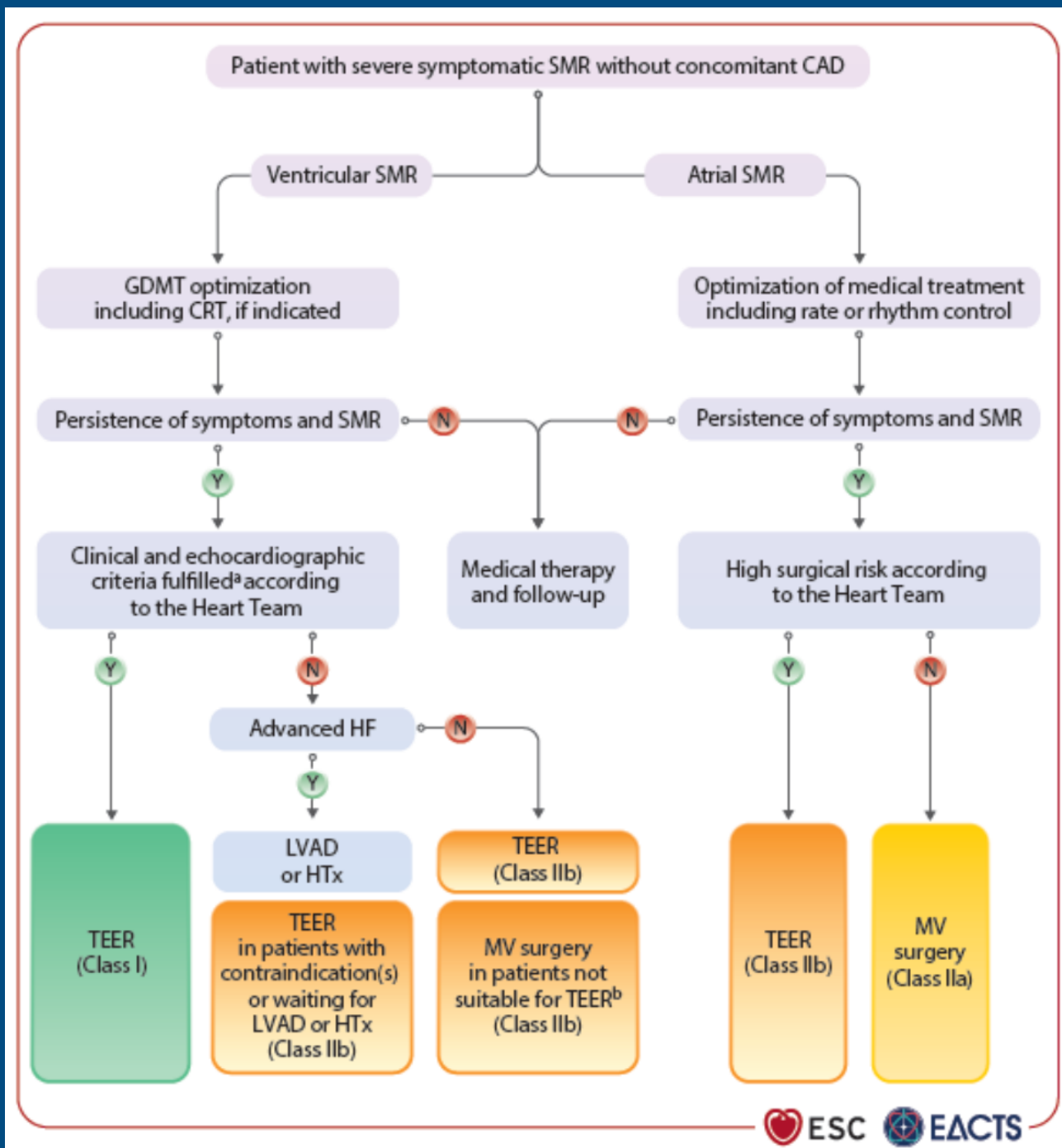
Choose surgery when

- Symptoms persist on optimal medical therapy
- Operable patient; consider AF ablation, LAAO and TR repair in the same operation



Consider TEER when

- Patient is not eligible for surgery
- Medical and rhythm-control optimization is complete, and gradient / MV-area risk has been weighed



Summary

- ✓ Primary MR – Surgery
- ✓ Atrial secondary MR – Surgery > TEER
- ✓ Ventricular secondary MR - TEER

Indications for mitral stenosis

Mitral stenosis — first ask: is PMC appropriate?

Clinically severe
rheumatic MS



Favorable valve
anatomy?

YES

PMC

Standard of care for most
suitable patients.

NO

SURGERY

Consider when symptomatic and PMC is contraindicated/unfavorable, or
when significant MR / other cardiac surgery changes the strategy.

Indications for mitral stenosis

Recommendation	Class	LOE
<u>PMC is recommended</u> in symptomatic patients with <u>no unfavourable characteristics for PMC</u> .	I	B
PMC is recommended in any symptomatic patient with a contraindication or high risk for surgery.	I	C
<u>MV surgery is recommended</u> in symptomatic patients who are <u>not suitable for PMC</u> .	I	C
PMC should be considered as initial treatment in symptomatic patients with suboptimal anatomy but no unfavourable clinical characteristics.	IIa	C
PMC should be considered in asymptomatic patients without unfavourable clinical and anatomical characteristics who have (a) high thromboembolic risk (history of systemic embolism, dense spontaneous contrast in the LA, new-onset or paroxysmal AF) and/or (b) high risk of haemodynamic decompensation (SPAP >50 mmHg at rest, need for major non-cardiac surgery, pregnancy or desire for pregnancy).	IIa	C
NEW TMVI may be considered in symptomatic patients with <u>extensive MAC and severe MV dysfunction</u> , at experienced Heart Valve Centres.	IIb	C

Summary

- ✓ Primary MR – Surgery
- ✓ Atrial secondary MR – Surgery > TEER
- ✓ Ventricular secondary MR – TEER
- ✓ MS – PMC > Surgery > TMVI (extensive MAC)

Indications for Tricuspid regurgitation

Recommendation	Class	LOE	vs 2021
NEW Careful evaluation of TR aetiology, <u>disease stage (TR severity, RV and LV dysfunction, PH)</u> , operative risk and likelihood of recovery by a multidisciplinary Heart Team is recommended in patients with severe TR prior to intervention.	I	C	New row
TV surgery is recommended in symptomatic patients with <u>severe primary TR</u> without severe RV dysfunction or severe PH.	I	C	
TV surgery should be considered in <u>asymptomatic patients</u> with <u>severe primary TR</u> who have RV dilatation or RV function deterioration, but without severe LV/RV dysfunction or severe PH.	IIa	C	
TV surgery should be considered in patients with <u>severe secondary TR</u> who <u>are symptomatic</u> or have RV dilatation/RV function deterioration, but without severe LV/RV dysfunction or PH.	IIa	B	
Transcatheter TV treatment should be considered to improve quality of life and RV remodelling in high-risk patients with symptomatic severe TR despite optimal medical therapy, in the absence of severe RV dysfunction or pre-capillary PH.	IIa	A	2021: IIb C (inoperable secondary TR)

Indications for Tricuspid regurgitation

Recommendation	Class	LOE	vs 2021
Tricuspid regurgitation with left-sided valvular heart disease requiring surgery			
Concomitant TV surgery is recommended in patients with <u>severe primary or secondary TR</u> .	I	B	2021: I C (primary), I B (secondary)
Concomitant TV repair should be considered in patients with <u>moderate primary or secondary TR</u> , to avoid progression of TR and RV remodelling.	IIa	B	2021: IIa C (primary)
Concomitant TV repair may be considered in selected patients with mild secondary TR and tricuspid annulus dilatation (≥ 40 mm or >21 mm/m ²), to avoid progression of TR and RV remodelling.	IIb	B	2021: IIa B (mild or moderate secondary TR)

Indications for Tricuspid Stenosis

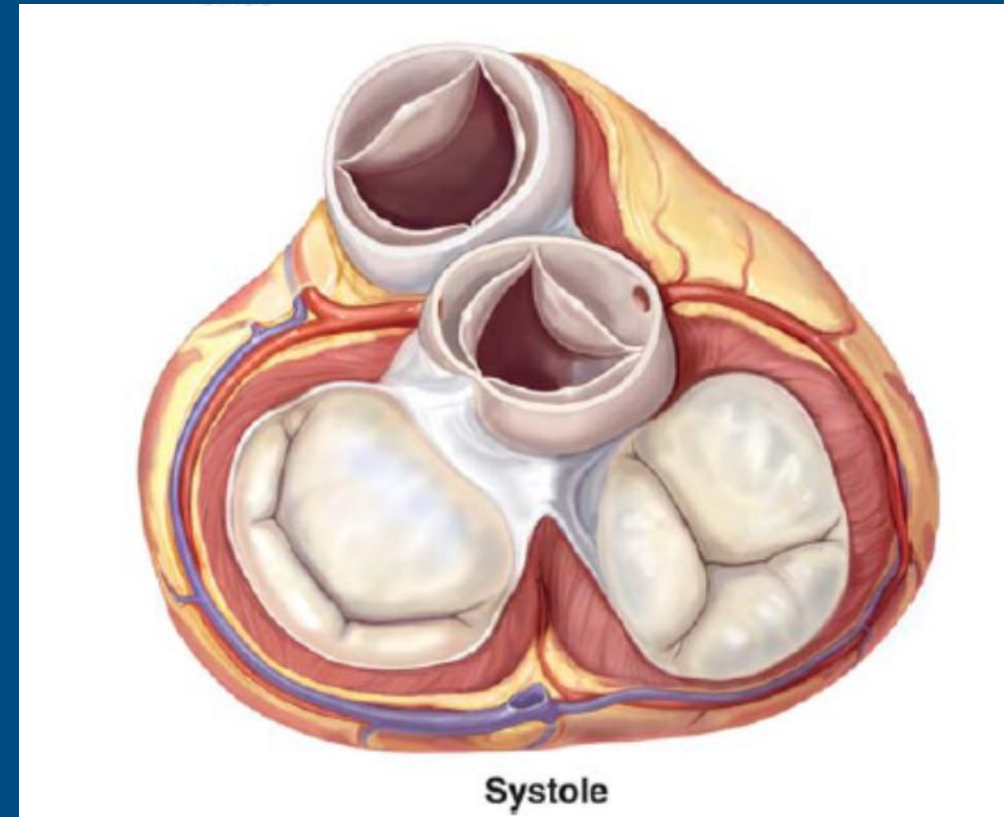
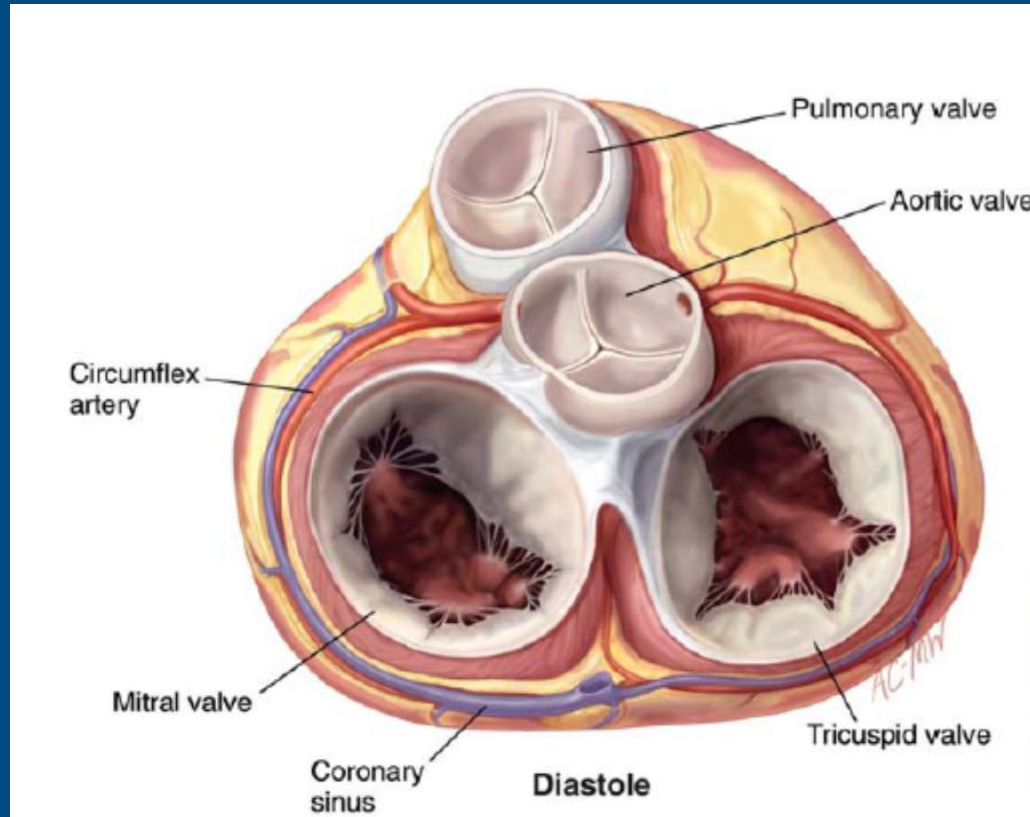
Recommendation	Class	LOE
<u>Surgery (usually TV replacement)</u> is recommended in symptomatic patients with severe TS.	I	C
Surgery is recommended in patients with severe TS undergoing <u>left-sided valve intervention</u> .	I	C

Summary

- ✓ Primary MR – Surgery
- ✓ Atrial secondary MR – Surgery > TEER
- ✓ Ventricular secondary MR – TEEAR
- ✓ MS – PMV > Surgery > TMVI (extensive MAC)
- ✓ Symptomatic primary or secondary severe TR – Surgery (I, IIa)
- ✓ Asymptomatic primary severe TR – surgery (IIa)
- ✓ Symptomatic severe TS - Surgery

