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Surgical Management of Arrhythmia

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김준범

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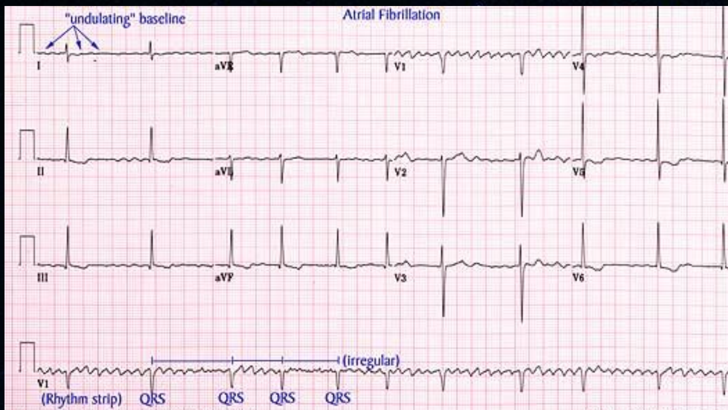
Atrial Fibrillation



Sudden death

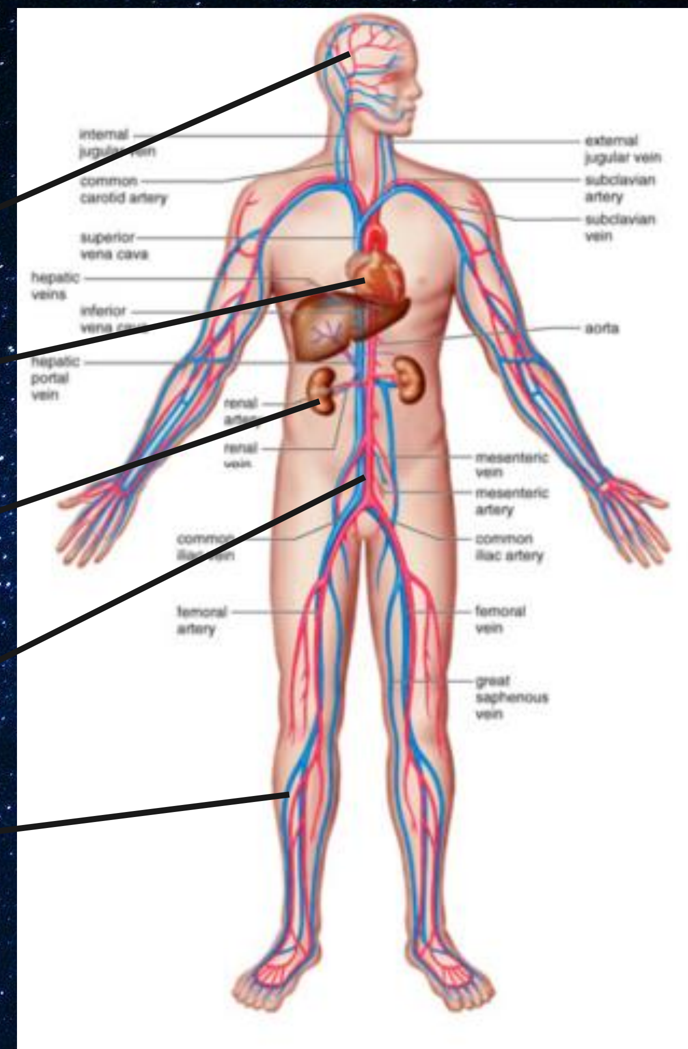
Stroke

Myocardial

Renal

Mesenteric

Limbs



Atrial Fibrillation

- Most common arrhythmia requiring treatment: prevalence ≈ 2%
- Age > 70 yrs: prevalence ≈ 10%

- Clinical issues – Palpitation symptoms
  – CHF
  – Thromboembolism (stroke)
- Response to anti-arrhythmic agents: 30-60%
- Long-term efficacy: <30%
- Most patients need lifelong anticoagulation therapy

Stroke prevention

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REFLECTIONS OF THE PIONEERS

The first Maze procedure

_In 1987_

James L. Cox, MD

J Thorac Cardiovasc Surg 2011;141:1093-7

Development of Maze Procedure

- 1st animal (canine) model for AF in 1980 (Duke University)
  - Stepwise chordae rupture → MR induction
  - Wait > 3 months→ AF induction

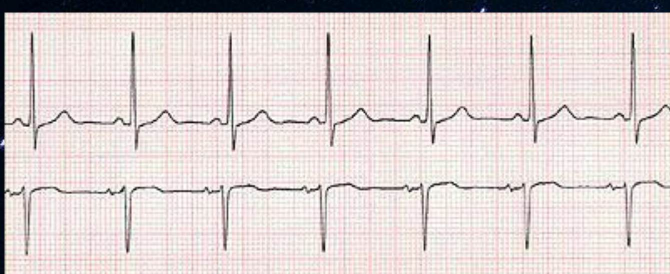
"Transmural scar in the atrium block the conduction"

Development of Maze Procedure

- 1st digital mapping in mid-1980s (Washing University)

  1. "Multiple macro-reentrant circuits in the atria"
  2. It remains in one location for only 0.2 sec
     → map-guided surgery is impractical…
  3. Diameter of macro-reentrant circuit:
     5-6cm in LA, much larger in RA

Observations from Animals



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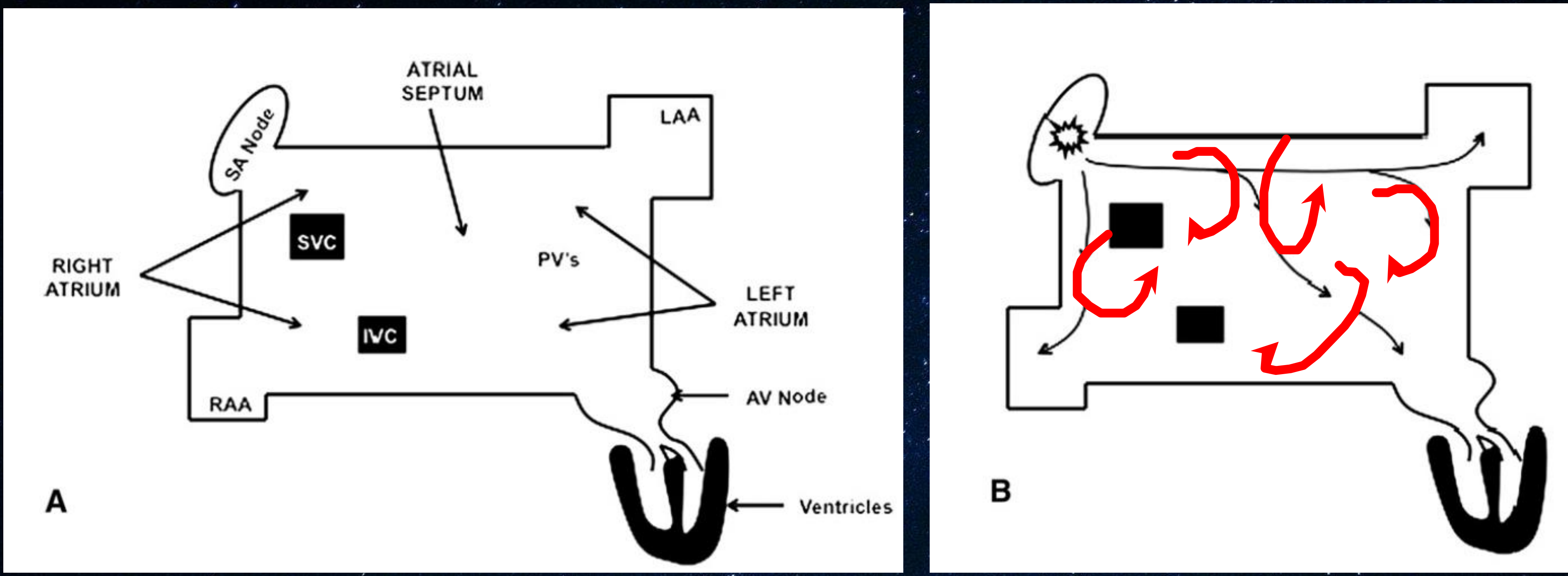
Development of Maze Procedure



Cox et al. J Thorac Cardiovasc Surg 2011

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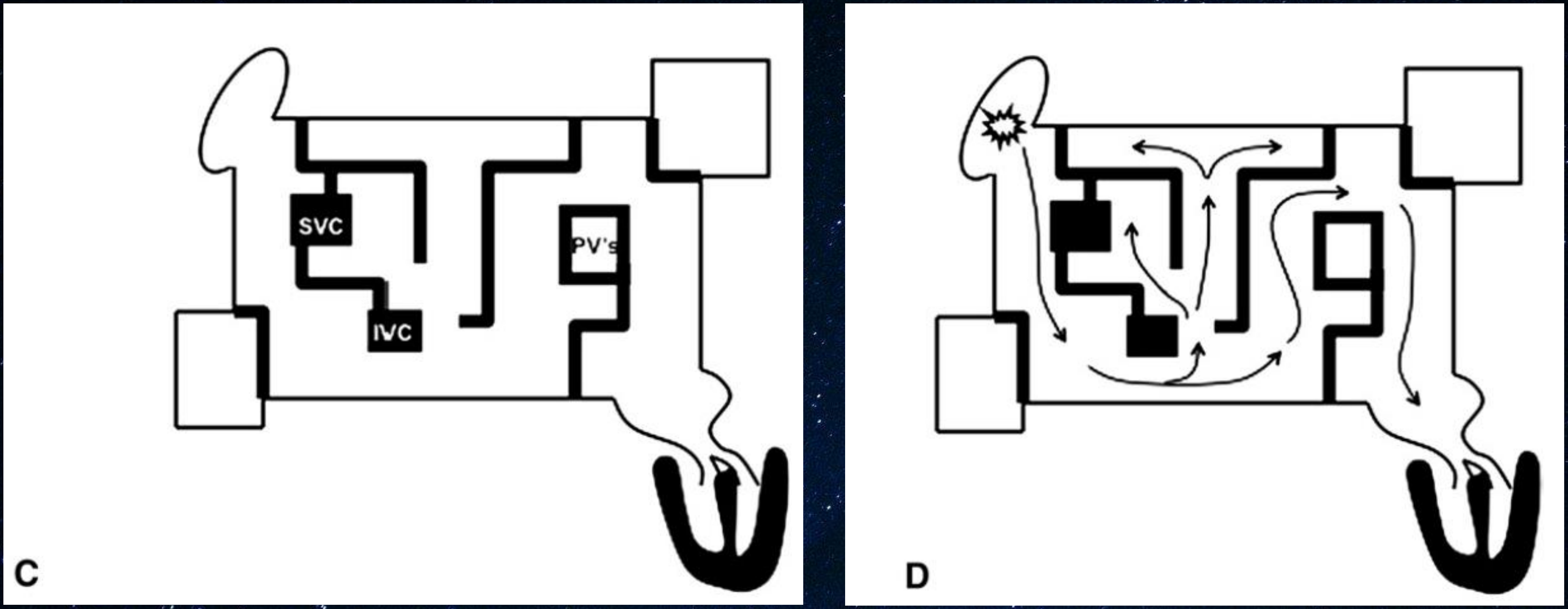
Development of Maze Procedure



Cox et al. J Thorac Cardiovasc Surg 2011

Initial Cox-Maze Procedure

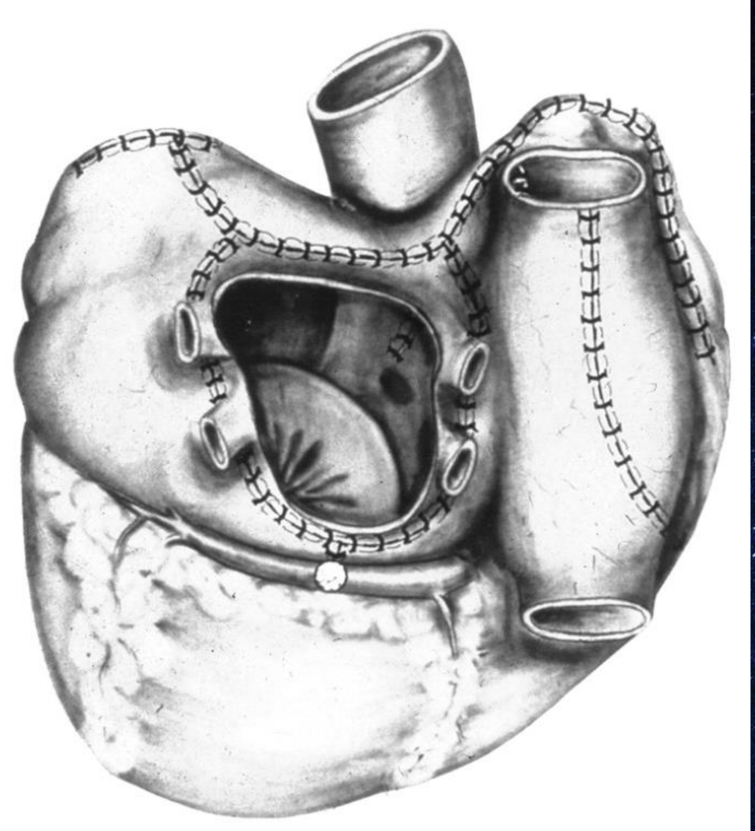


FIGURE 2. Three-dimensional representation of the original Maze I procedure. A "window" has been drawn in the posterior left atrium to allow visualization of the location of the mitral valve, atrial septum, and AV node.

Cox et al. JAMA 1991

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Initial Cox-Maze Procedure

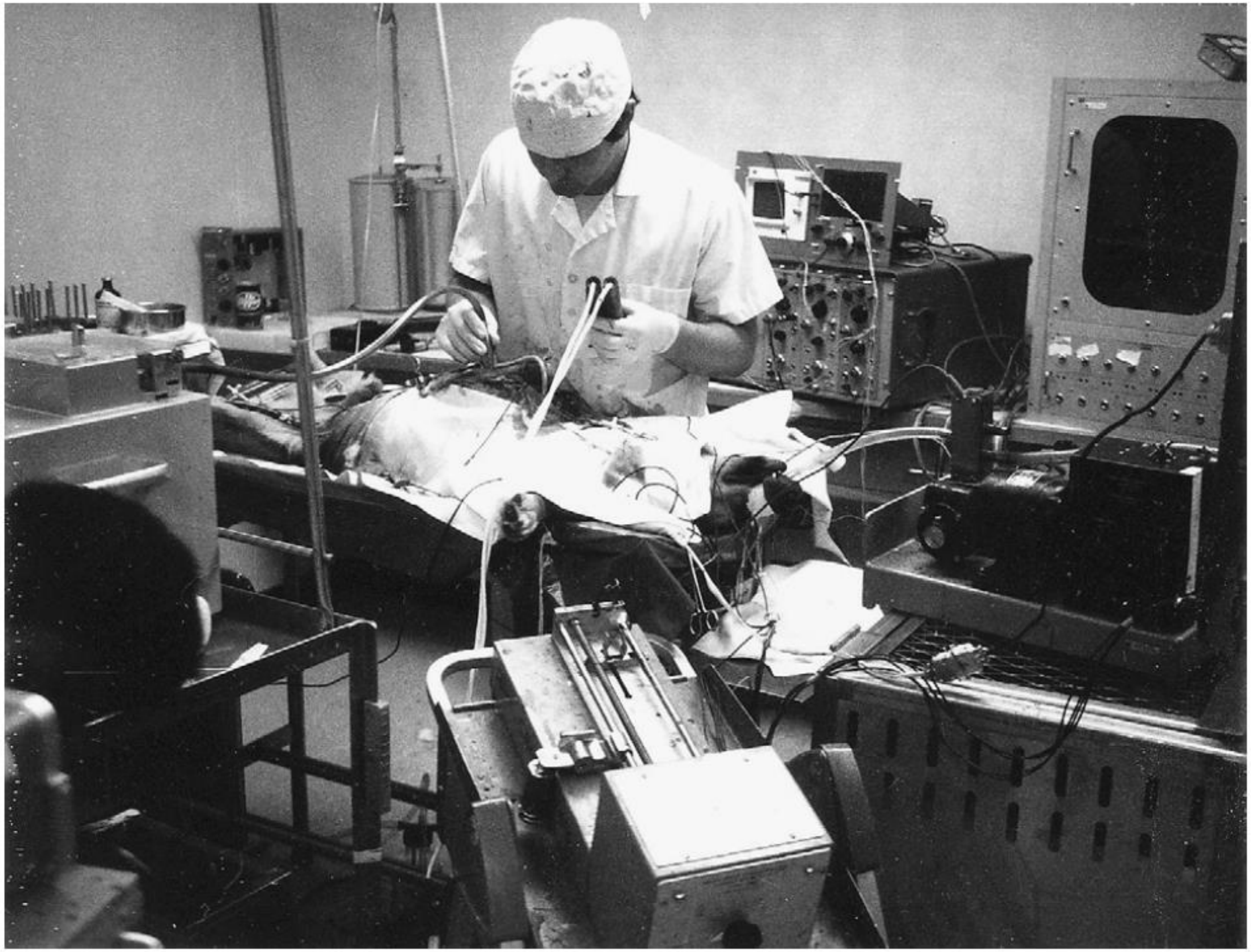

FIGURE 3. Photograph taken by Research Fellow Byung-Chul Chang, now the Professor and Chief of Cardiothoracic Surgery at Yonsei University in Seoul, Korea, in early 1987 of the author performing the first experimental Maze procedure in the Cardiothoracic Surgery Research Laboratories at Washington University in St Louis.

Successful Surgical Treatment of Atrial Fibrillation

Review and Clinical Update

James L. Cox, MD; John P. Boineau, MD; Richard B. Schuessler, PhD; T. Bruce Ferguson, Jr, MD; Michael E. Cain, MD; Bruce D. Lindsay, MD; Peter B. Corr, PhD; Kathy M. Kater, MSN; Demetrios G. Lappas, MD

Atrial fibrillation is the most common of all sustained cardiac arrhythmias, yet it has no effective medical or surgical therapy. During the past decade, multipoint computerized electrophysiological mapping systems were used to map both experimental and human atrial fibrillation. On the basis of these studies, a new surgical procedure was developed for atrial fibrillation. Between September 25, 1987, and July 1, 1991, this procedure was applied in 22 patients with paroxysmal atrial flutter (n = 2), paroxysmal atrial fibrillation (n = 11), or chronic atrial fibrillation (n = 9) of 2 to 21 years' duration. All patients were refractory to all antiarrhythmic medications, and each patient failed to receive the desired therapeutic benefits of an average of five drugs administered preoperatively. There were no operative deaths and all perioperative morbidity resolved. All 22 patients have been successfully treated for atrial fibrillation with surgery alone. Three patients developed one late isolated episode of atrial flutter at 5, 6, and 15 months postoperatively, and each of these patient's symptoms is now controlled by a single antiarrhythmic drug. Preservation of atrial transport function has been documented in all patients postoperatively, and all have experienced marked clinical improvement.

(*JAMA*. 1991;266:1976-1980)

symptomatic. However, the threat of thromboembolism is more ominous.[10]

Pharmacologic treatment of atrial fibrillation is directed initially at converting the rhythm to normal sinus. When the abnormal rhythm cannot be controlled, pharmacologic therapy is directed at decreasing the ventricular response rate by limiting the number of atrial impulses that can traverse the atrioventricular node (AVN). Control of the heart rate in the presence of continued atrial fibrillation, however, does not alleviate the untoward subjective symptoms associated with an irregular heartbeat, does not restore cardiac hemodynamics to normal, and does not decrease the risk of thromboembolism. Thus, it is apparent that a more effective form of therapy for atrial fibrillation is needed.

Initial Maze Procedure

Summary of the Preoperative Status and Postoperative Results of the Maze Procedure for Atrial Flutter and Atrial Fibrillation*

Patient/ Age, y/ Gender	Sick Sinus Syndrome	Duration of Preoperative Rhythm, y: Paroxysmal A-Flutter	Paroxysmal A-Fib	Chronic A-Fib	Preoperative Drugs That Failed	In-Hospital Perioperative Arrhythmia	Rhythm at Hospital Discharge	Follow-up Rhythm	Post-operative Permanent Pacemaker	Post-operative Drugs	Atrial Transport Function	Time Since Surgery, mo
1/59/M	No	3	No	No	V,Q,D,P,Pr, Am	A-Flutter	NSR	NSR	None	None	Preserved	46
2/40/M	No	No	2	No	D,P,Pr,F,Am	A-Fib	NSR	NSR	None	None	Preserved	42
3/52/M	No	No	3	No	D,E,Am	None	NSR	NSR	DDD-R	None	Preserved	32
4/62/F	Yes	No	No	10	Q,D,P	None	Sin brady	Sin brady	DDD-R	None	Preserved	23
5/31/M	No	No	No	3	D,E,Am	None	NSR	NSR	None	None	Preserved	21
6/51/M	Yes	No	3	No	V,Q,D,Pr,F	None	Sin brady	Sin brady	DDD-R	None	Preserved	20
7/38/F	No	No	9	No	V,Q,D,Pr,F,E, Di,Ac,Am	None	NSR	NSR	None	D	Preserved	18
8/51/M	Yes	No	No	4	V	None	Junctional	Sin brady	DDD-R	None	Preserved	13
9/40/F	No	No	2	No	A,V,D,M,F,E,	A-Flutter	NSR	NSR	None	None	Preserved	13
10/31/M	No	5	No	No	D,Di,Q,V,A, Pr,F,E,Am	None	Junctional	NSR	None	None	Preserved	13
11/46/M	No	No	4	1	D	None	NSR	NSR	None	None	Preserved	11
12/56/M	No	No	No	1.5	D,E,P,V,Am	None	NSR	NSR	None	E	Preserved	11
13/40/M	No	No	2	No	Pr,F,E,Di,A, Am	A-Flutter	Junctional	Accelerated junctional	None	None	Preserved	11
14/66/F	No	No	7	No	Di,Pf,Ac,D,V, Am	None	Junctional	NSR	DDD-R	None	Preserved	10
15/68/M	No	No	13	No	Q,Di,M,D,V	None	NSR	NSR	None	None	Preserved	8
16/57/M	No	No	11	No	V,Pr,F,Pf,Am	A-Flutter	Junctional	NSR	DDD-R†	None	Preserved	8
17/53/M	No	No	10	No	D,Di,Q,P,Pr,V	None	NSR	NSR	None	None	Preserved	8
18/30/F	No	No	8	No	D,Q,Di,Pf,F,E	None	NSR	NSR	None	None	Preserved	8
19/53/M	No	No	No	16	D,Q,So,V,A, Nf	A-Fib	NSR	NSR	None	Di	Preserved	7
20/48/M	No	No	19	2	D,Q,Pr,F	A-Fib	NSR	NSR	DDD-R†	None	Preserved	7
21/51/M	Yes	No	8	7	D,V,Q,Pf,Am	A-Fib	Sin brady	Sin brady	DDD-R	None	Preserved	6
22/69/F	Yes	No	10	2	D,P,V,Q,F	None	Sin brady	Sin brady	DDD-R	None	Preserved	4

Cox et al. JAMA 1991

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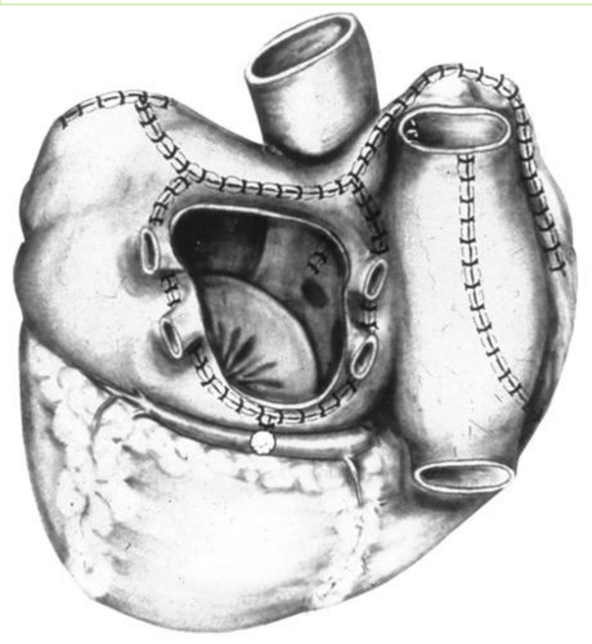
Initial Maze Procedure

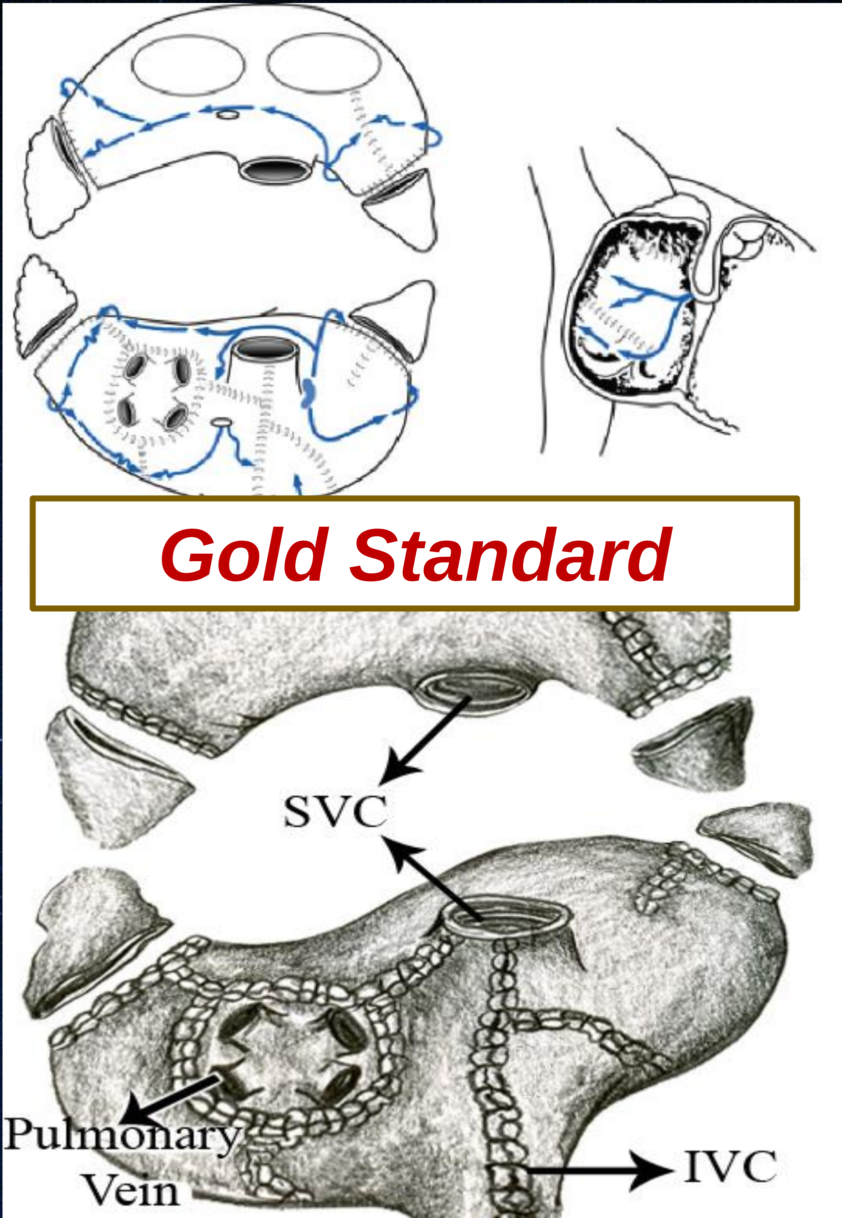
- There were no operative deaths
- Perioperative atrial arrhythmias in 8 (36%)
- Surgical bleeding in 3 (14%)
- Stroke in 1 (5%)
- Pneumonia in 1 (5%)
- PPM in 9 (41%)