Surgical Anatomy of Mitral and Tricuspid Valve

Anatomy



Anatomy – mitral valve

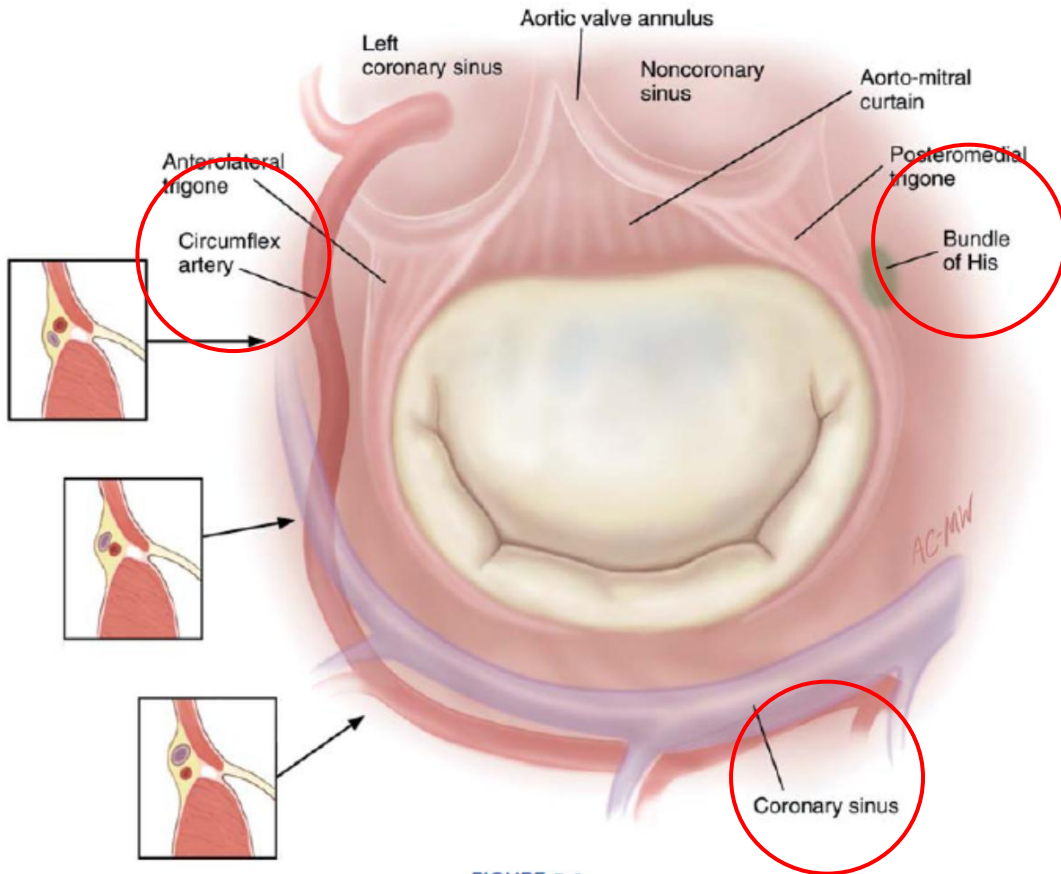
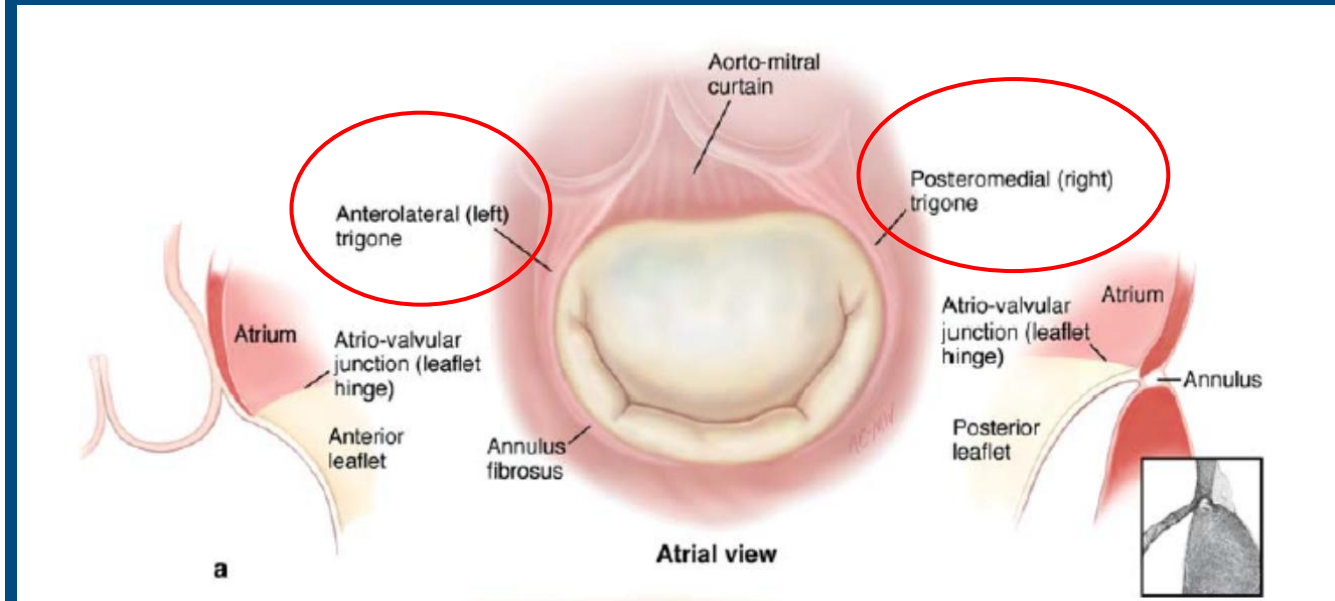
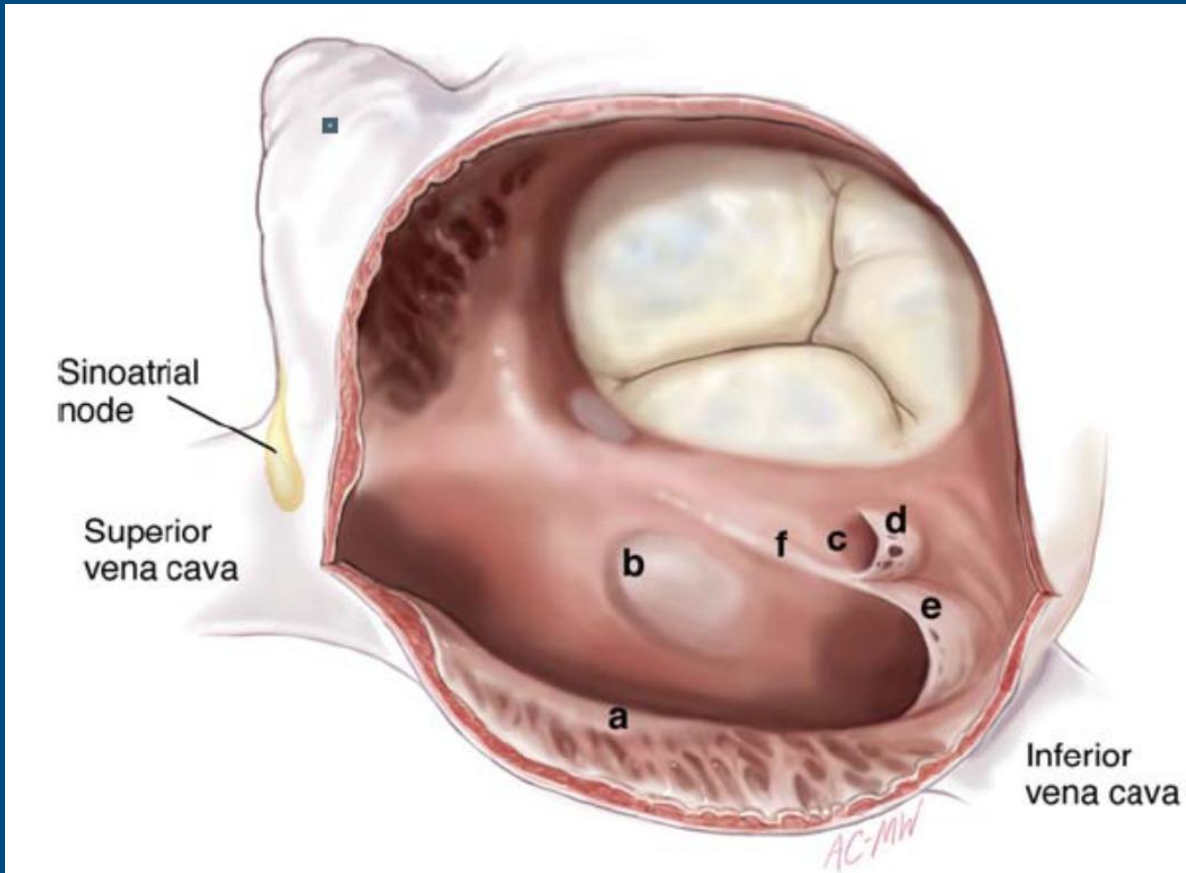


FIGURE 5-6

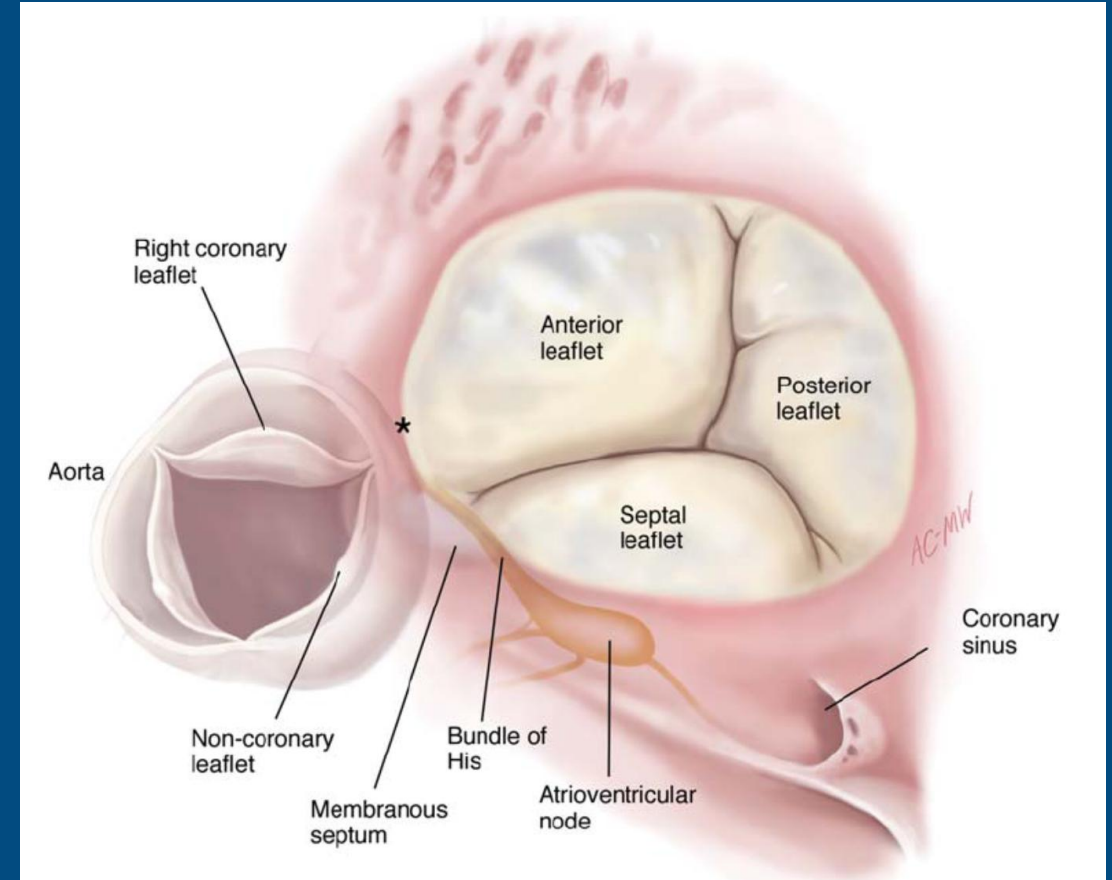


The annulus of the mitral valve is not visible from the atrium. It is deeper and 2 mm external to the visible hinge of the leaflets.

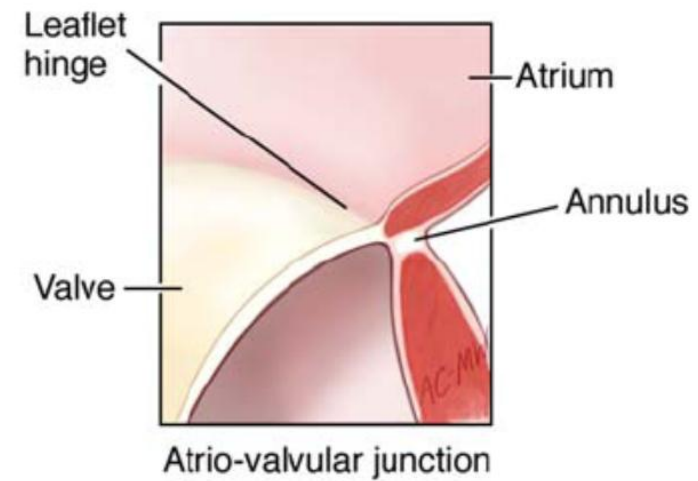
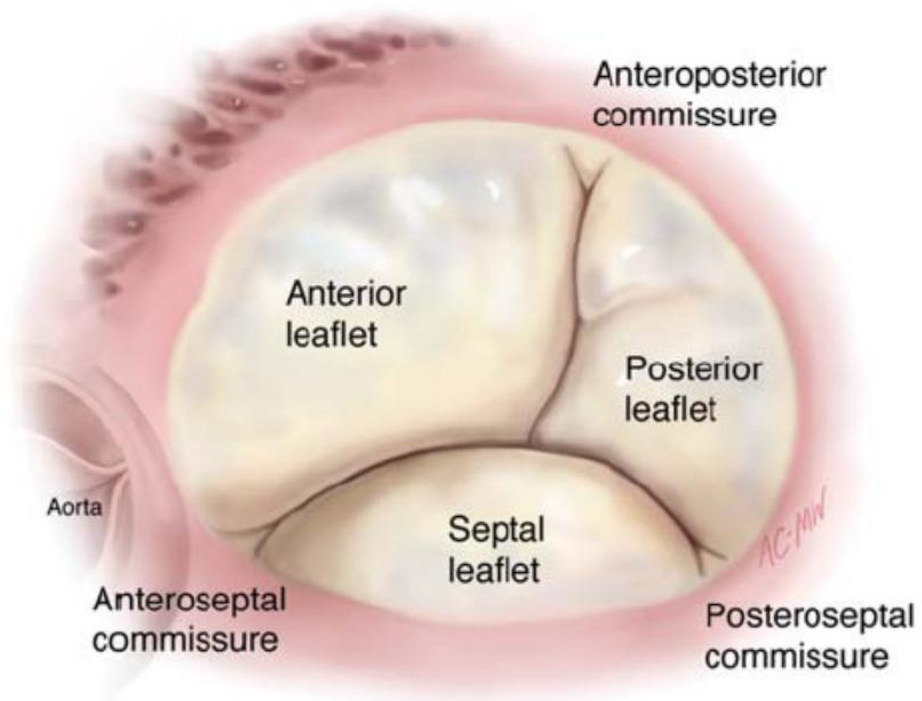
Anatomy – tricuspid valve