Cox et al. JAMA 1991

Modifications of Maze Procedure

Cox-Maze I in 1987



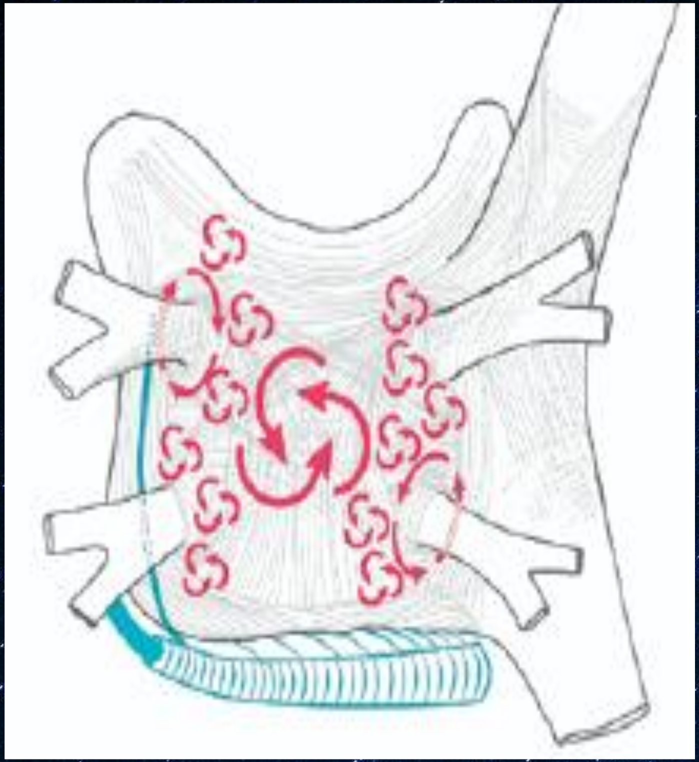


Gold Standard

Cox-Maze III in 1994

Current Understandings on Pathophysiologic Mechanisms of Atrial Fibrillation

Multiple Wavelet Hypothesis



- Multiple reentry wavelets in the atrium
- Theoretical rationale of the Maze operation

Heart Rhythm 2007; 4: 816-61.

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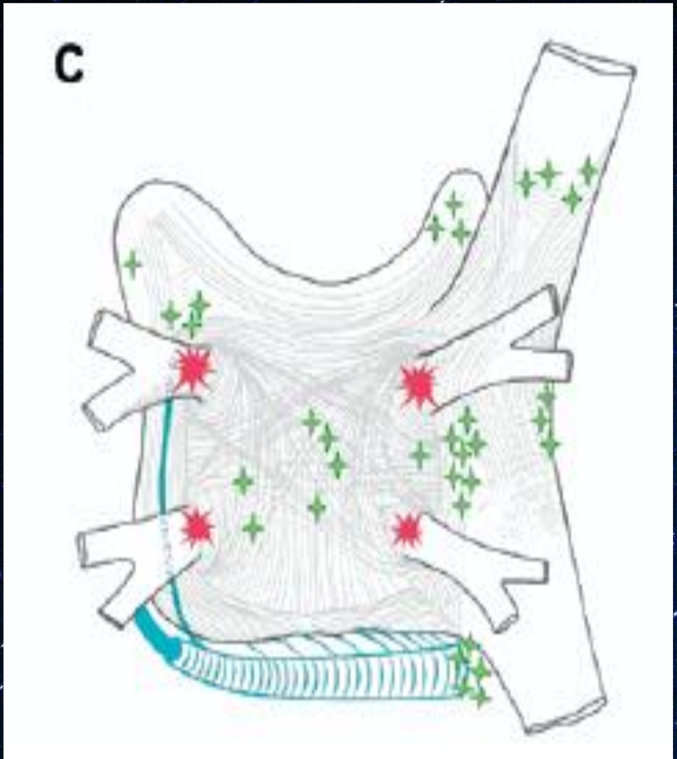
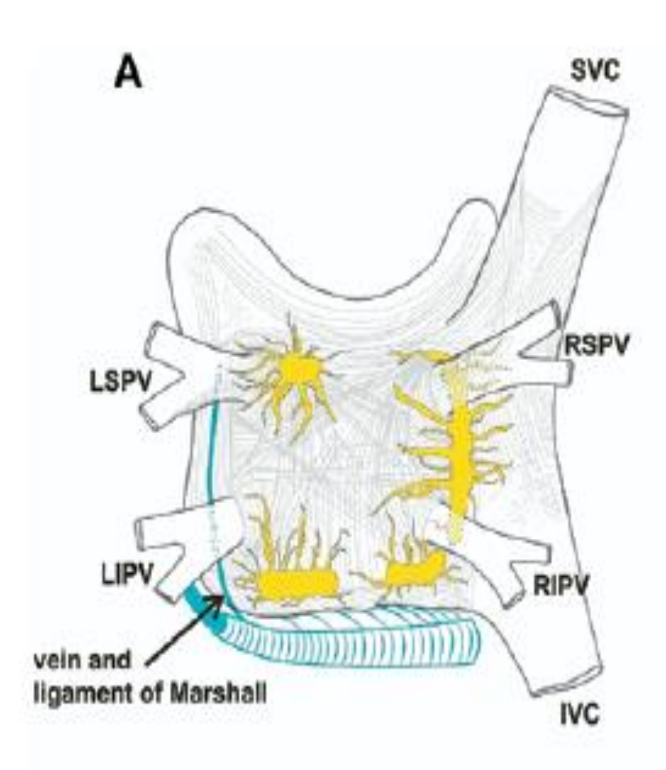
Focal Trigger



- Pacemaker activity
- Especially in pulmonary veins → “PV isolation”

Heart Rhythm 2007; 4: 816-61.

Autonomic Nervous System



- Ganglionic plexi

Heart Rhythm 2007; 4: 816-61.

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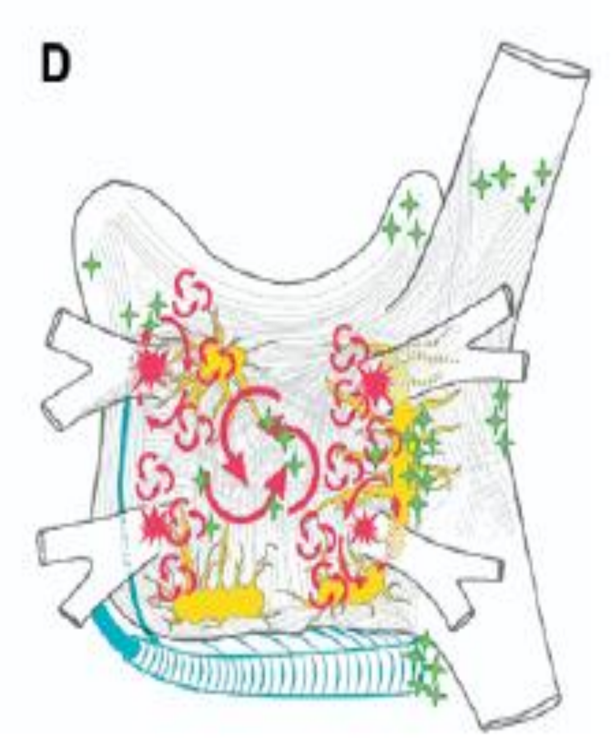
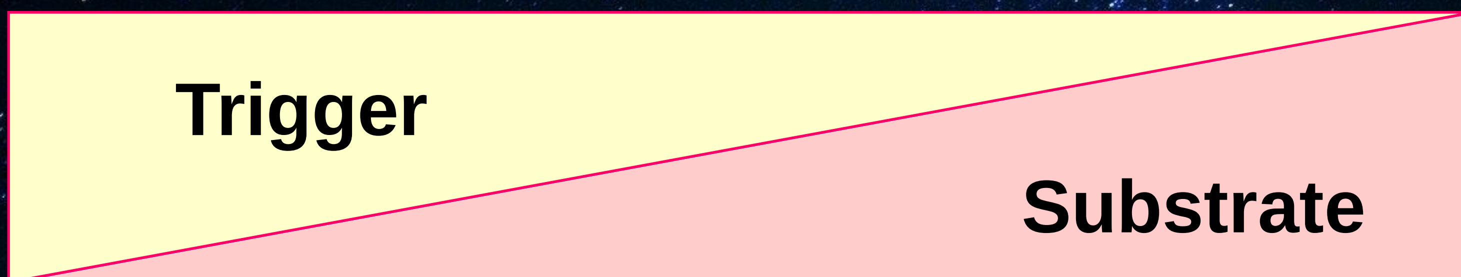
Multifactorial Mechanism

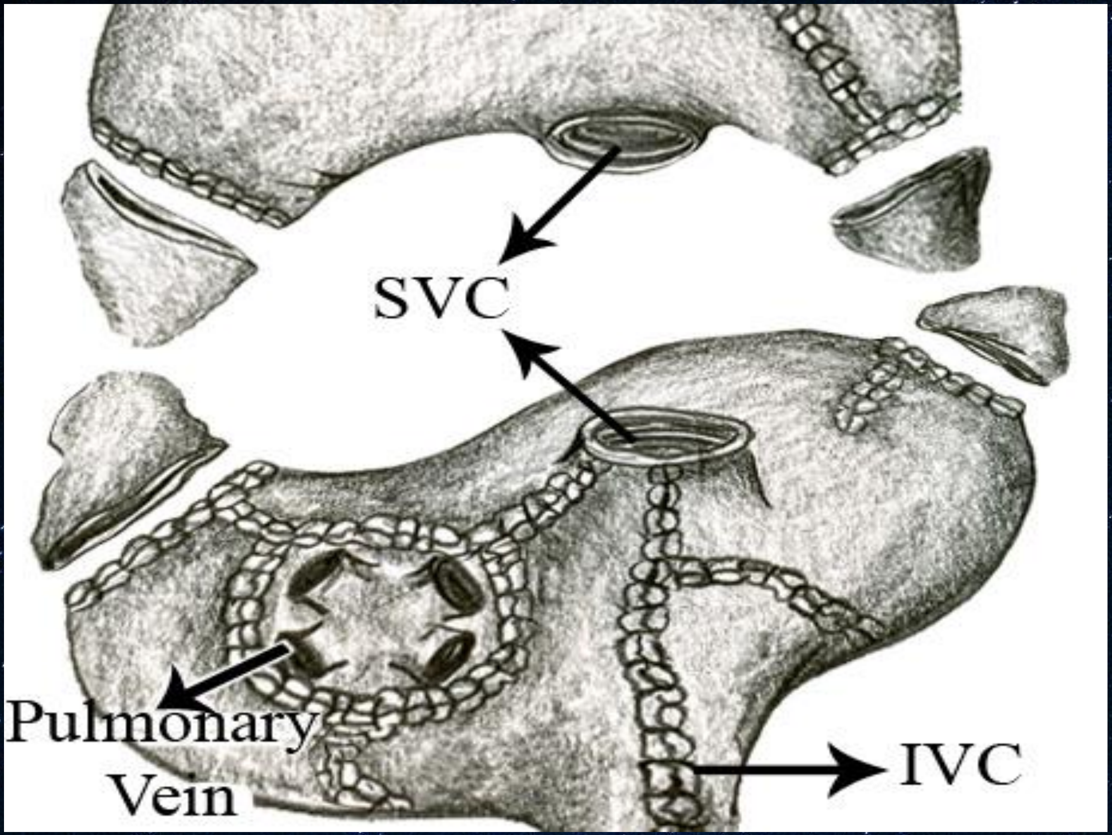


Heart Rhythm 2007; 4: 816-61.

Paroxysmal AF		*Persistent AF*
Coarse AF wave	→	*Fine AF wave*
Preserved atrial size		*Enlarged atrial size*
Preserved atrial thickness		*Atrial wall thinning*



Cut-and Sew Maze



Alternative Energy Sources

Replace the surgical incision

Lines of transmural ablation → conduction block

Alternative Energy Sources

1. Cryoablation
2. Radiofrequency
3. ~~Microwave~~
4. ~~High-intensity focused ultrasound (HIFU)~~

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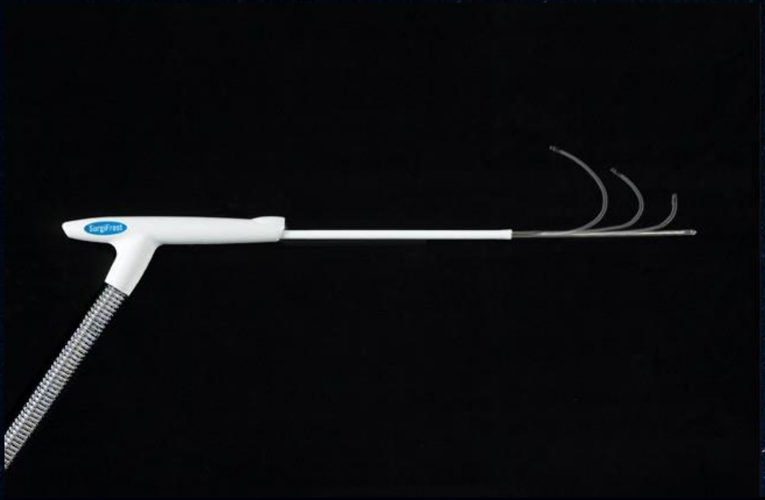
Cryoablation

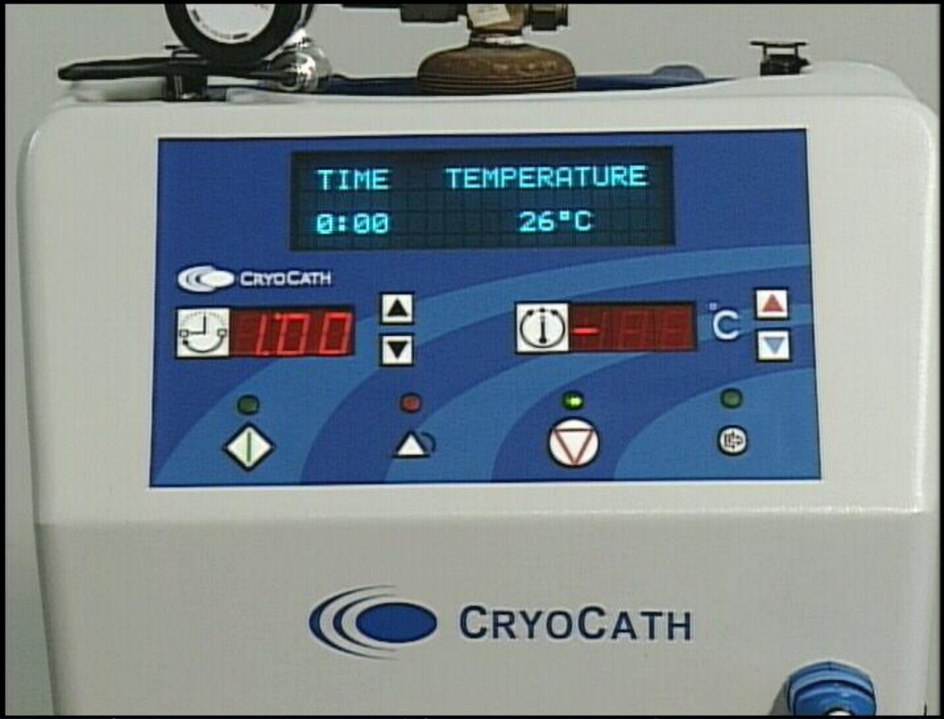
- 1st alternative approach in AF ablation surgery
  → most time-tested
  + well-characterized safety profile
- Maintain structural integrity
- Inexpensive, reasonable results

- N_2O-based Frigitronics® cryoprobe: 2min, -60℃
- Argon-based technology: rapidly achieve -160°C

Cryoablation

SurgiFrost CryoSurgical System





Radiofrequency Lesions

- More incisive than cryotherapy
- Current of 350 kHz to 1MHz
- Adjacent tissue injuries
- Saline irrigation
- Unipolar probe, bipolar clamp

Radiofrequency Lesions

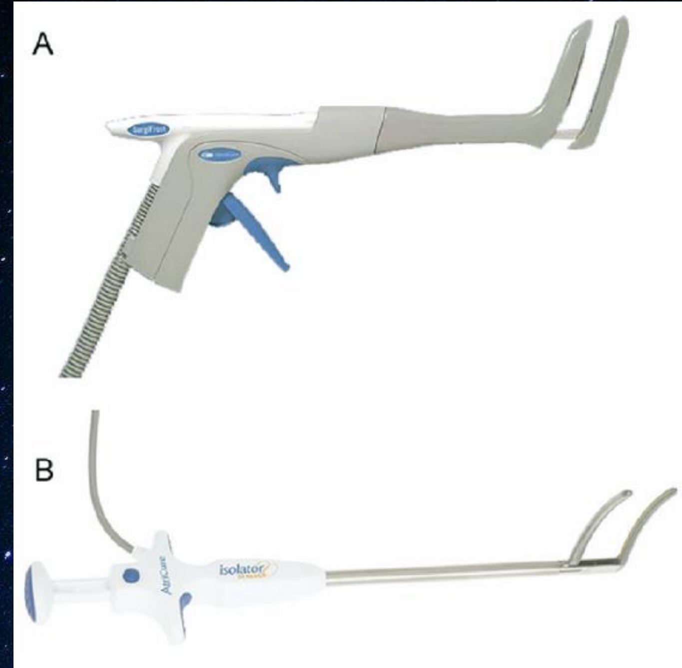


Fig 1. Ablation devices used in this study. (A) Argon-based cryothermy clamp (FrostByte Clamp on SurgiFrost, CryoCath Technologies Inc, Montreal, Quebec, Canada). (B) Radiofrequency clamp (Isolator Synergy, Atricure Inc, Cincinnati, OH).

RF unipolar probe

RF bipolar clamp

Low efficacy

Cox-Maze IV

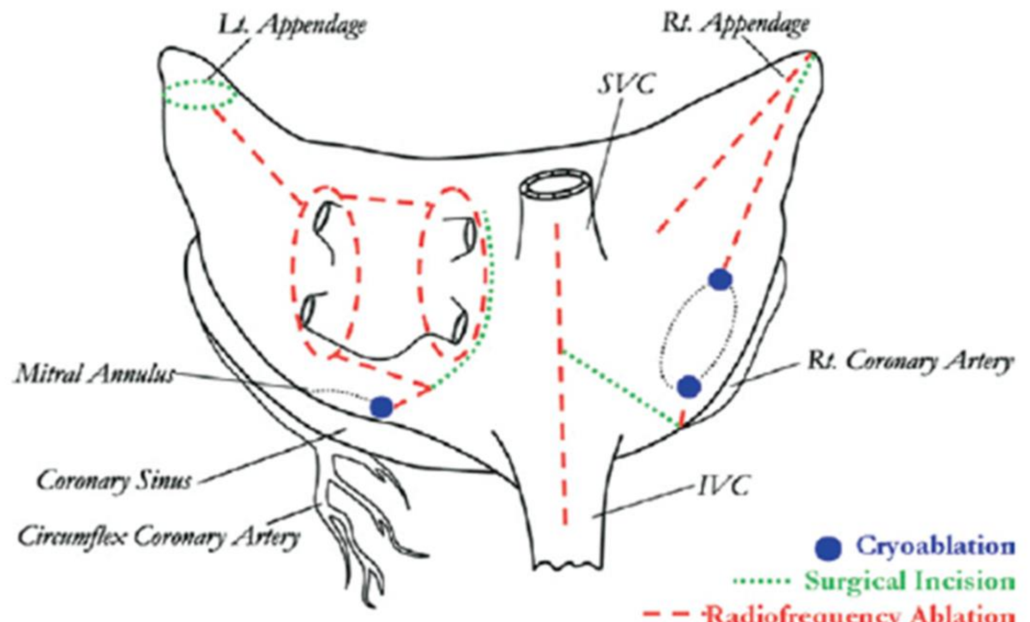
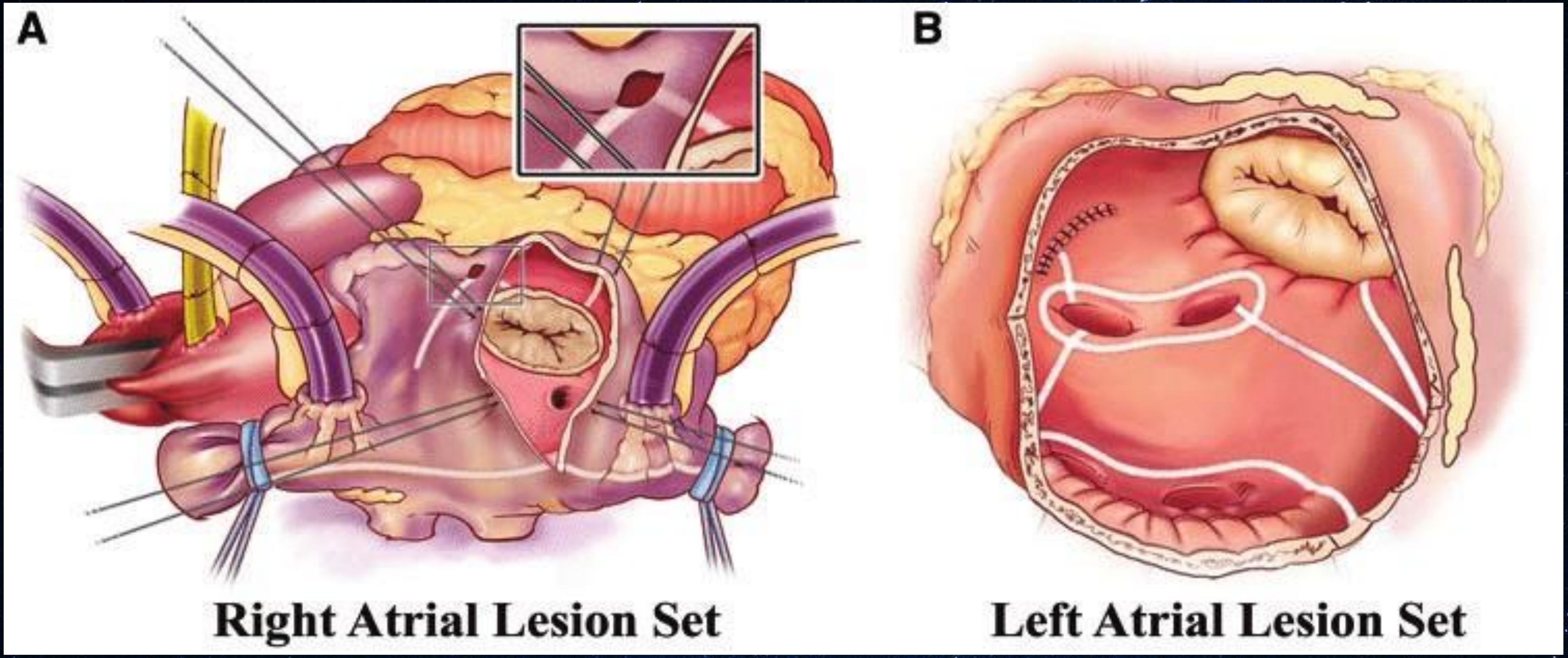


Figure 1. Cox-maze IV procedure lesion set. *Lt. Appendage*, Left atrial appendage; *SVC*, superior vena cava; *Rt. Appendage*, right atrial appendage; *IVC*, inferior vena cava; *Rt. Coronary Artery*, right coronary artery.