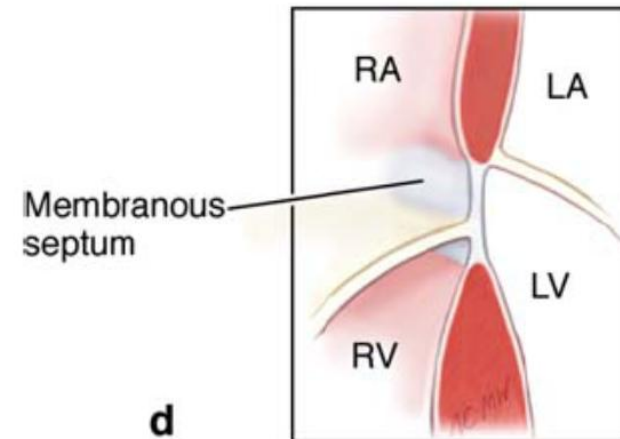
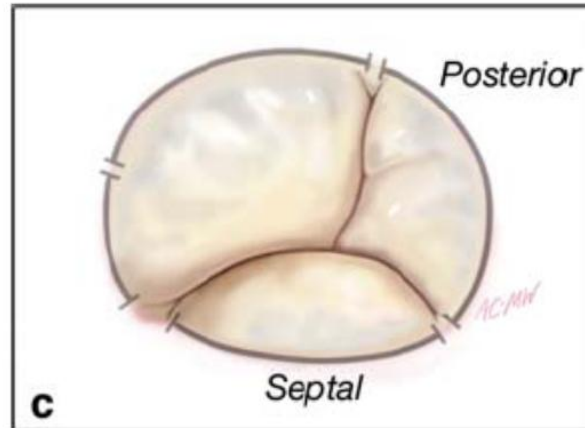
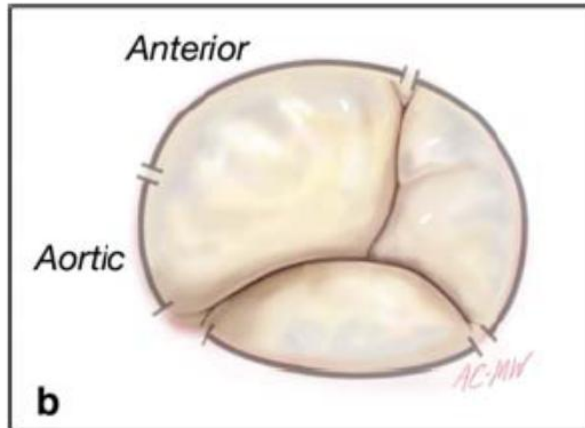
(a) Crista terminalis (b) fossa ovalis (c) coronary sinus (d) thebesian valve (e) Eustachian valve (f) tendon of Todaro



AV node는 triangle의 첨부(apex), 즉 tendon of Todaro와 삼첨판 중격엽 부착부가 만나는 부위 근처



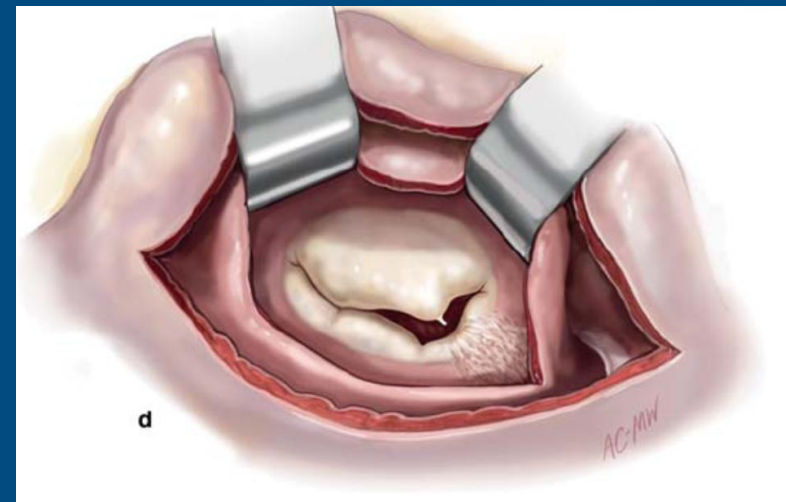
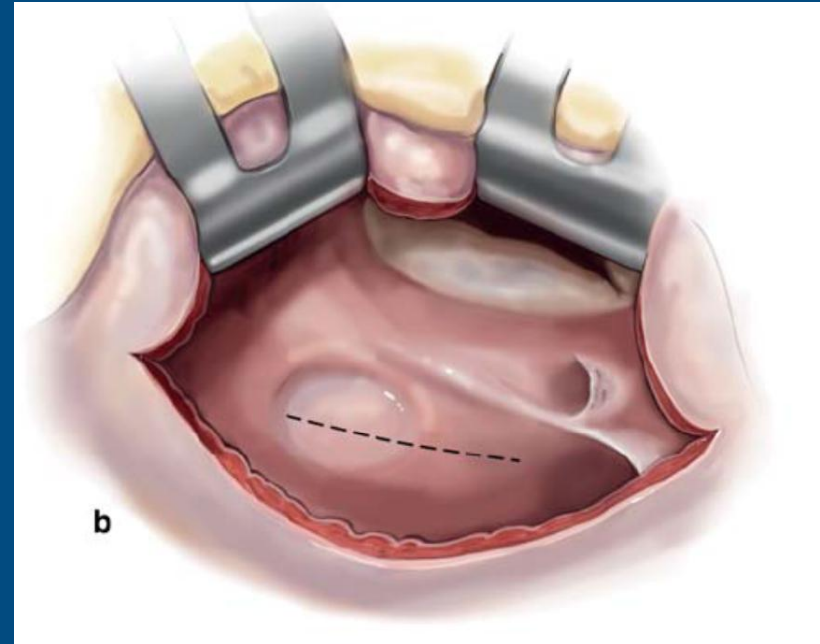
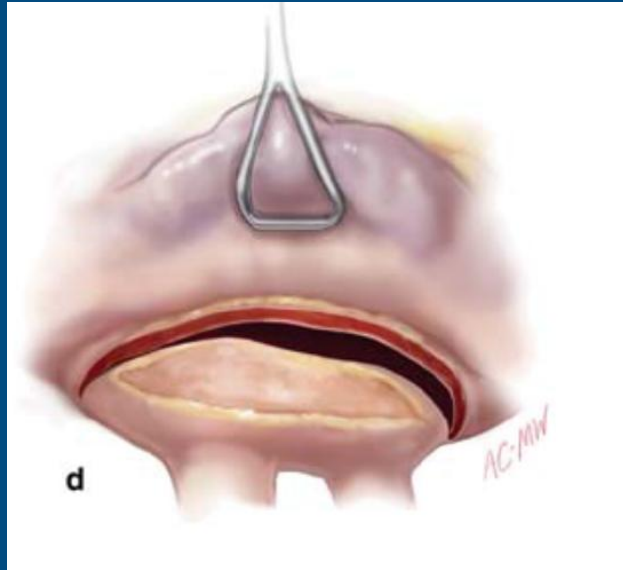
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Considering Factors for Mitral and Tricuspid Valve Surgery

MV repair의 기본 원칙

✓ Approach : Left atrium, transseptal



Valve analyses and repair

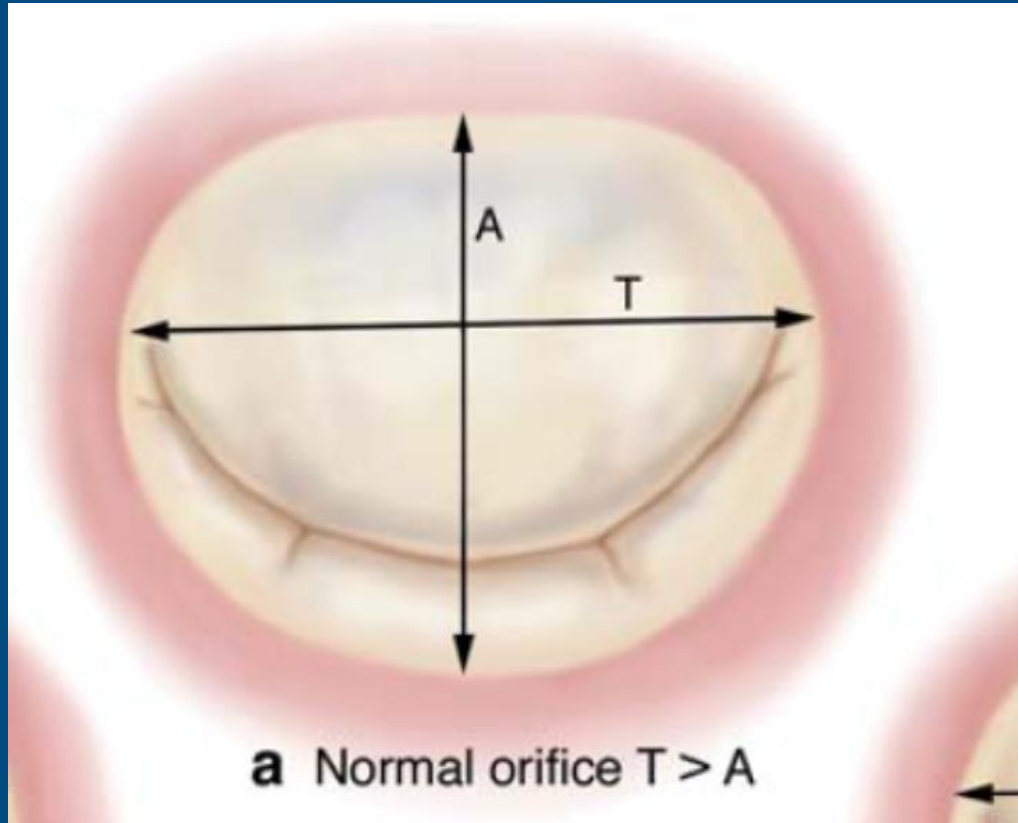
- ✓ *Valve analysis of all leaflet segments is carried out in an organized manner using P1 as a “reference point” in most instances.*
- ✓ One lesion one technique principle

The three fundamental principles of valve reconstruction are:

- 1. Preserve or restore normal leaflet motion.*
- 2. Create a large surface of coaptation.*
- 3. Remodel and stabilize the annulus.* Ring annuloplasty !!!

Ring Annuloplasty

The remodeling ring restores the normal systolic shape and size of the annulus, a condition needed for optimal leaflet coaptation. It also prevents further deformation.