Damiano et al. J Thorac Cardiovasc Surg 2007

Cox-Maze IV



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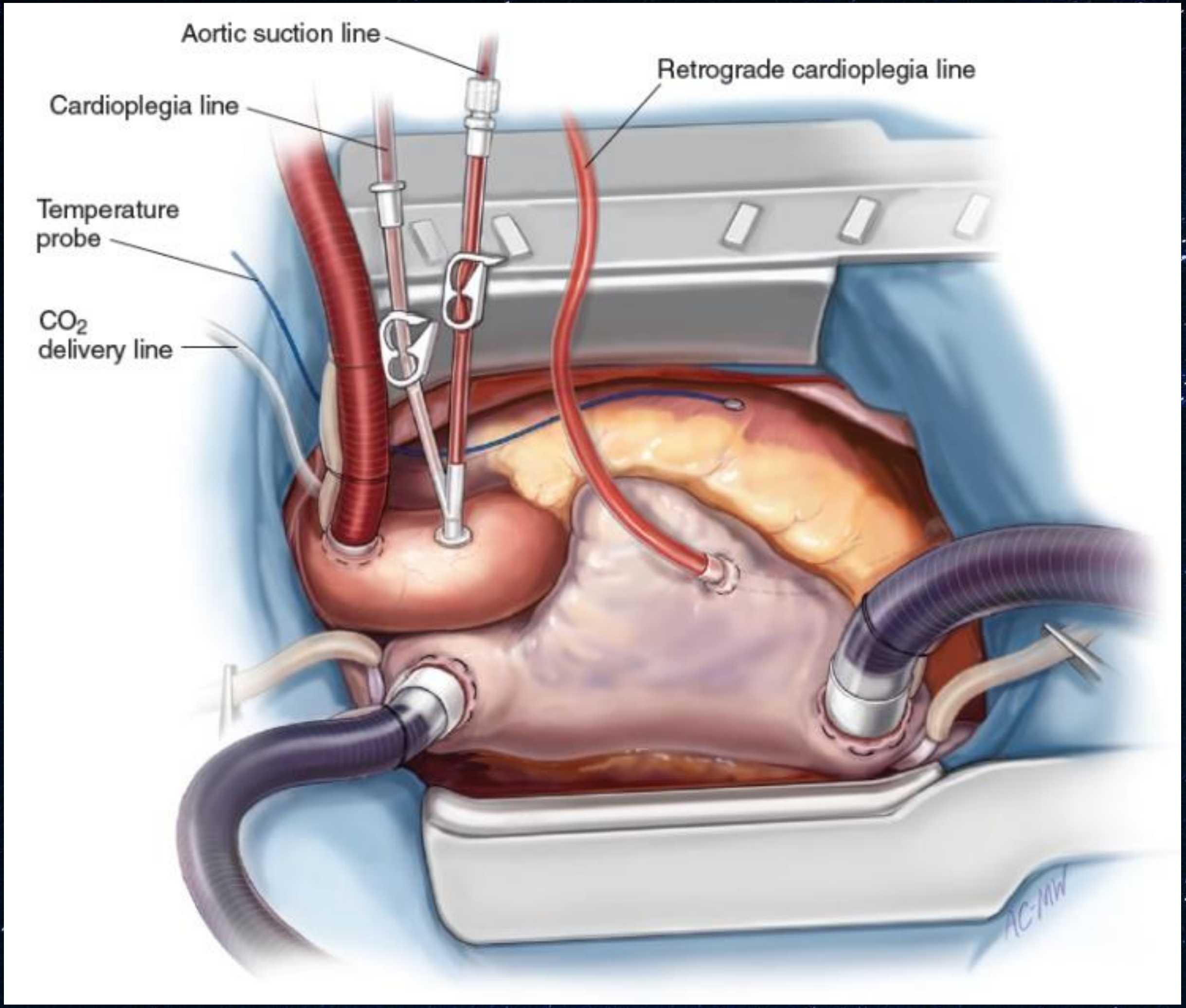
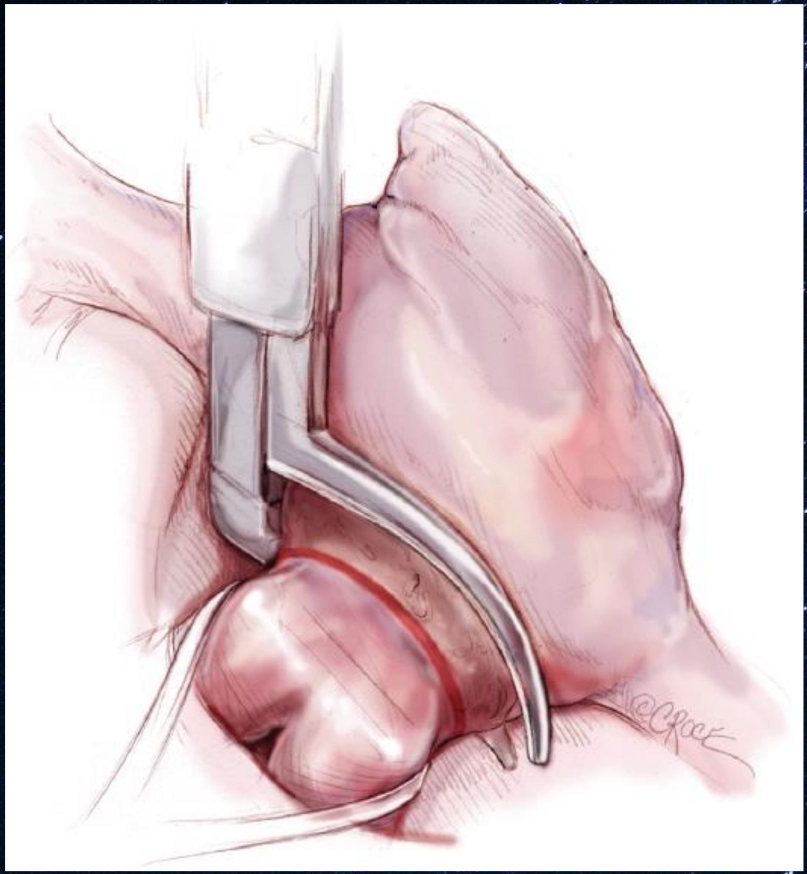
Approach



Let Atrial Lesion



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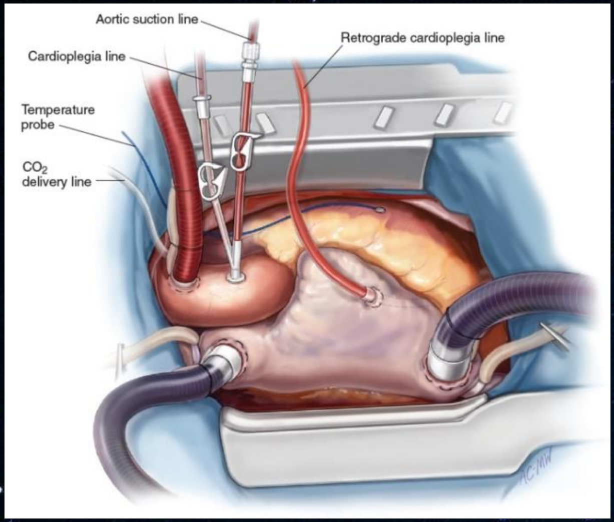

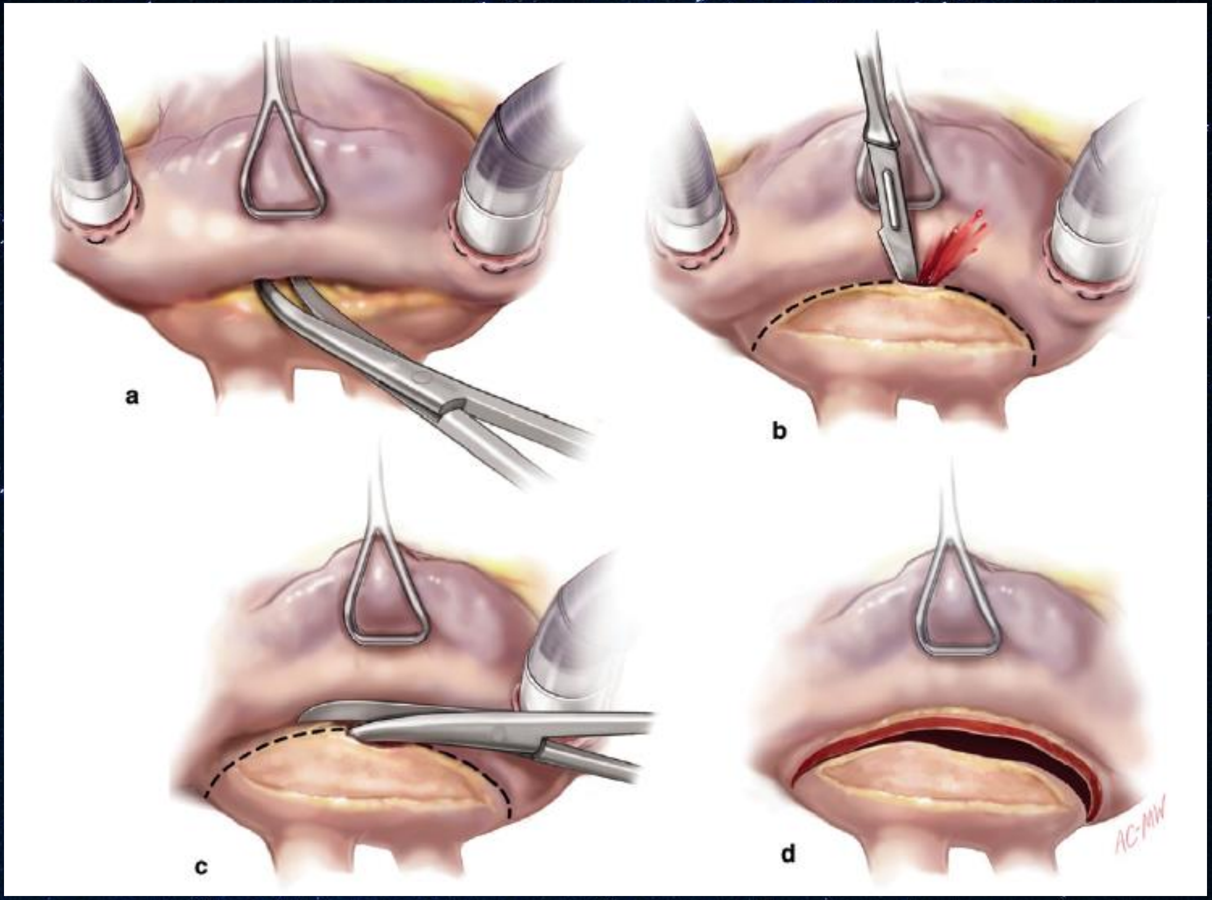

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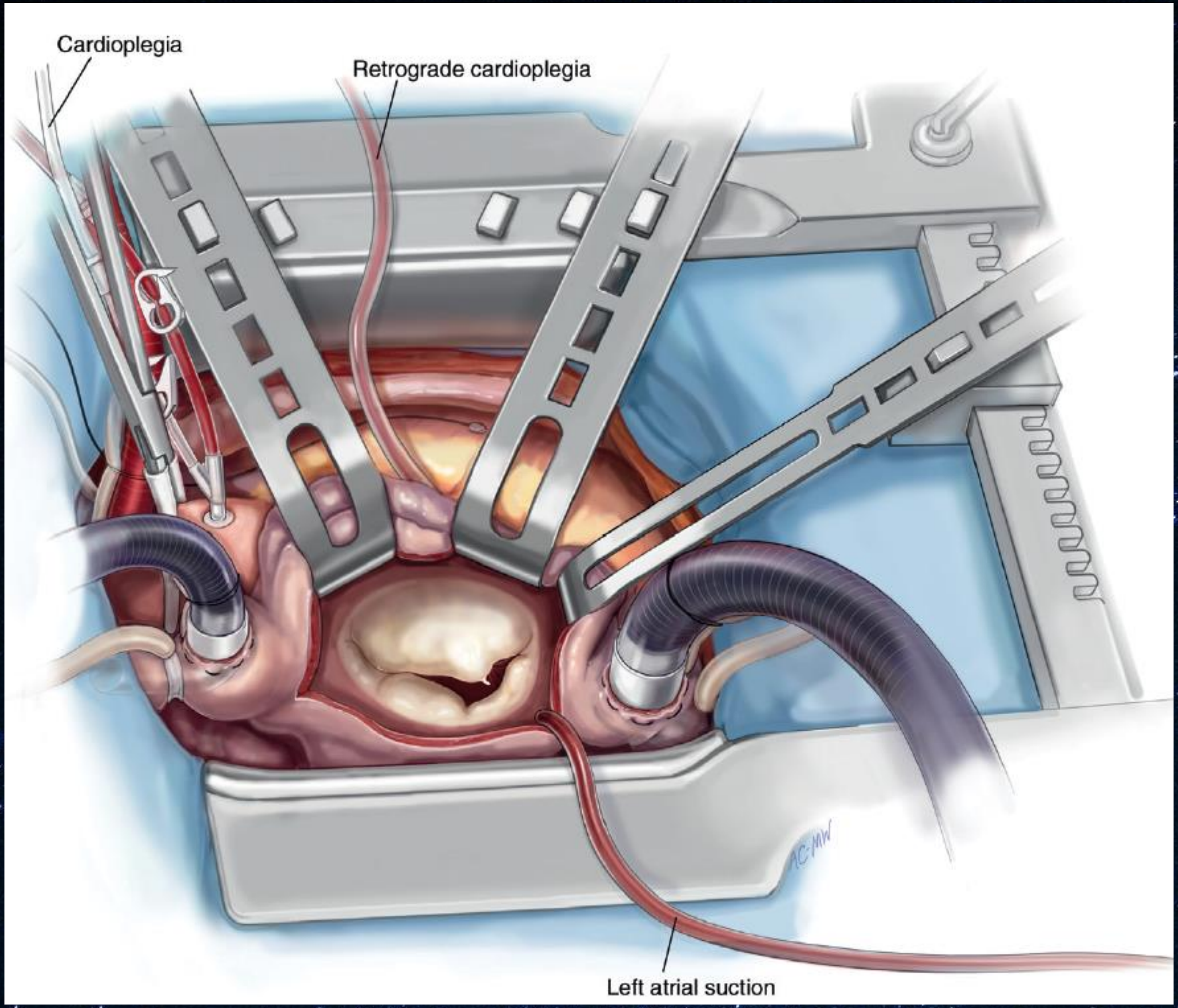

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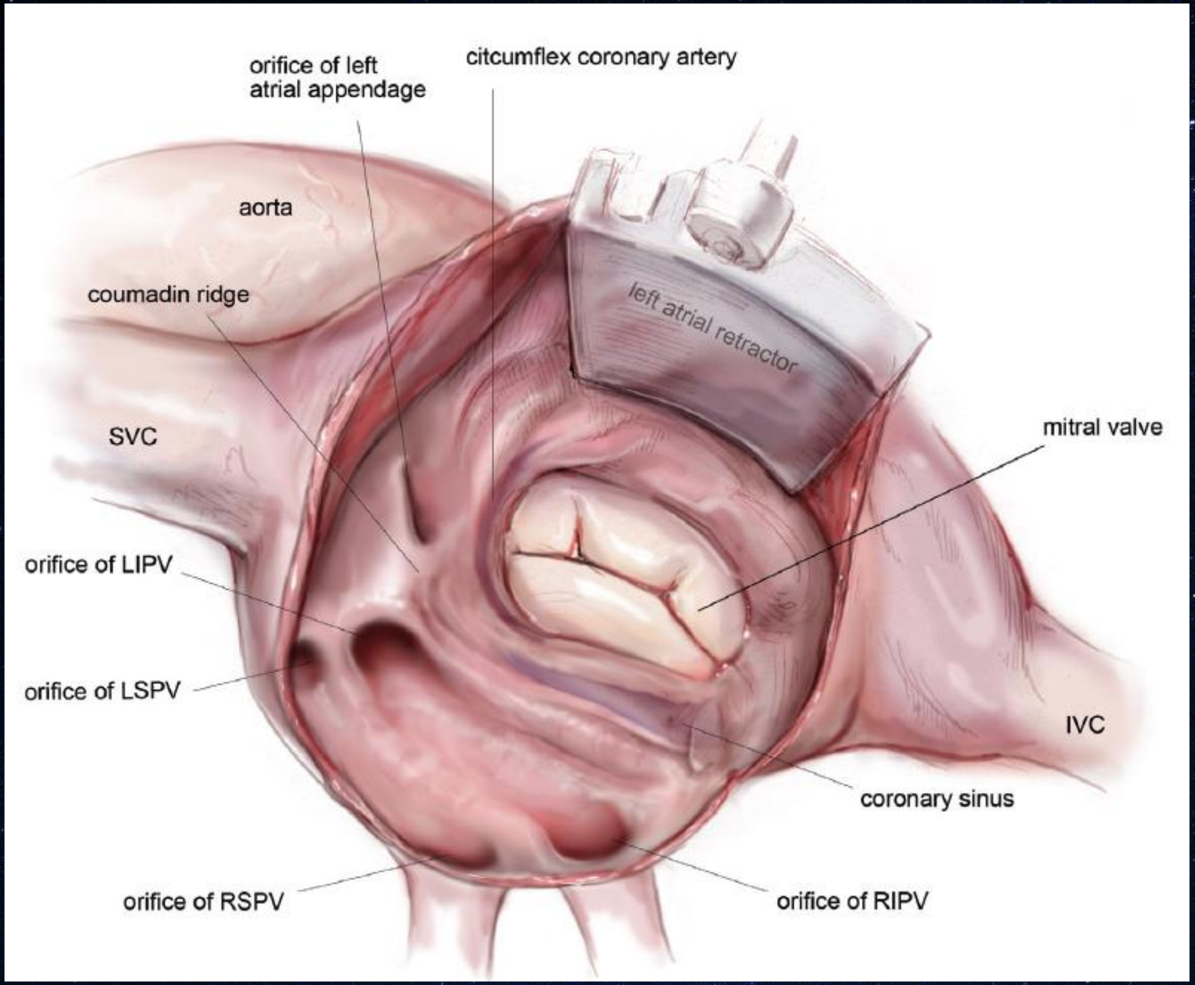

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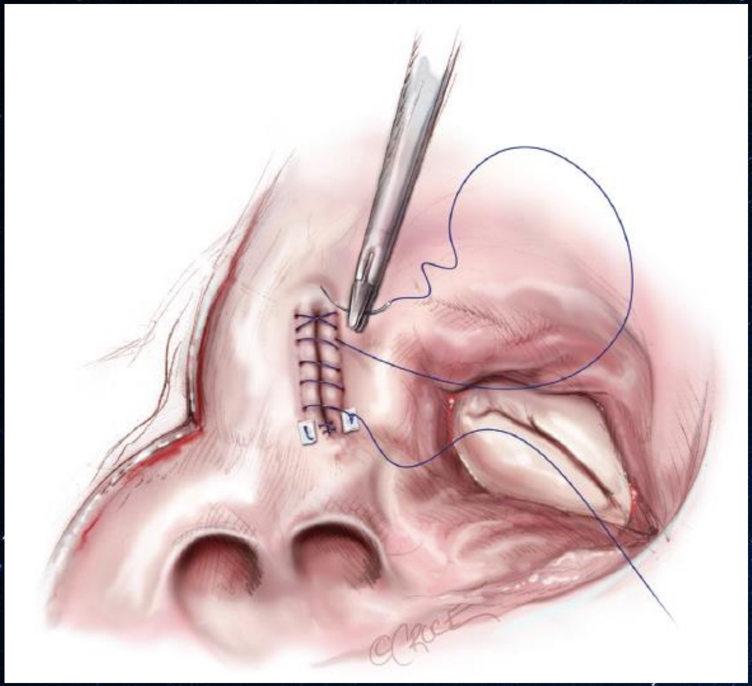

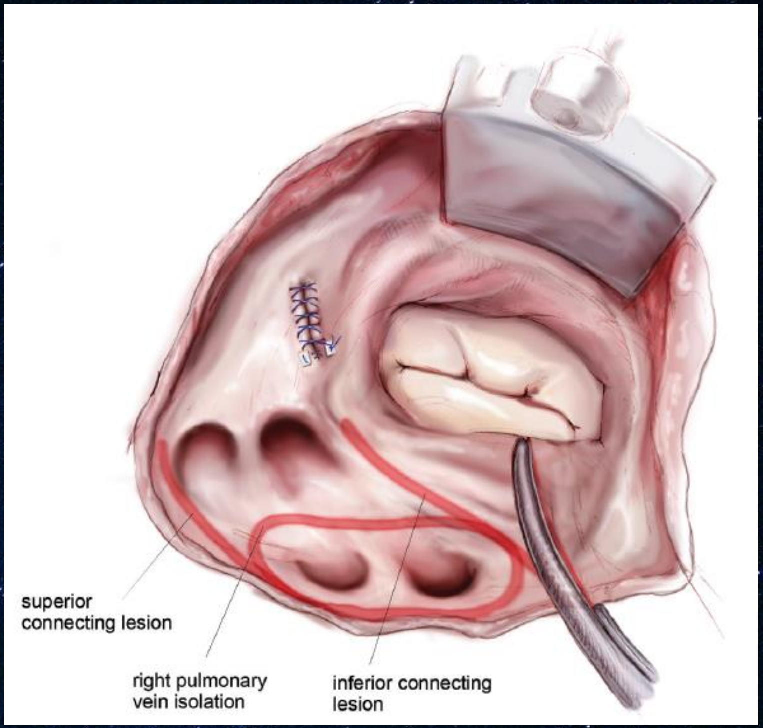

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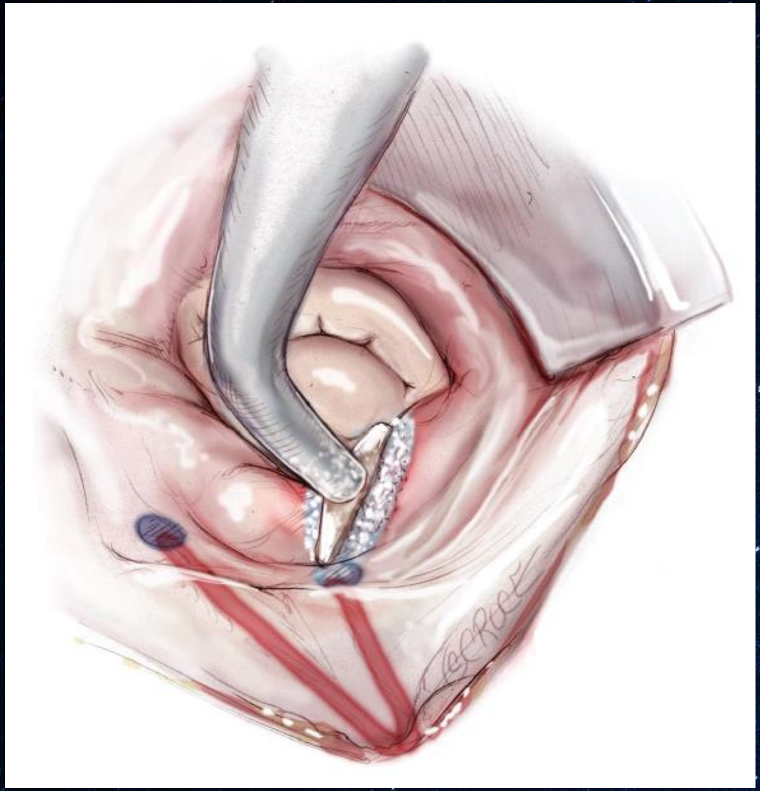
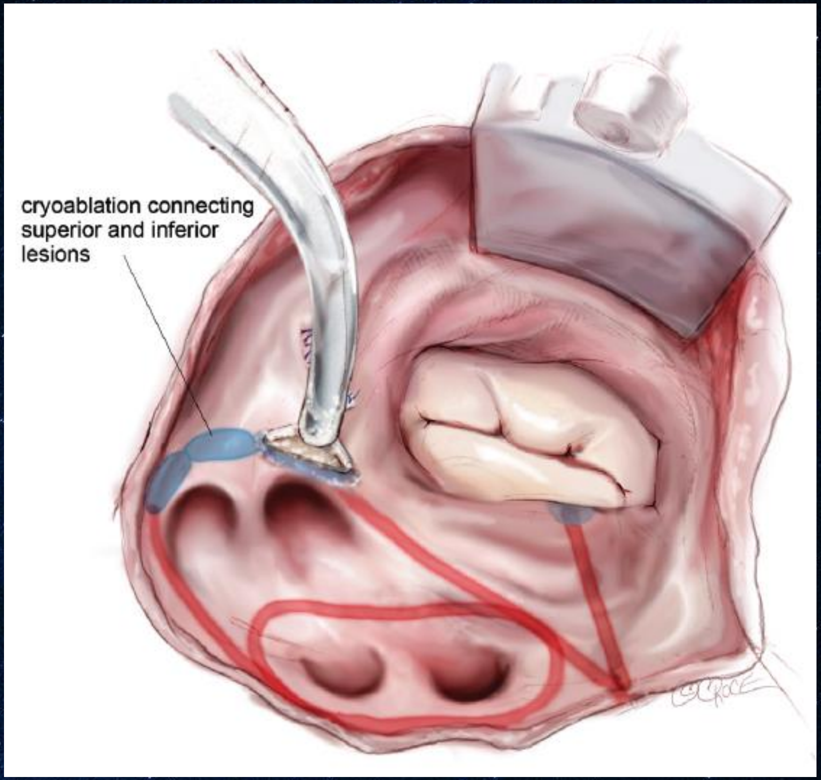
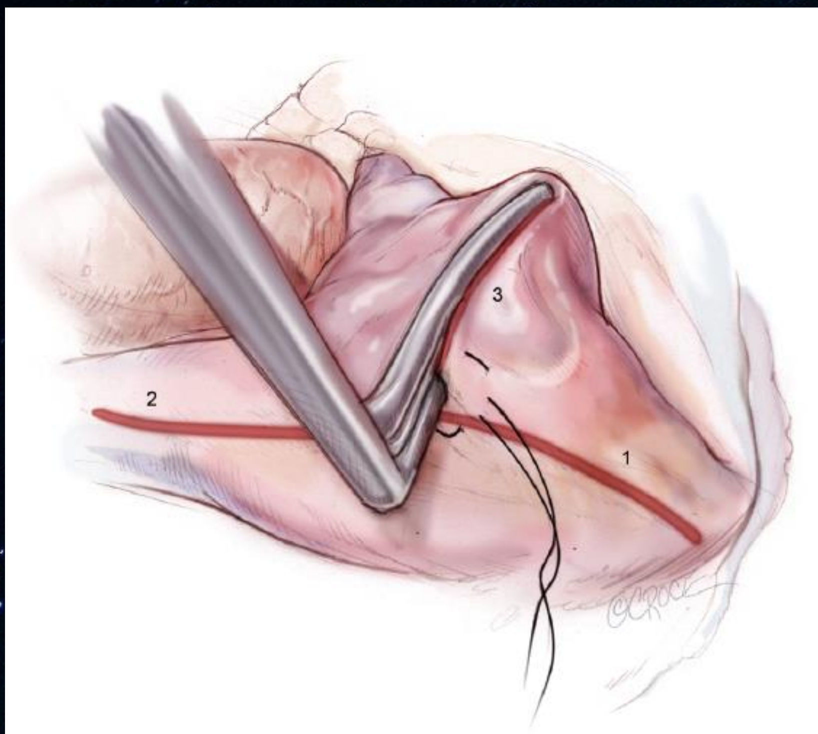
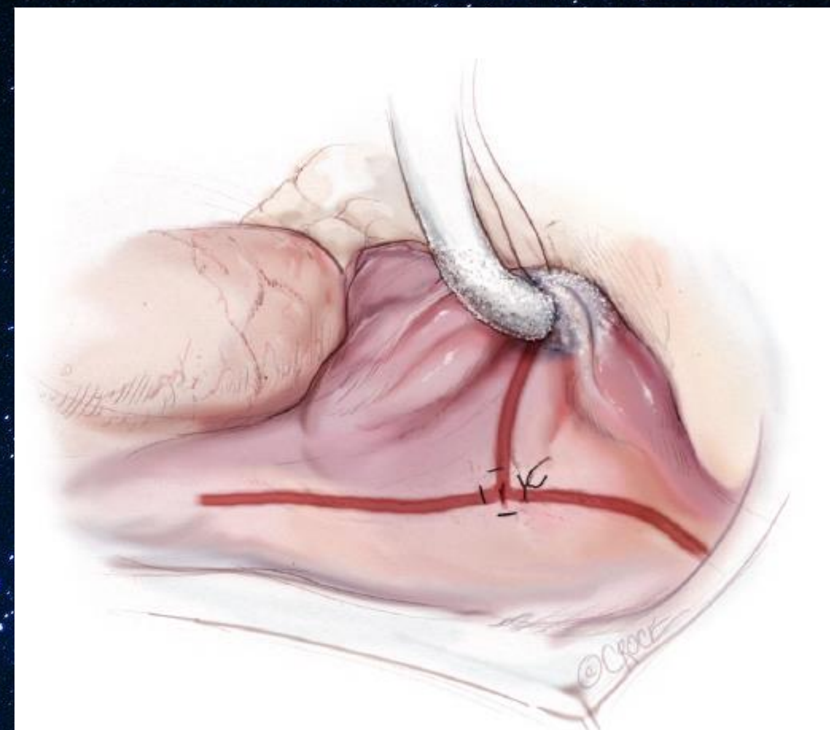