$$T : A = 4 : 3$$

Ring Annuloplasty - sizing

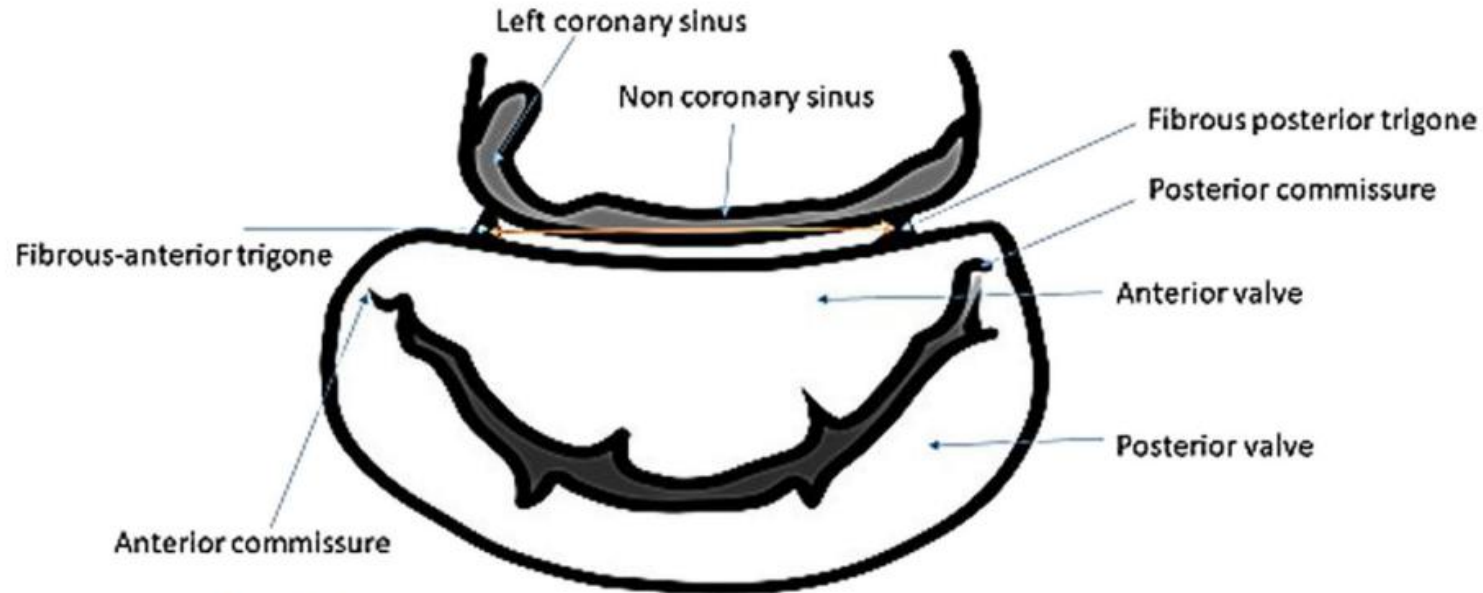
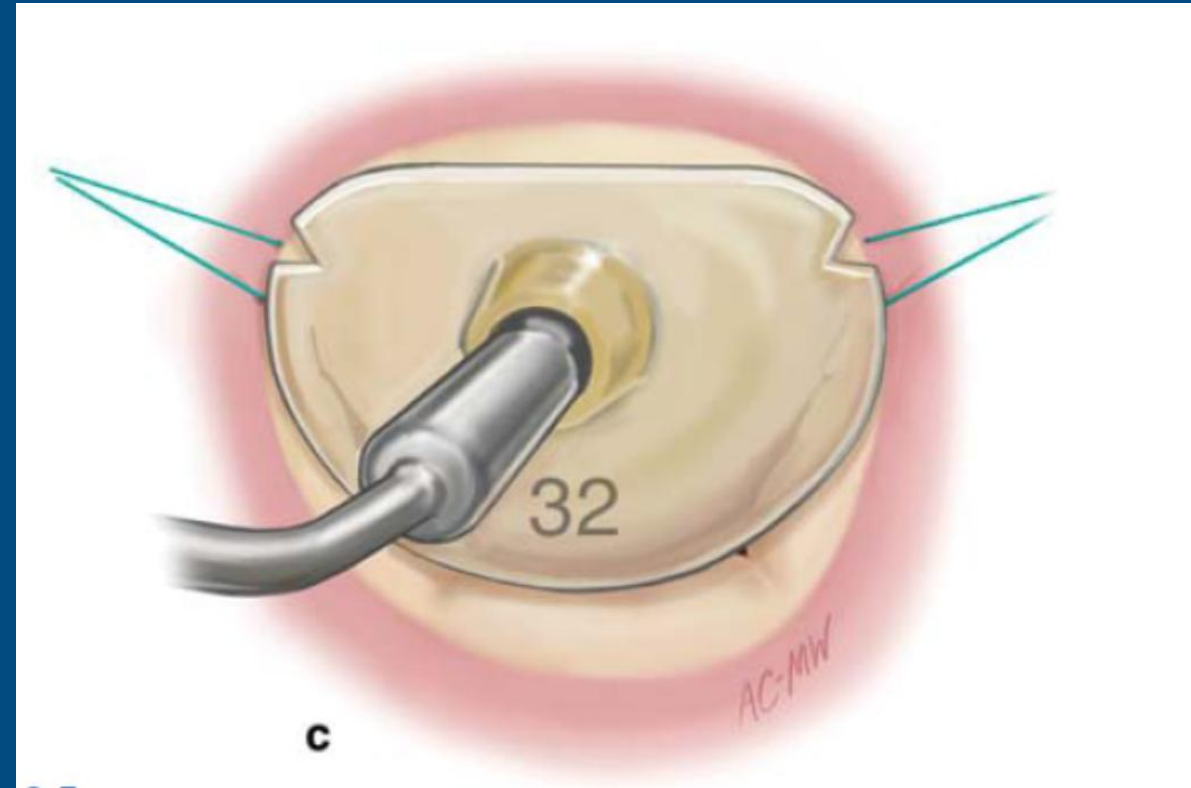
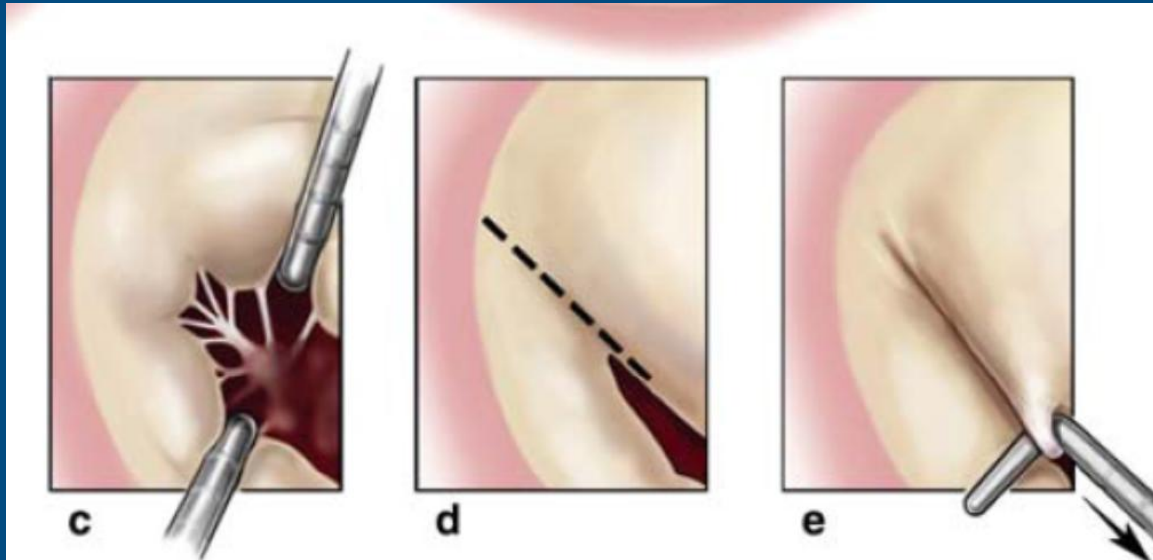


Fig. 3 Representation of the distance between two trigons

- ✓ Intertrigonal distance !!!
- ✓ Intercommissural distance !!!

Ring Annuloplasty - sizing

- ✓ Intercommissural distance !!! – CE ring



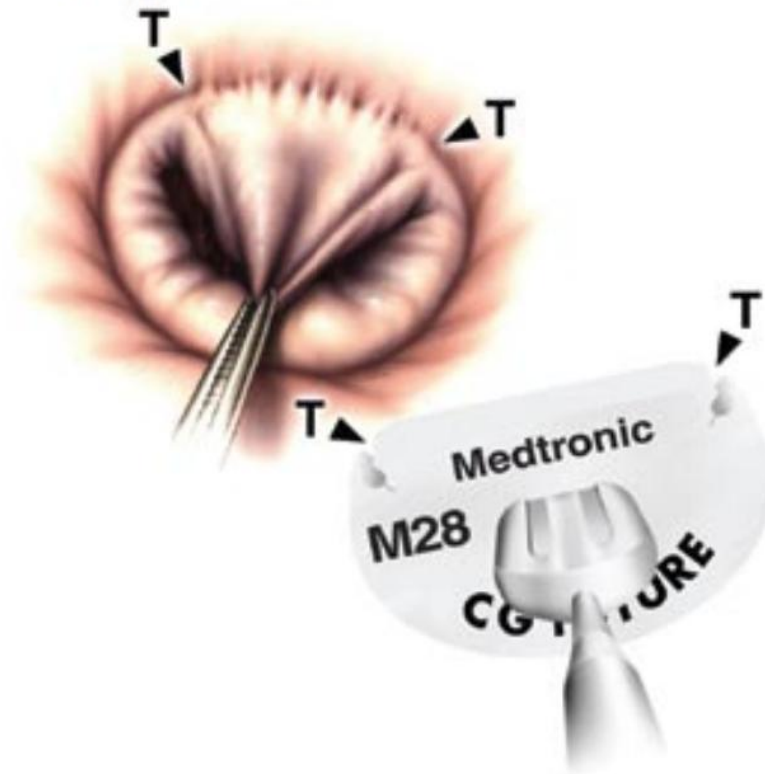
Ring Annuloplasty - sizing

- ✓ Intertrigonal distance !!! – CG future ring

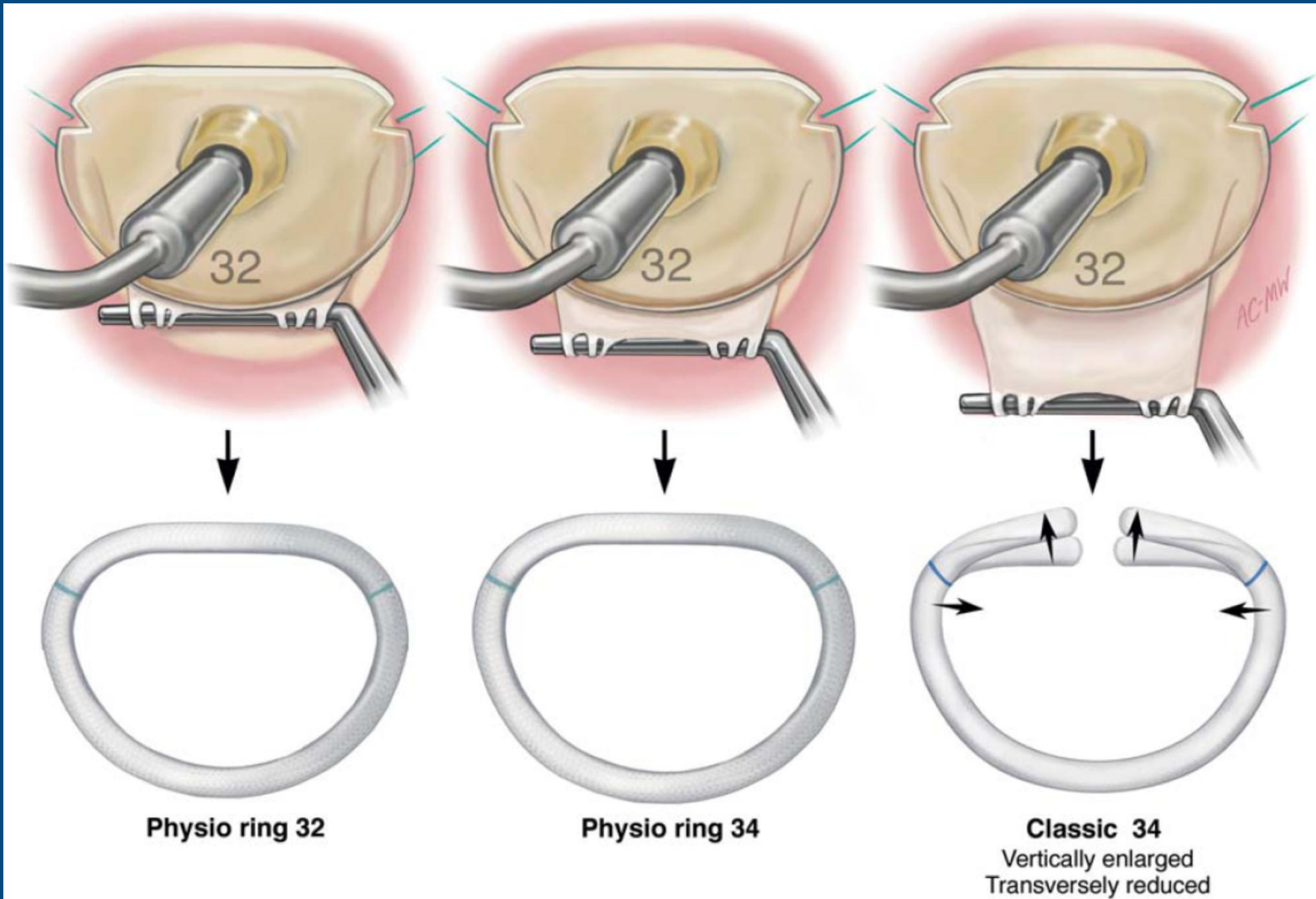
Sizing the Annulus

To determine the proper CG Future® Ring size to be used requires measuring both the distance between the trigones (intertrigonal distance) and the area of the anterior leaflet.

Lower the sizer onto the valve annulus and align the sizer notches with the trigones.



Ring Annuloplasty - sizing

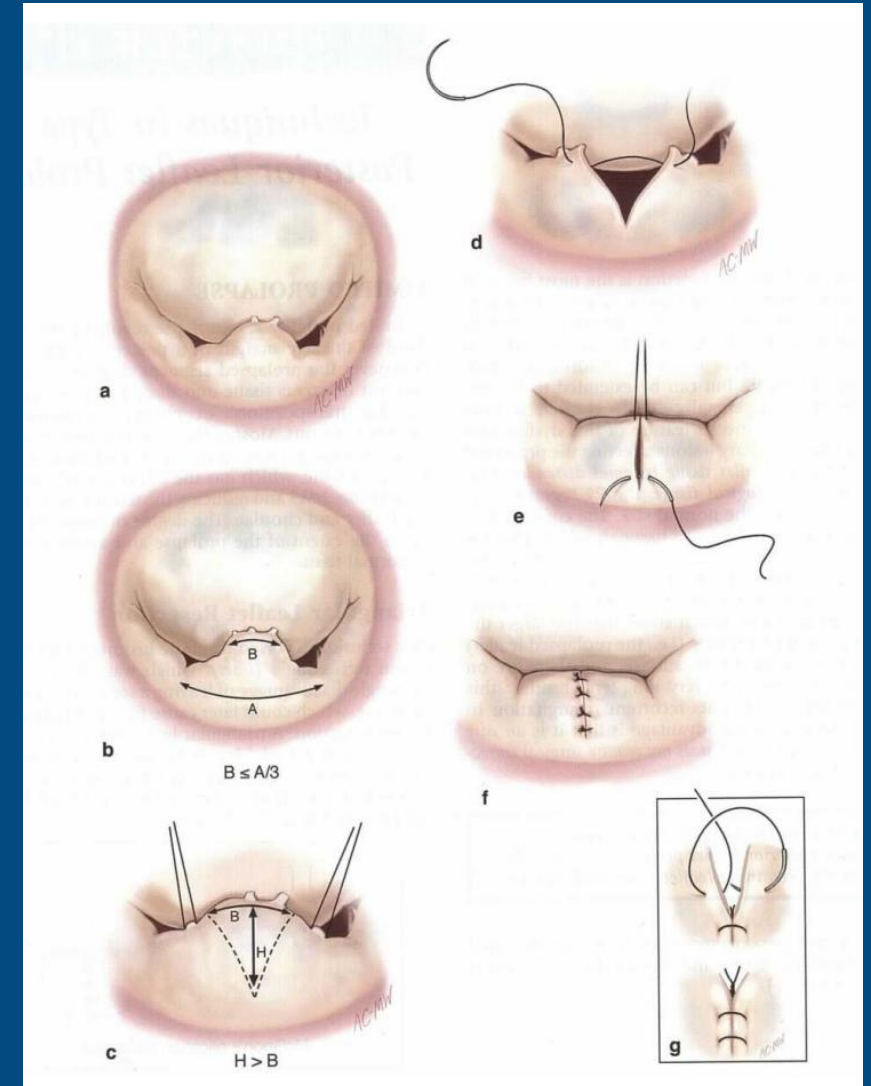


Anterior leaflet height 고려

→ mismatch가 있을 경우
large size 선택

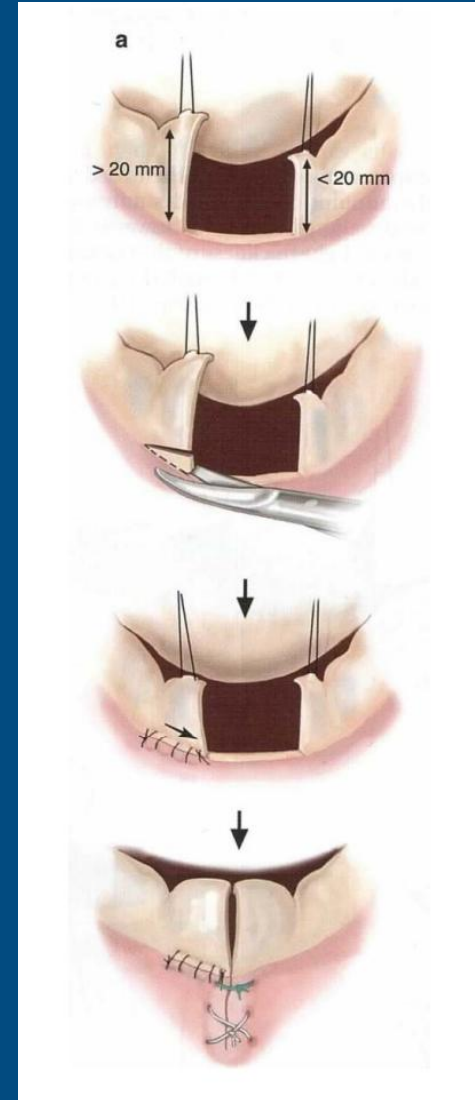
Basic repair technique – posterior prolapse