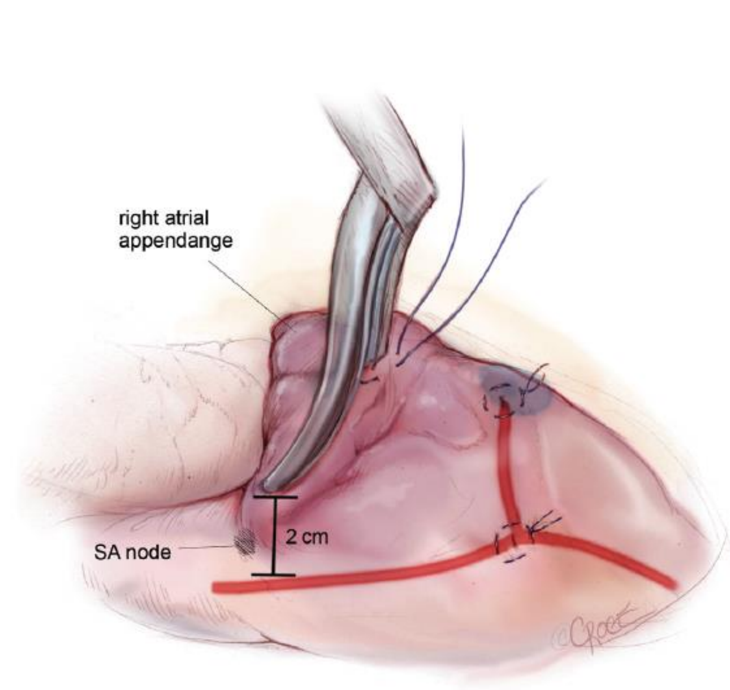


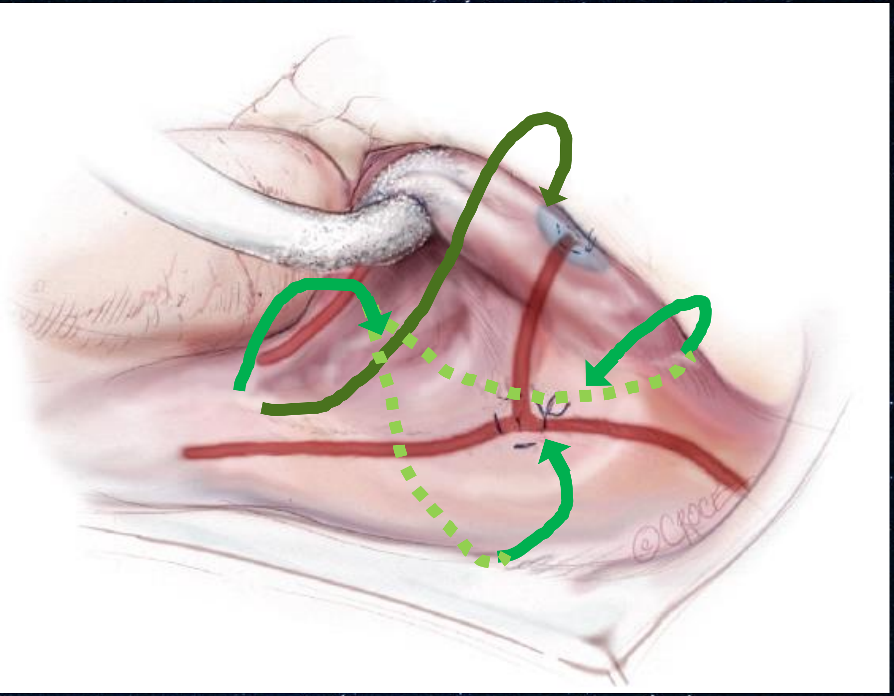
Right Atrial Lesion





Right Atrial Lesion





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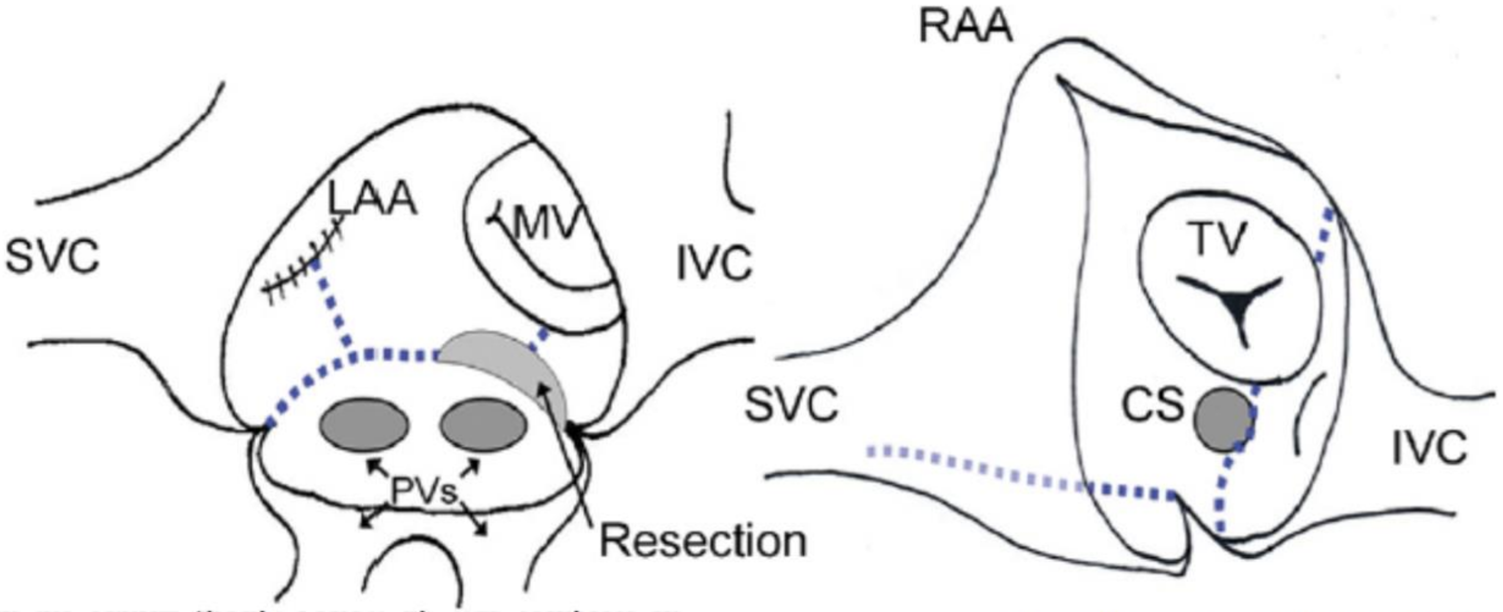
Left Atrial Ablation Versus Biatrial Ablation in the Surgical Treatment of Atrial Fibrillation

Joon Bum Kim, MD, Ji Hyun Bang, MD, Sung Ho Jung, MD, Suk Jung Choo, MD, Cheol Hyun Chung, MD, and Jae Won Lee, MD

Department of Thoracic and Cardiovascular Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, South Korea



(Ann Thorac Surg 2011;92:1397–405)

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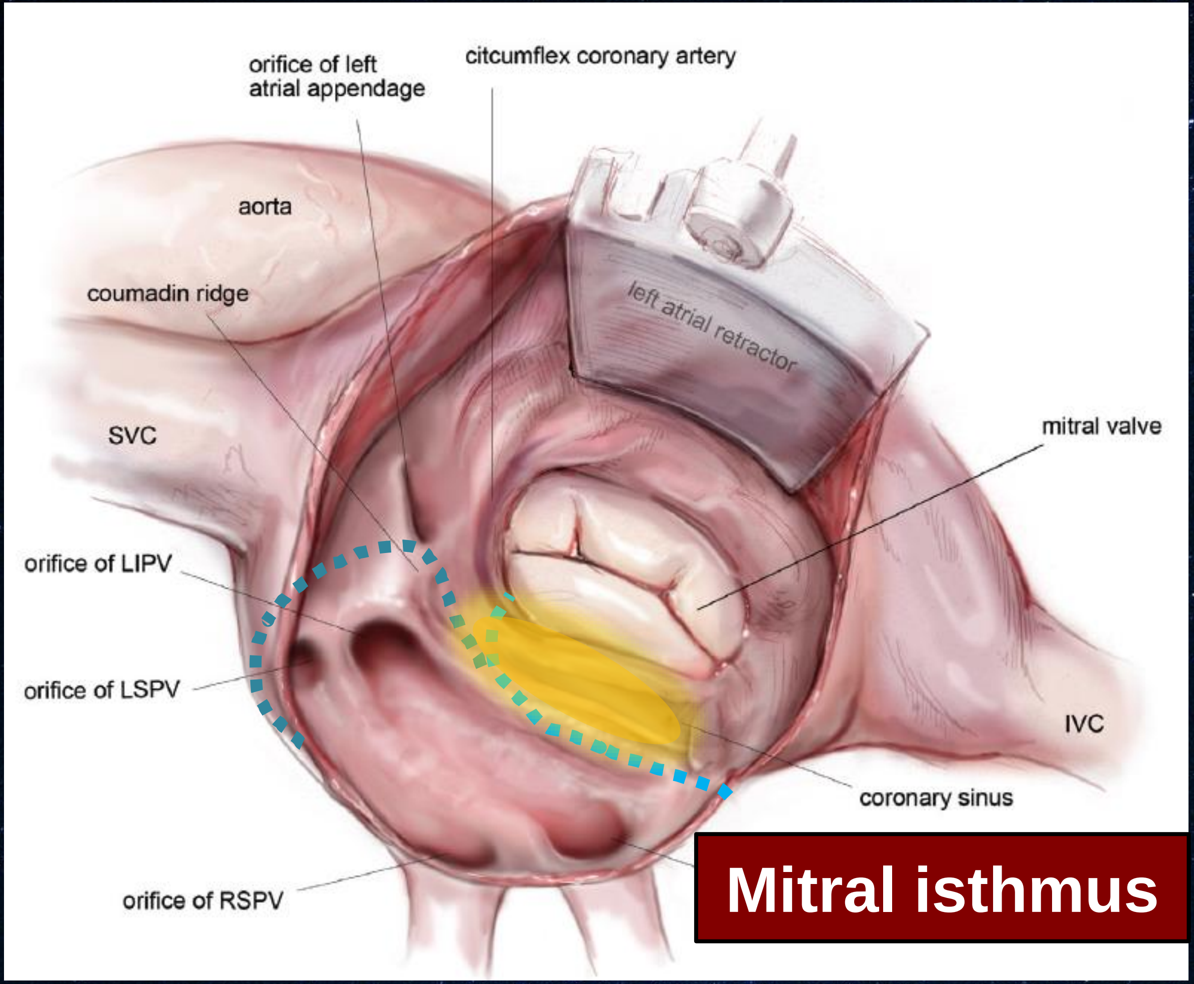

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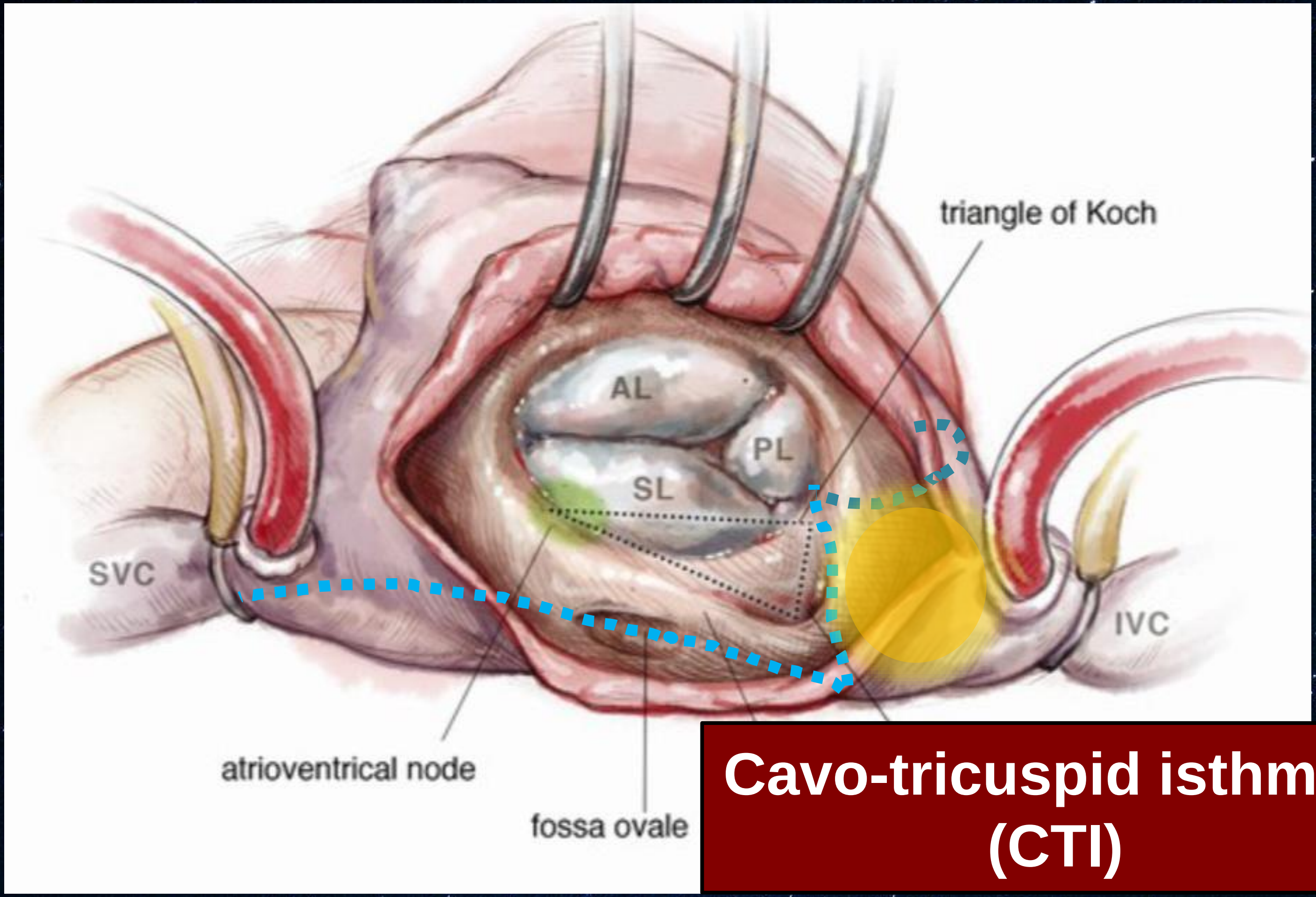