- ✓ Triangular resection : lesion $\leq$
1/3 of free margin of leaflet
segment



Basic repair technique – posterior prolapse

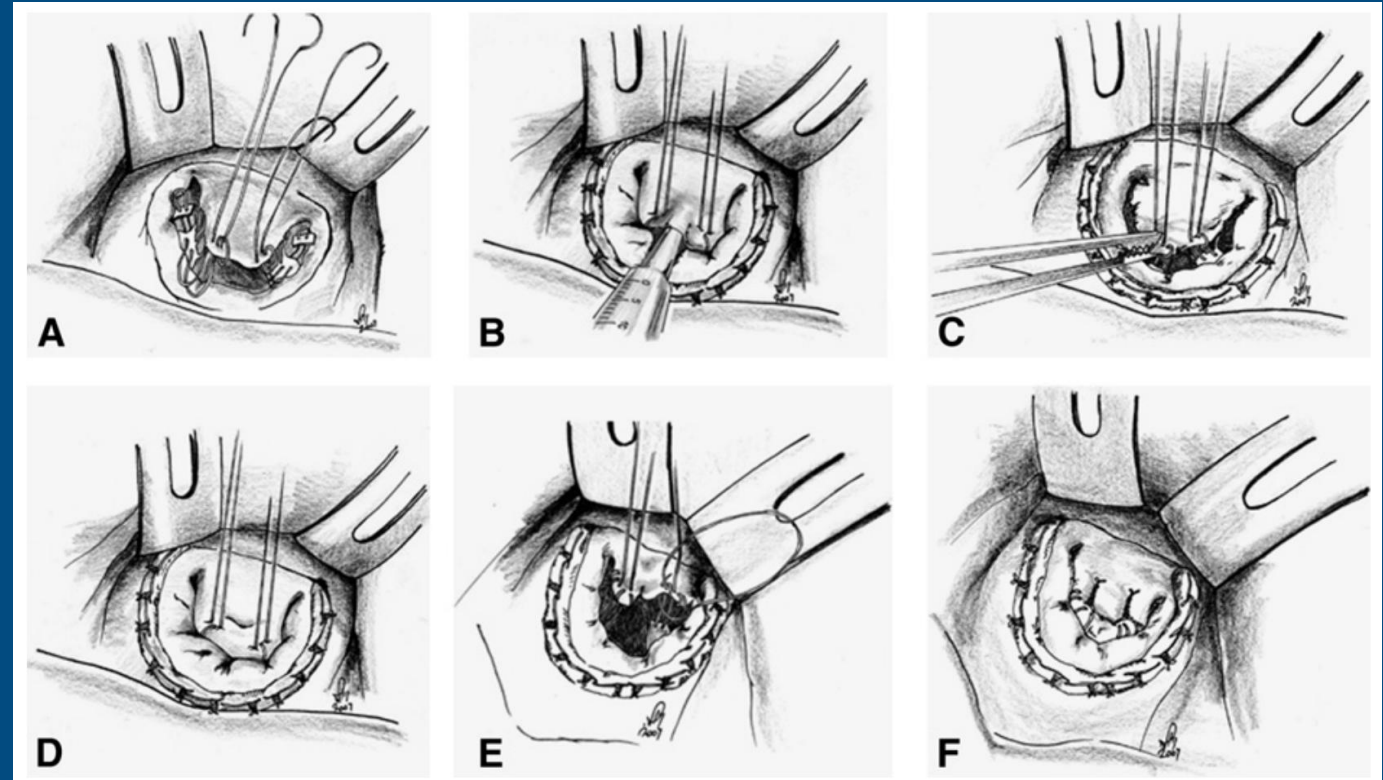
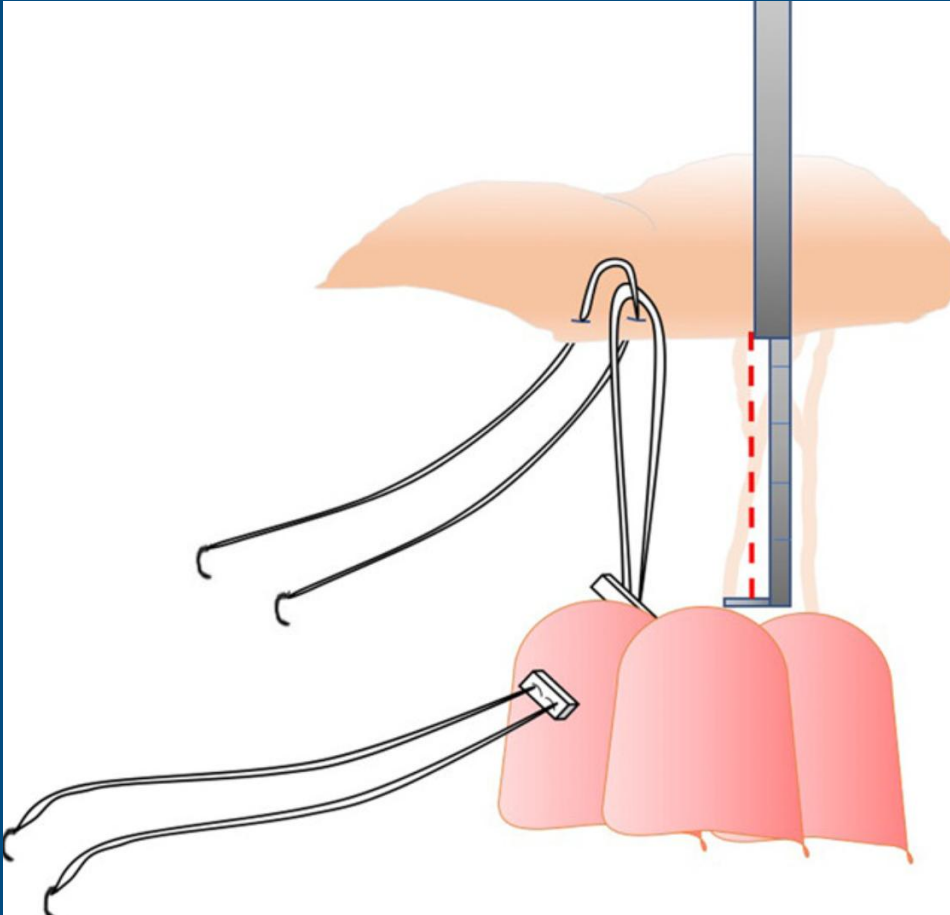
- ✓ Quadrangular resection with annular plication
: lesion $> 1/3$ of free margin of leaflet segment



Basic repair technique – anterior prolapse

Artificial chorda

- Premeasured loop
- Single loop technique : adjustment using saline test



Basic repair technique – anterior prolapse

- ✓ Alfieri (double orifice) technique
- complex problem

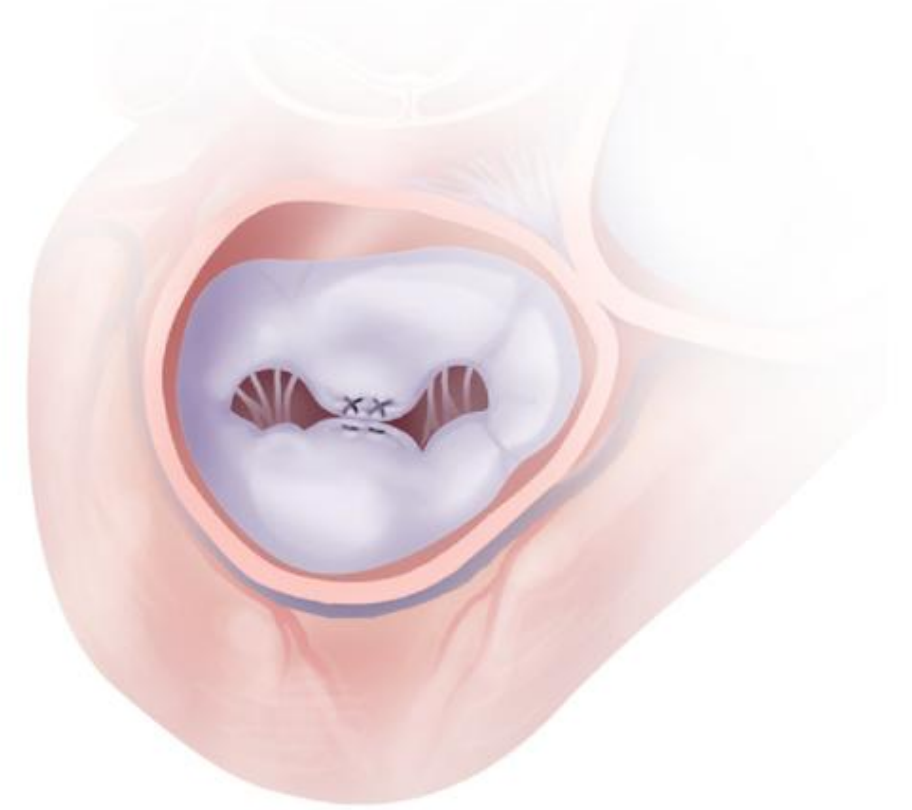


Figure 1

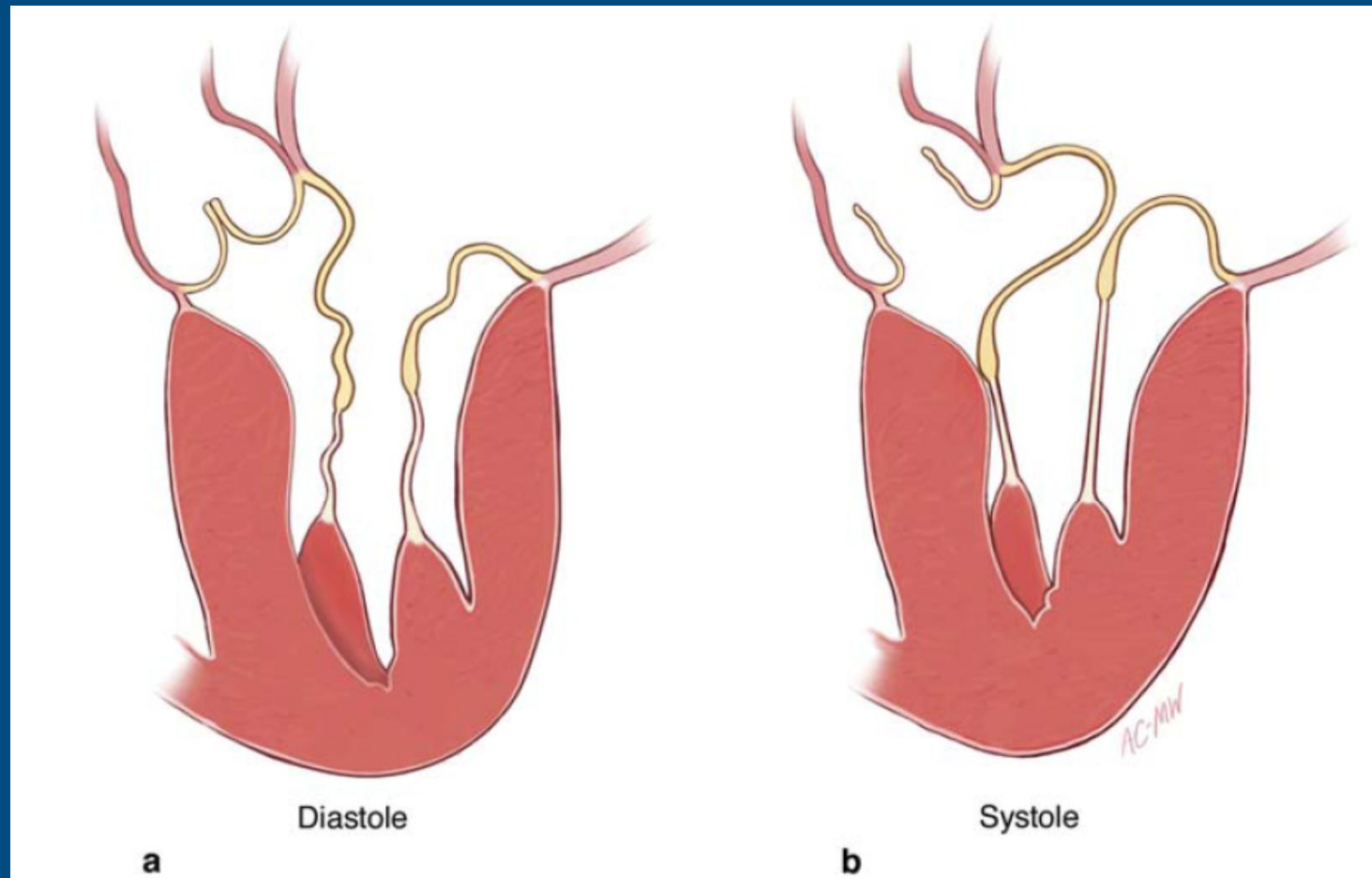
Double Orifice Surgical MV Repair With Suture

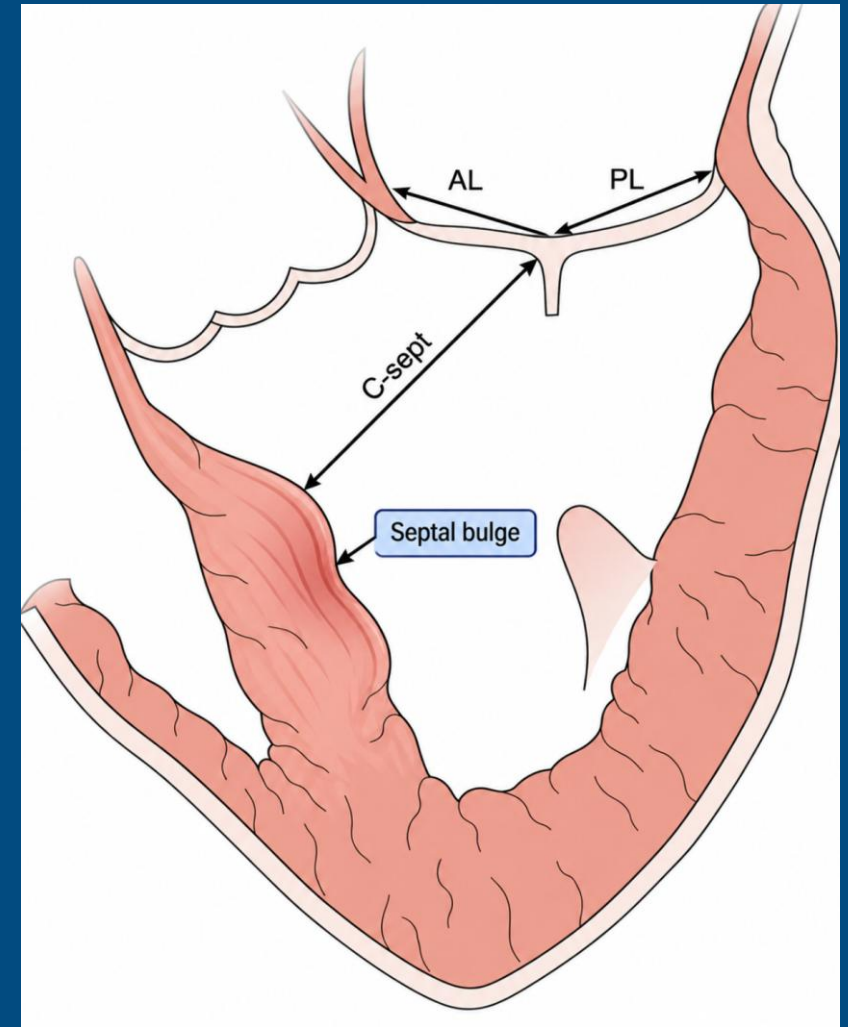
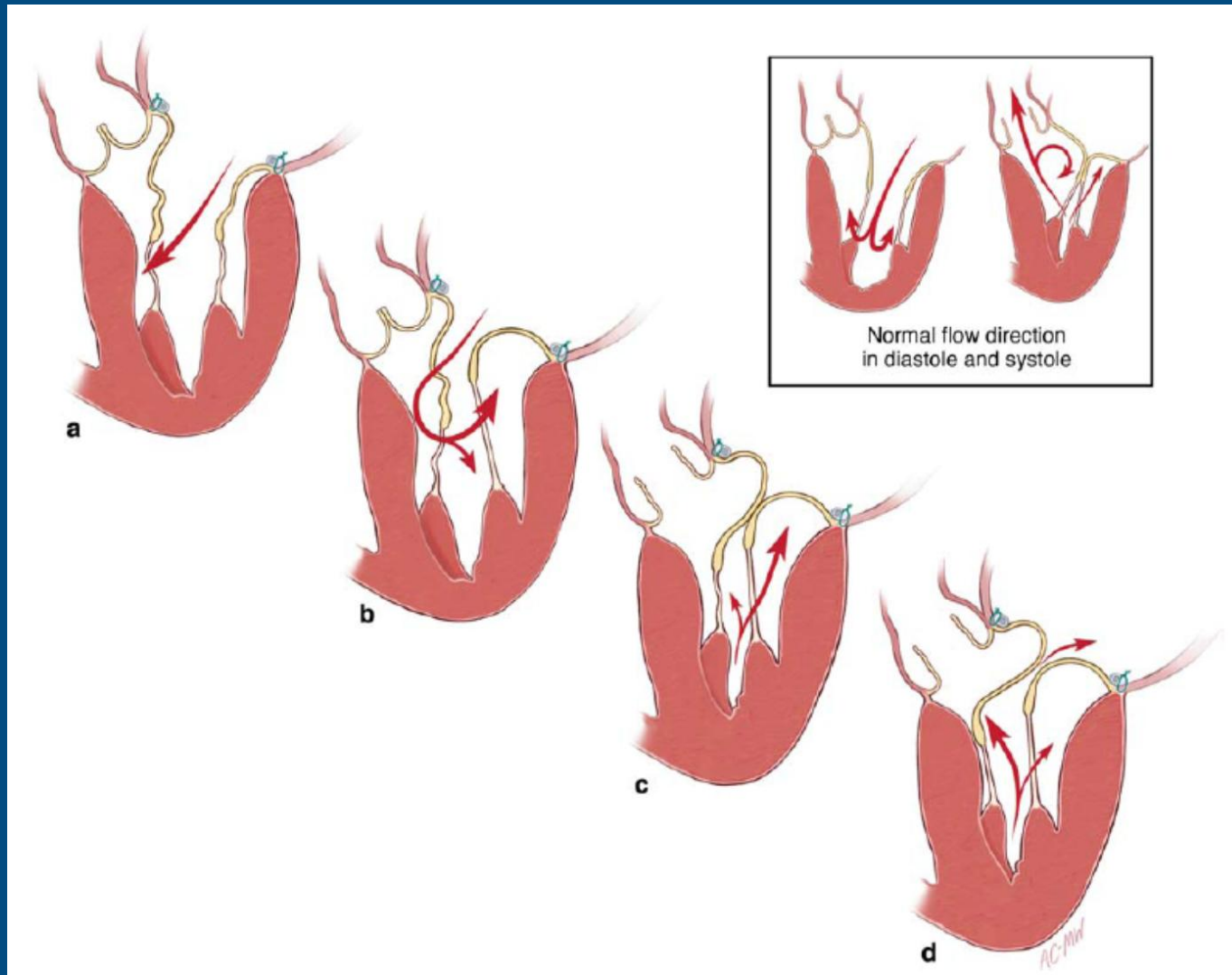
Illustration depicts a double-orifice mitral valve (MV) surgical repair. The MV is viewed from the left atrial side. The middle scallops of the anterior and posterior leaflets have been sutured together, which creates a double orifice, edge-to-edge, or bow-tie repair.

Systolic anterior leaflet motion

- ✓ SAM results from a discrepancy between the amount of valvular tissue and the mitral valve orifice area →

Mitral regurgitation, LVOT obstruction (대체적으로 작은 annulus에 비해 leaflet tissue가 과도 많을 때...)





Excess posterior leaflet tissue → posterior leaflet가 mitral orifice의 많은 부분을 차지 → anterior leaflet belly를 LVOT 쪽으로 밀어냄 → systolic flow가 anterior leaflet를 더 anteriorly displacement → SAM/LVOT obstruction → leaflet coaptation이 깨지면서 MR 발생

Systolic anterior leaflet motion - prevention

MITRAL VALVE / REPAIR

- Excessive leaflet tissue
- Tall posterior leaflet >15 mm
- Tall / elongated anterior leaflet
- Barlow valve / bileaflet prolapse
- Low AML/PML height ratio <1.3
- Undersized annuloplasty ring
- Anteriorly displaced coaptation

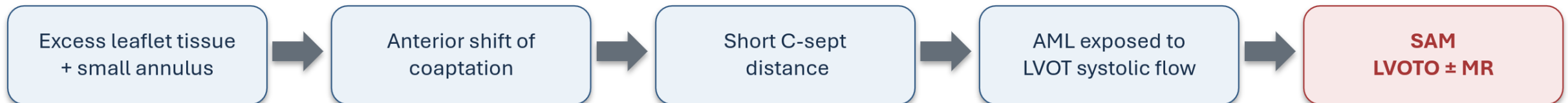
LV & LVOT ANATOMY

- Small LV cavity
- Hyperdynamic LV
- Basal septal hypertrophy >15 mm
- Short C-sept distance <25 mm
- Narrow aorto-mitral angle <120°
- Anteriorly displaced papillary muscles

HEMODYNAMIC TRIGGERS

- ↓ Preload / hypovolemia
- ↓ Afterload / vasodilation
- ↑ Contractility
- Tachycardia
- Inotropes

Key mechanism



TAKE-HOME | Excess leaflet tissue + anteriorly displaced coaptation + a small hyperdynamic LV / narrow LVOT = high SAM risk

Cause of Tricuspid valve disease

- ✓ Tricuspid Stenosis < 5%
- ✓ Tricuspid Regurgitation > 95%
- Primary TR : 10%
- Secondary/function TR : 90%

Etiologic classification of TR

TABLE 1 Etiologic Classification of TR

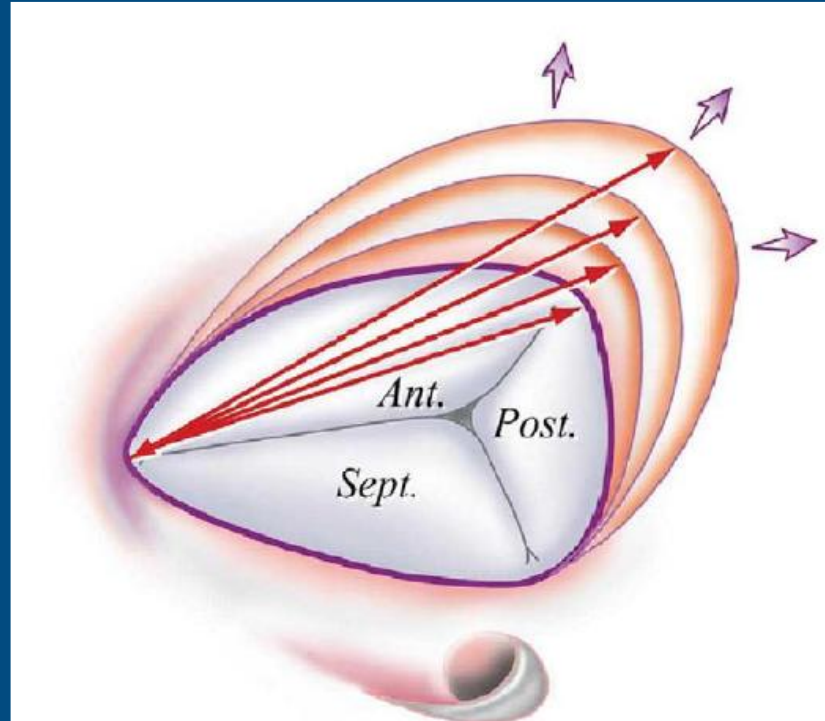
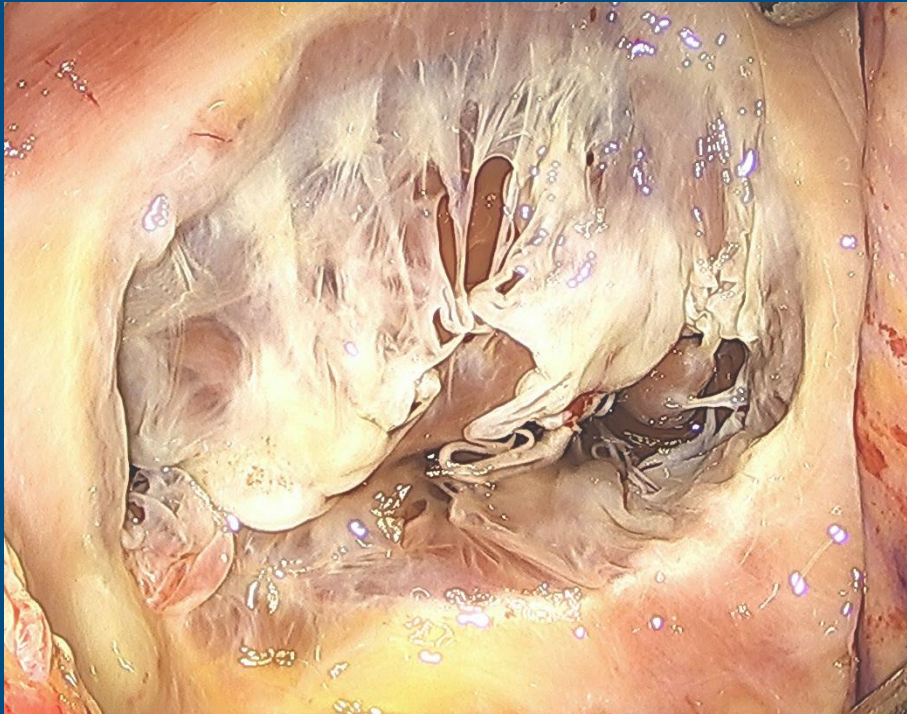
Classification	Subclassification	Etiologies
Primary TR		■ Degenerative (prolapse, flail) ■ Infective endocarditis ■ Trauma to the chest wall or leaflets ■ Ebstein anomaly ■ Carcinoid disease ■ Mediastinal radiation ■ Rheumatic disease
Secondary TR	V-STR	PH due to: ■ LV systolic dysfunction or left-sided valve disease ■ Pulmonary arterial hypertension ■ Chronic lung disease ■ Chronic pulmonary thromboembolic disease ■ Intracardiac shunt
	A-STR	■ Atrial arrhythmia ■ HFpEF
CIED-related TR	CIED-related causative TR	■ Direct interaction of the lead with the TV leaflets or sub-valvular apparatus
	CIED-related incidental TR	■ CIED present but not the direct cause of TR

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A-STR = atrial secondary tricuspid regurgitation; CIED = cardiac implantable electronic device; HFpEF = heart failure with preserved ejection fraction; LV = left ventricular; PH = pulmonary hypertension; TR = tricuspid regurgitation; TV = tricuspid valve; V-STR = ventricular secondary tricuspid regurgitation.

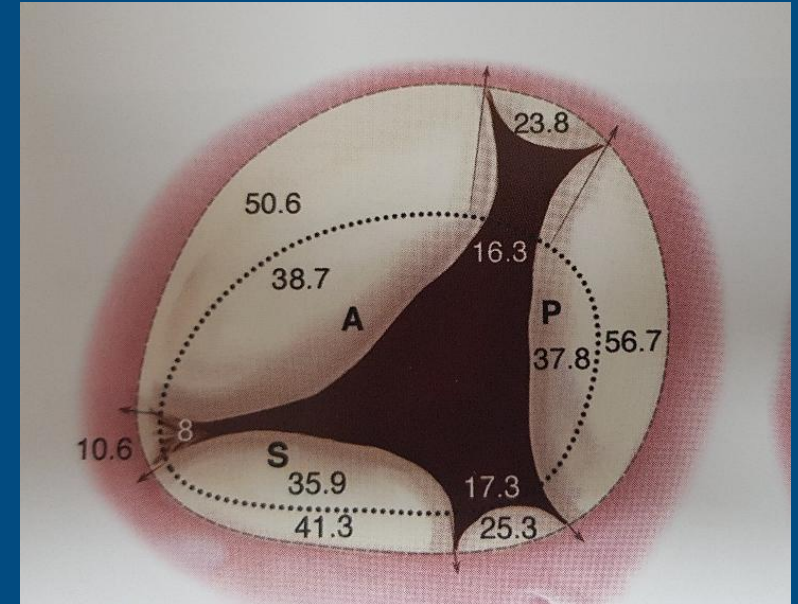
Secondary TR – changes of TV annulus

- Annular dilatation
→ ant. and post. aspect = free wall of RV

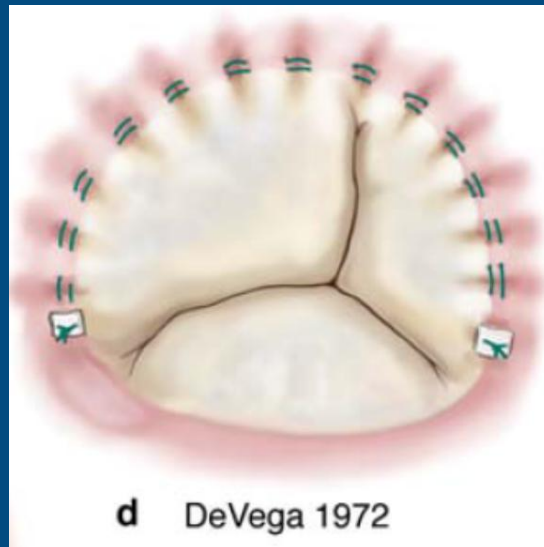
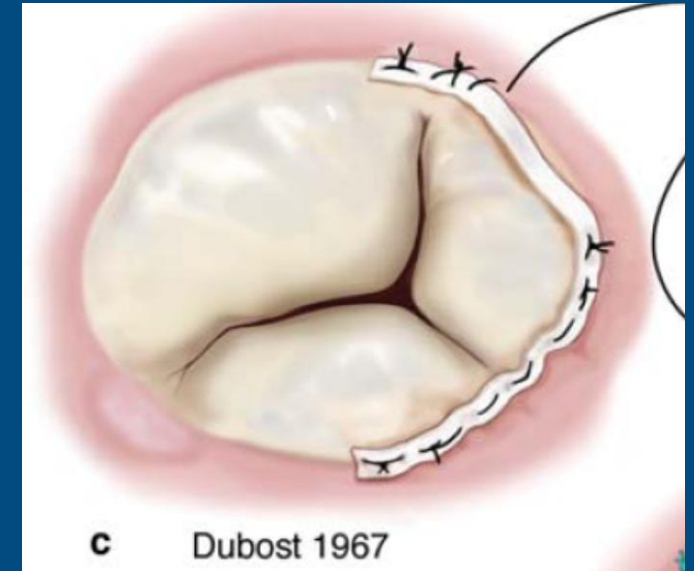
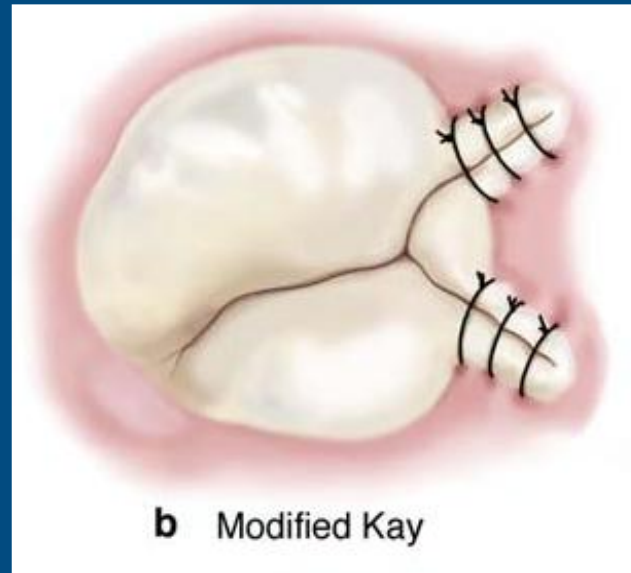
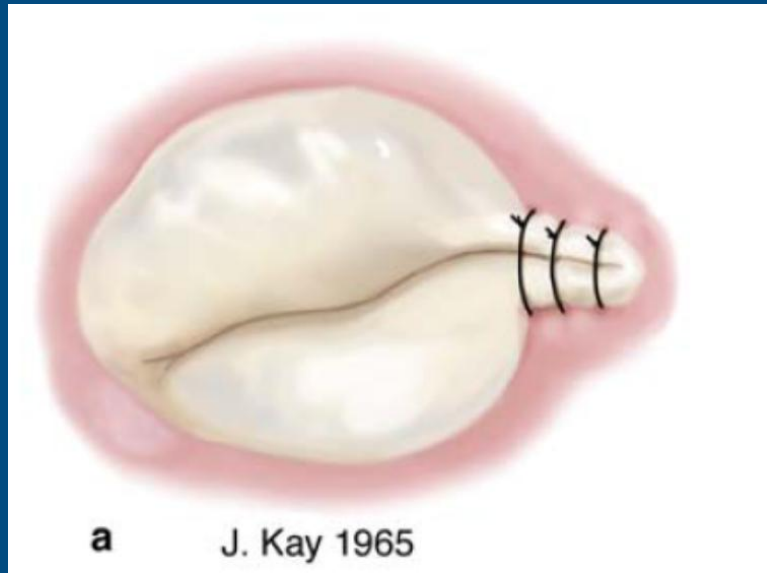


Secondary TR – changes of TV annulus

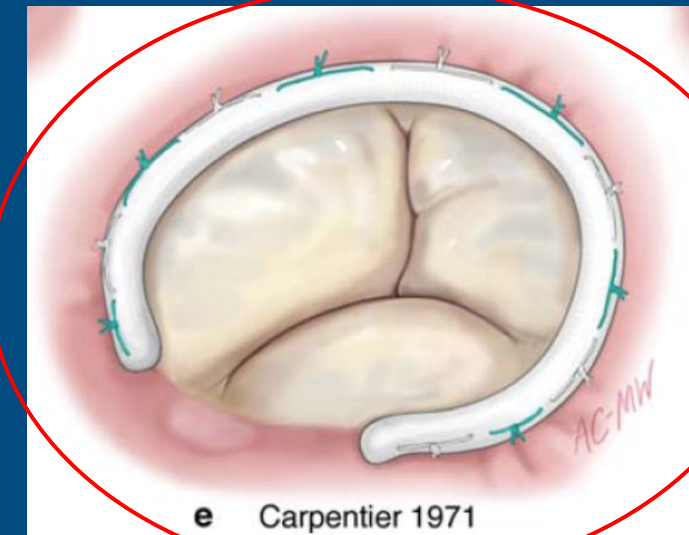
- : post. segment → increase 80%
- : ant. and aortic segment → 40%
- : anteroposterior and posteroseptal commissure → 30%
- : septal segment → lesser degree



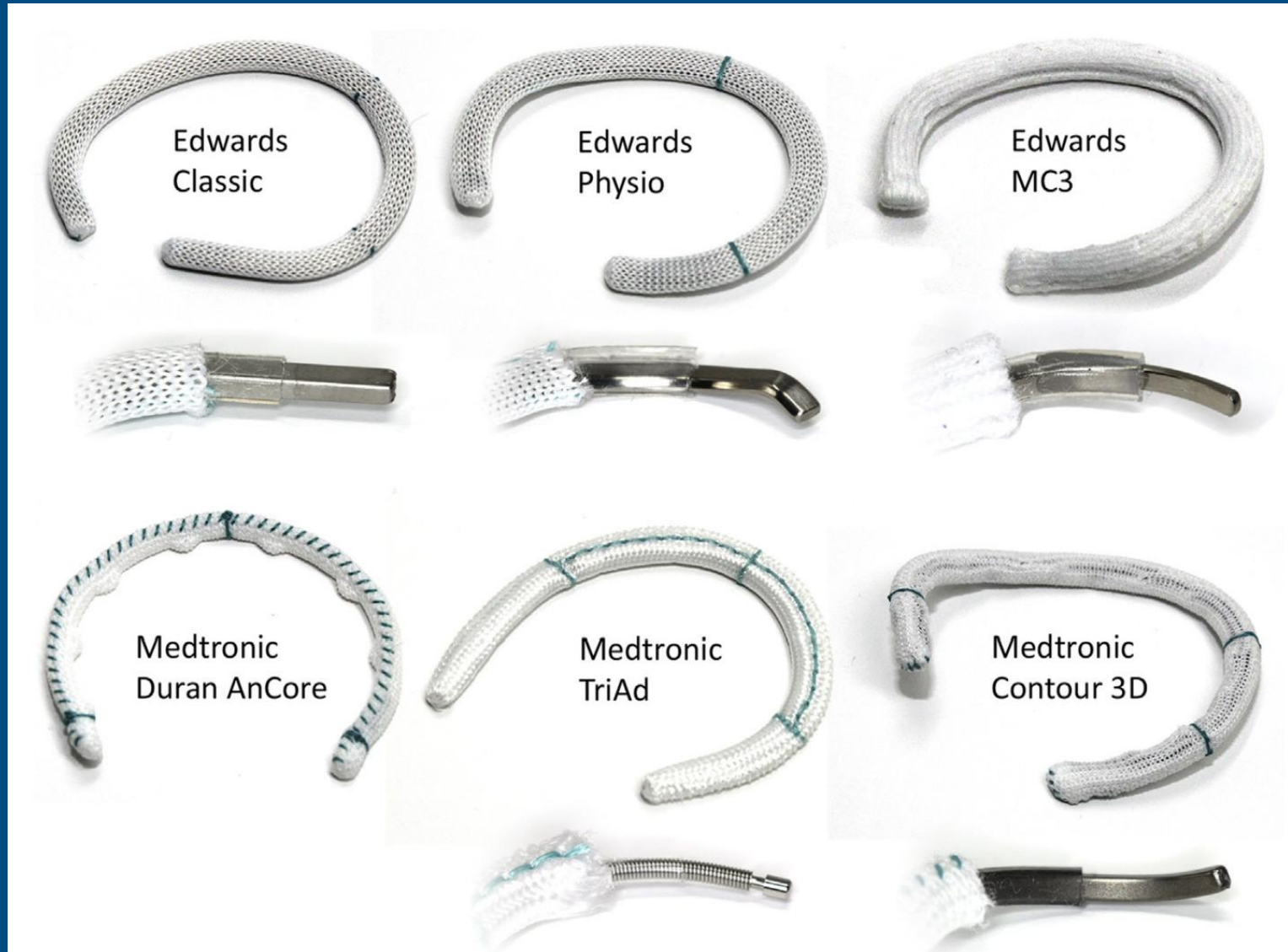
Surgery for secondary TR



VS

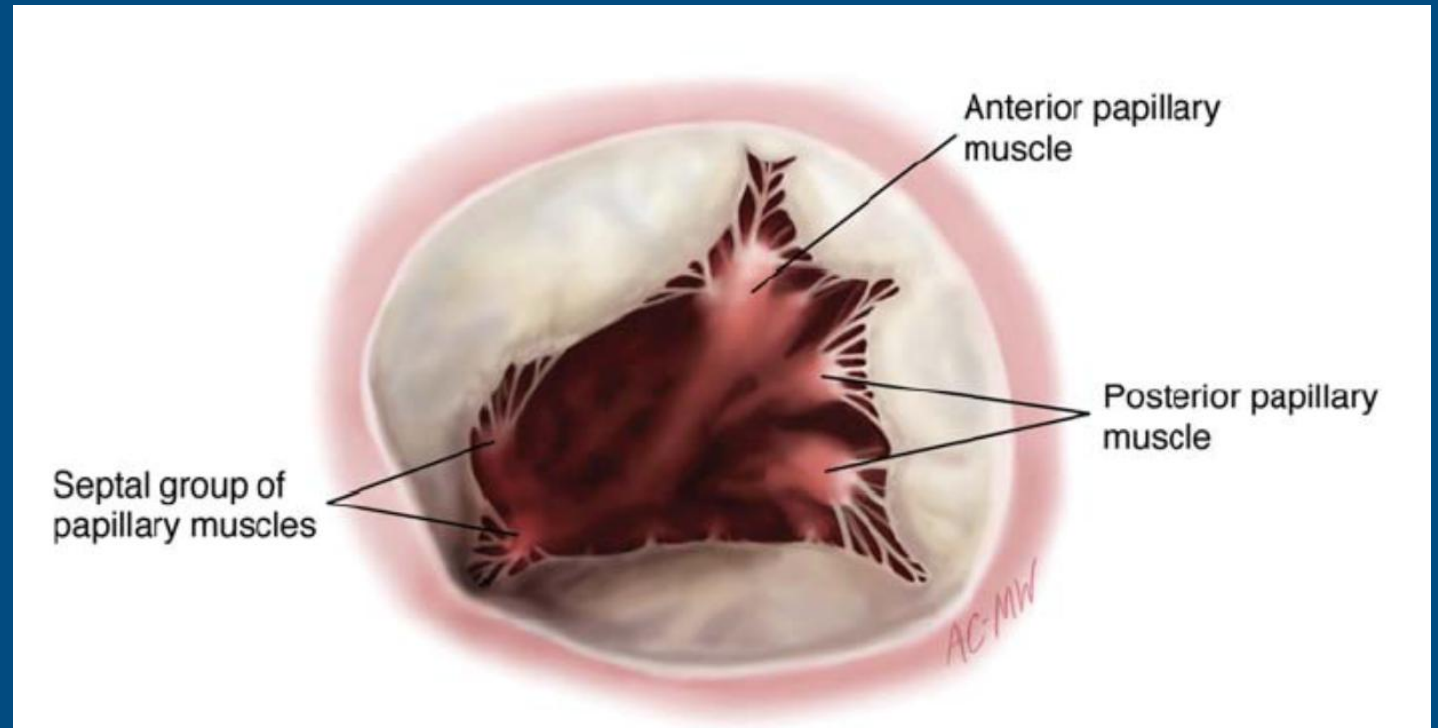


Various ring for TV

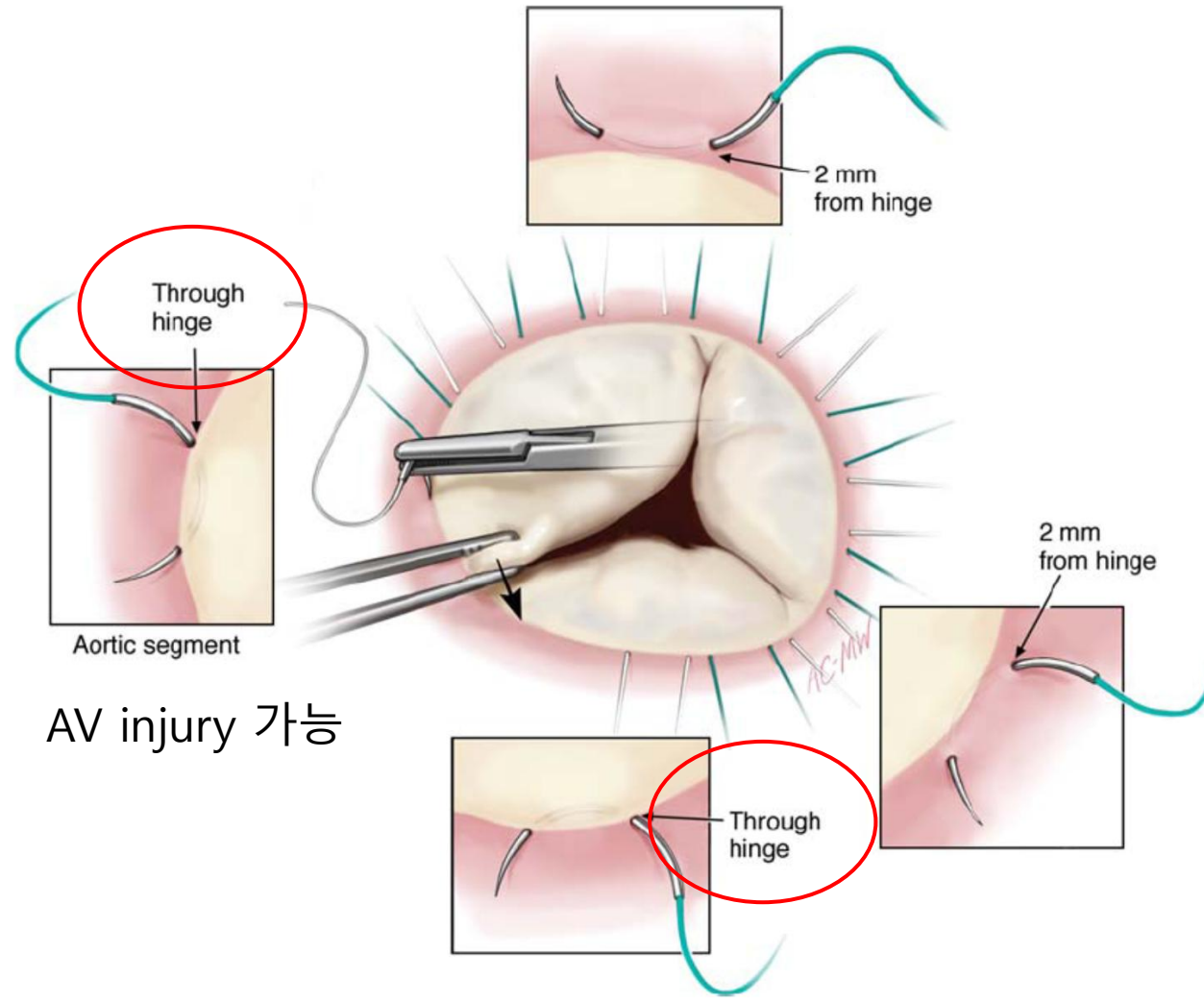


Ring Selection - sizing

- ✓ Septal leaflet base를 측정 → 임상에서는 참고 하는 정도...
- ✓ Anterior papillary muscle에서 나오는 chordae가 붙는 leaflet area 측정

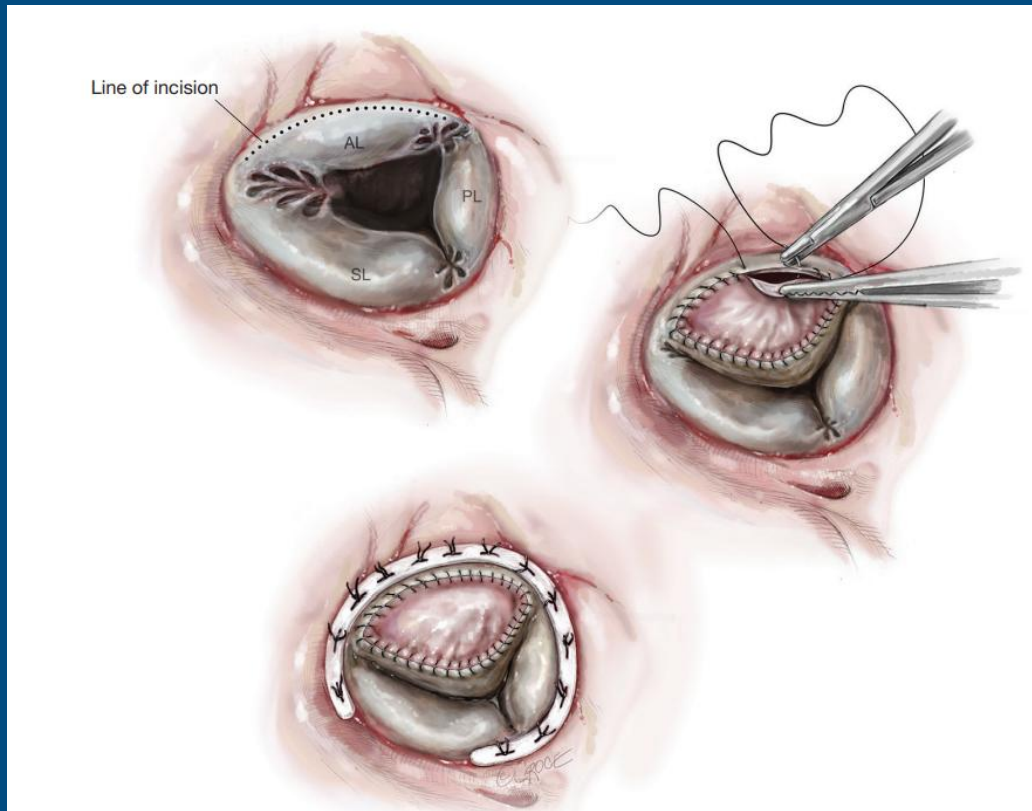


Annular suture - 주의사항

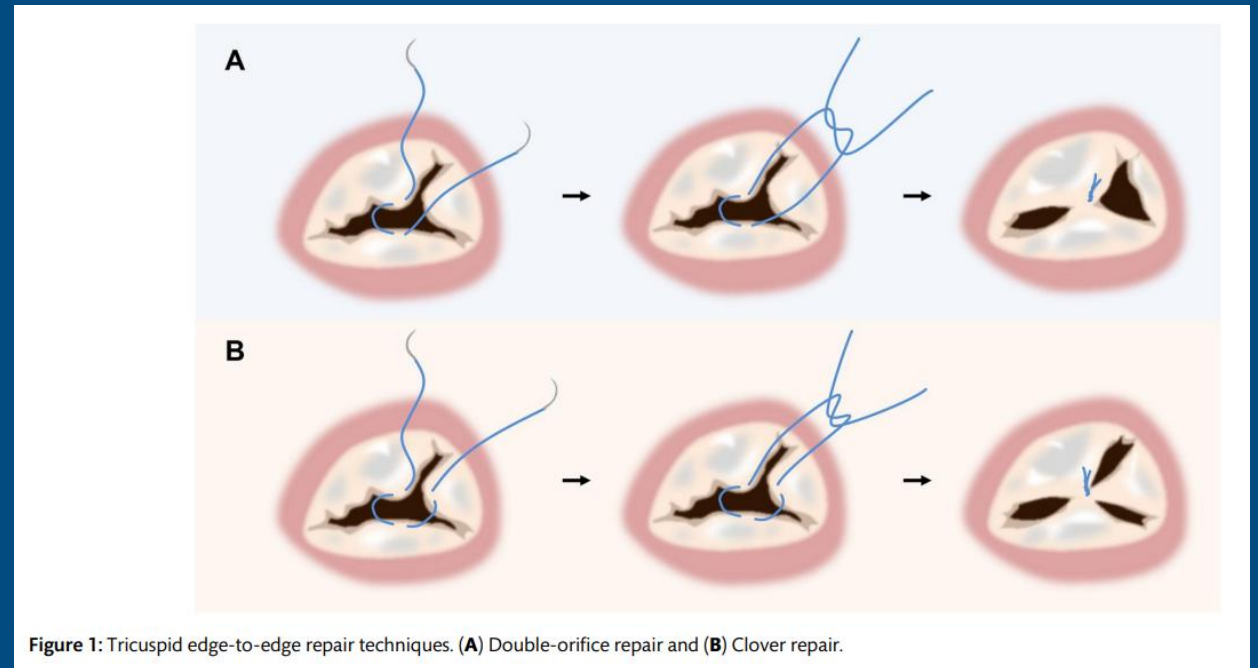


- ✓ 2 mm external to the visible hinge of the leaflets
- ✓ Septal area, aortic portion – hinge of the leaflet

Additional repair technique



Ant. Leaflet augmentation



Edge-to-edge repair

(A) double-orifice (B) clover

Conclusions

- ✓ 승모판, 삼첨판 질환의 수술 적응증을 이해한다.
- ✓ 승모판, 삼첨판의 해부학을 이해한다.
- ✓ 승모판, 삼첨판막 수술의 기본 원칙을 이해한다.

Systolic anterior leaflet motion - prevention

MITRAL VALVE / REPAIR

- **Excessive leaflet tissue**
- **Tall posterior leaflet >15 mm**
- Tall / elongated anterior leaflet
- **Barlow valve / bileaflet prolapse**
- Low AML/PML height ratio <1.3
- **Undersized annuloplasty ring**
- **Anteriorly displaced coaptation**

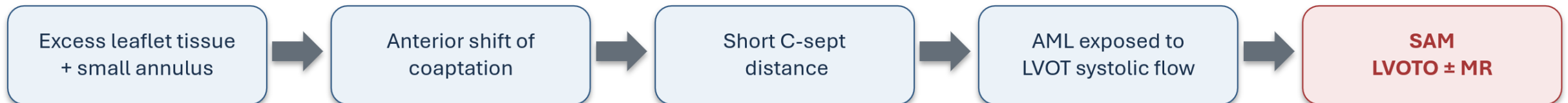
LV & LVOT ANATOMY

- Small LV cavity
- Hyperdynamic LV
- **Basal septal hypertrophy >15 mm**
- **Short C-sept distance <25 mm**
- **Narrow aorto-mitral angle <120°**
- Anteriorly displaced papillary muscles

HEMODYNAMIC TRIGGERS

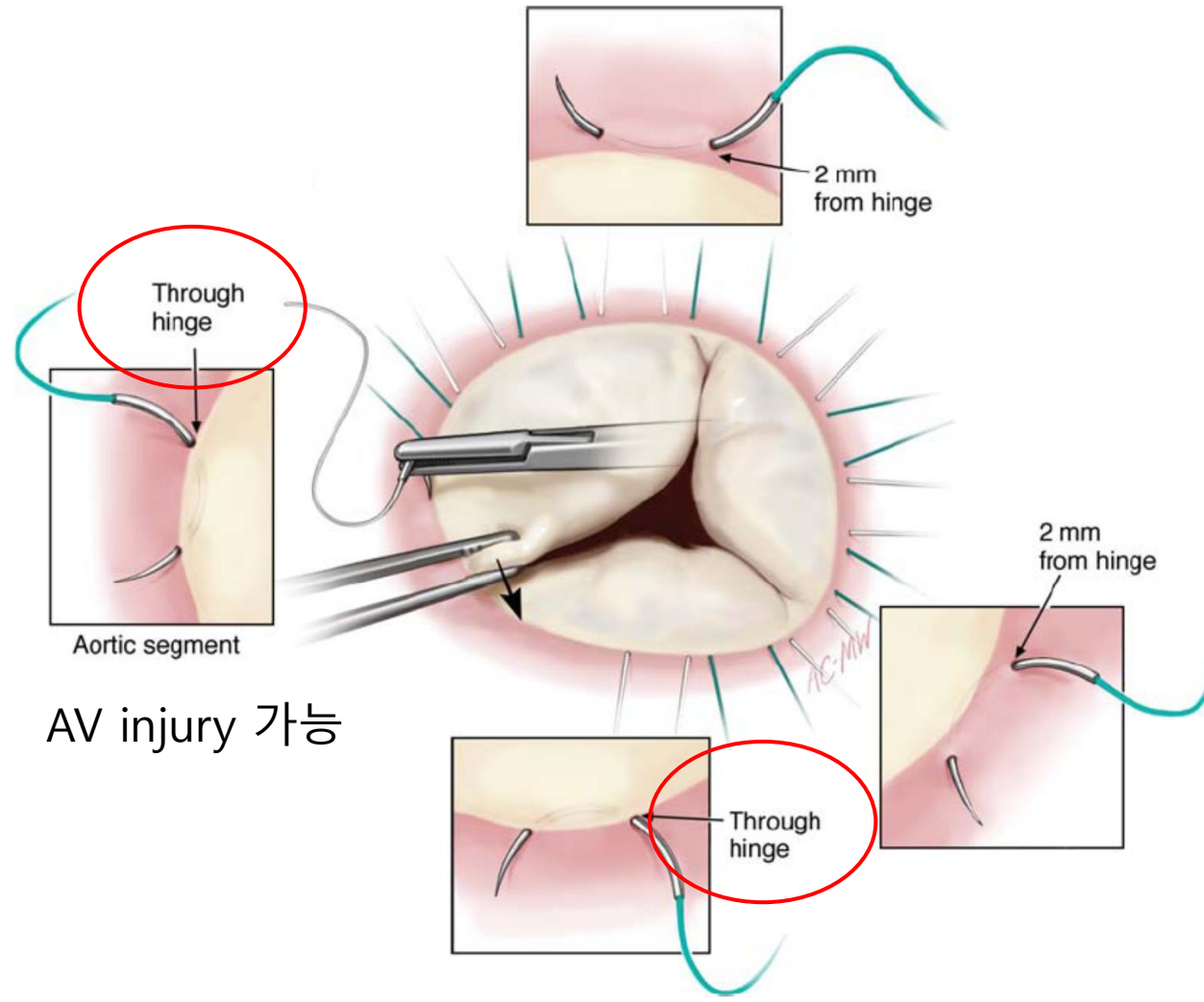
- ↓ Preload / hypovolemia
- ↓ Afterload / vasodilation
- ↑ **Contractility**
- Tachycardia
- Inotropes

Key mechanism



TAKE-HOME | Excess leaflet tissue + anteriorly displaced coaptation + a small hyperdynamic LV / narrow LVOT = high SAM risk

Annular suture - 주의사항



- ✓ 2 mm external to the visible hinge of the leaflets
- ✓ Septal area, aortic portion – hinge of the leaflet