Cavo-tricuspid isthmus (CTI)

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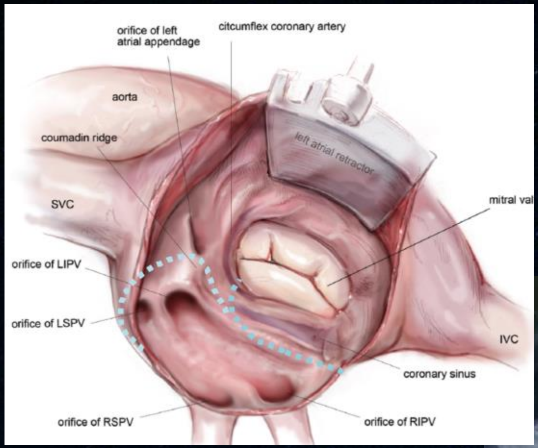
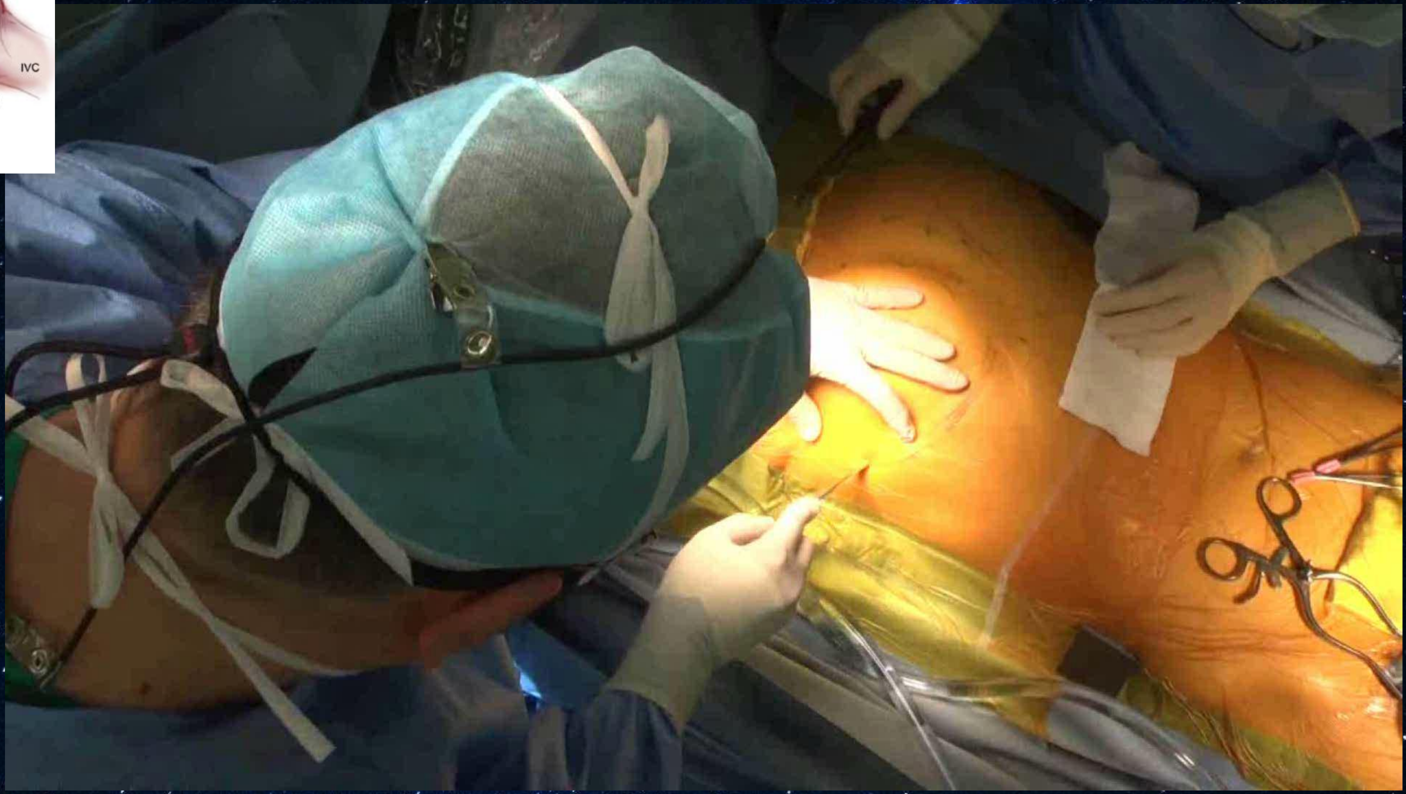
MICS Multi-Valve Surgery





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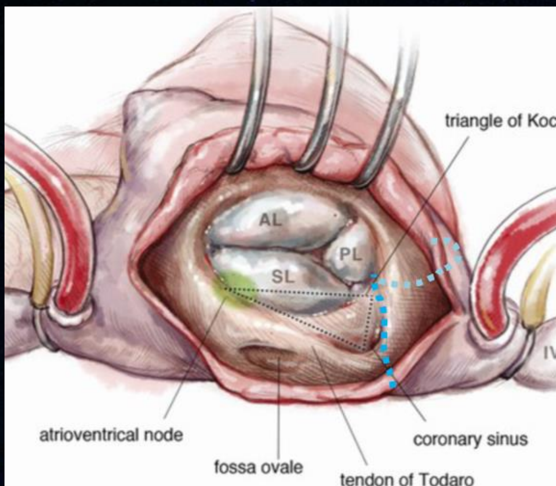
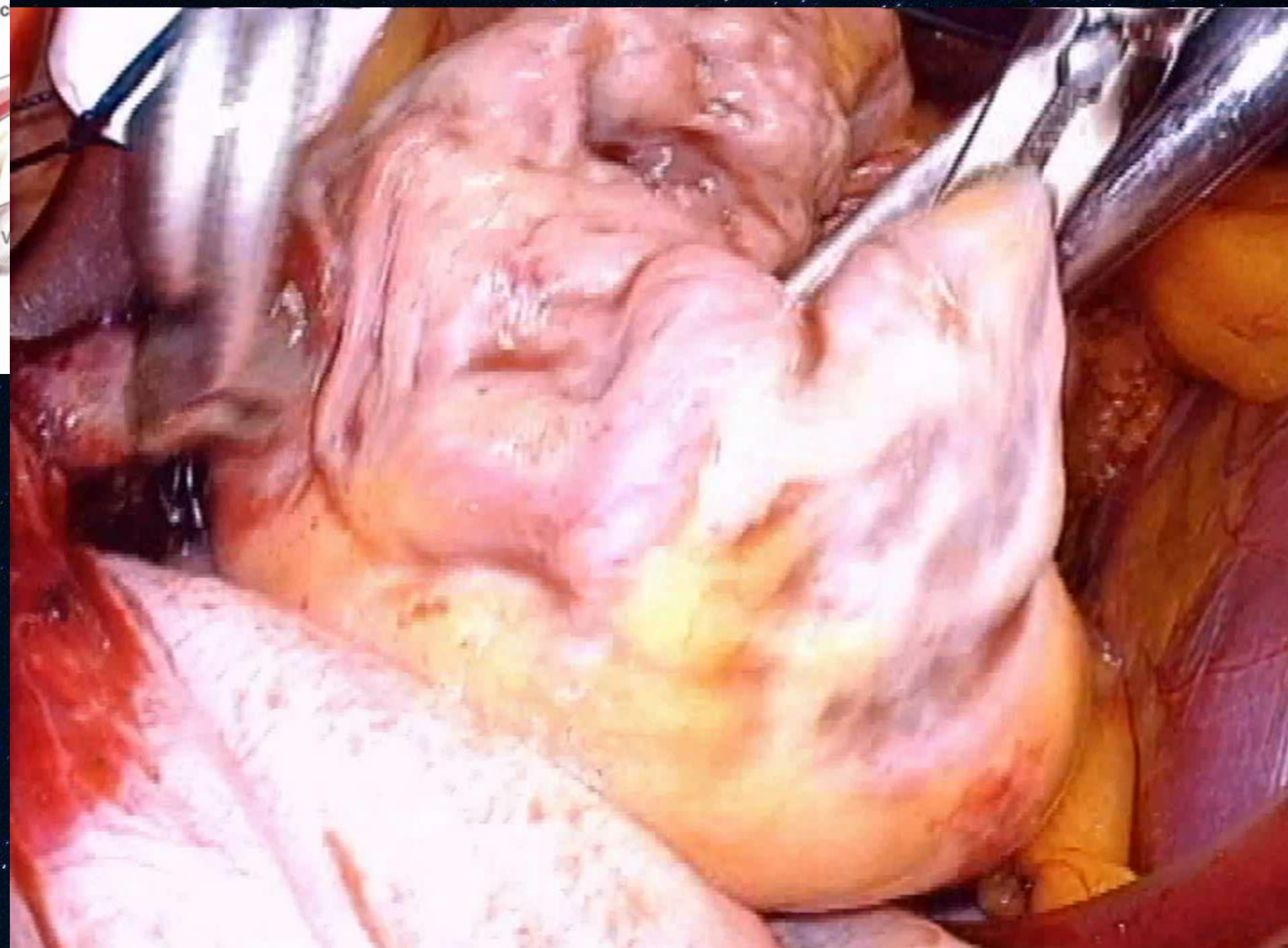
Right Side Lesion





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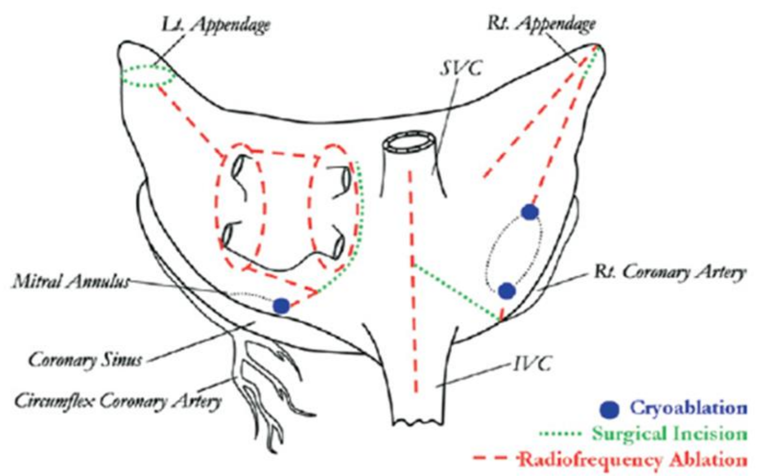
Which One Better?



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Left Atrial Ablation Versus Biatrial Ablation in the Surgical Treatment of Atrial Fibrillation

Joon Bum Kim, MD, Ji Hyun Bang, MD, Sung Ho Jung, MD, Suk Jung Choo, MD, Cheol Hyun Chung, MD, and Jae Won Lee, MD

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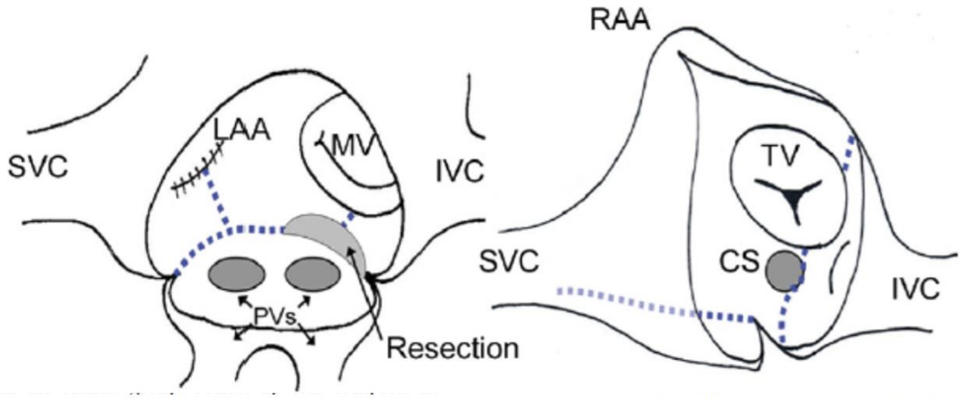

(Ann Thorac Surg 2011;92:1397–405)

Maze procedure

Surgical AF ablation

STS Database

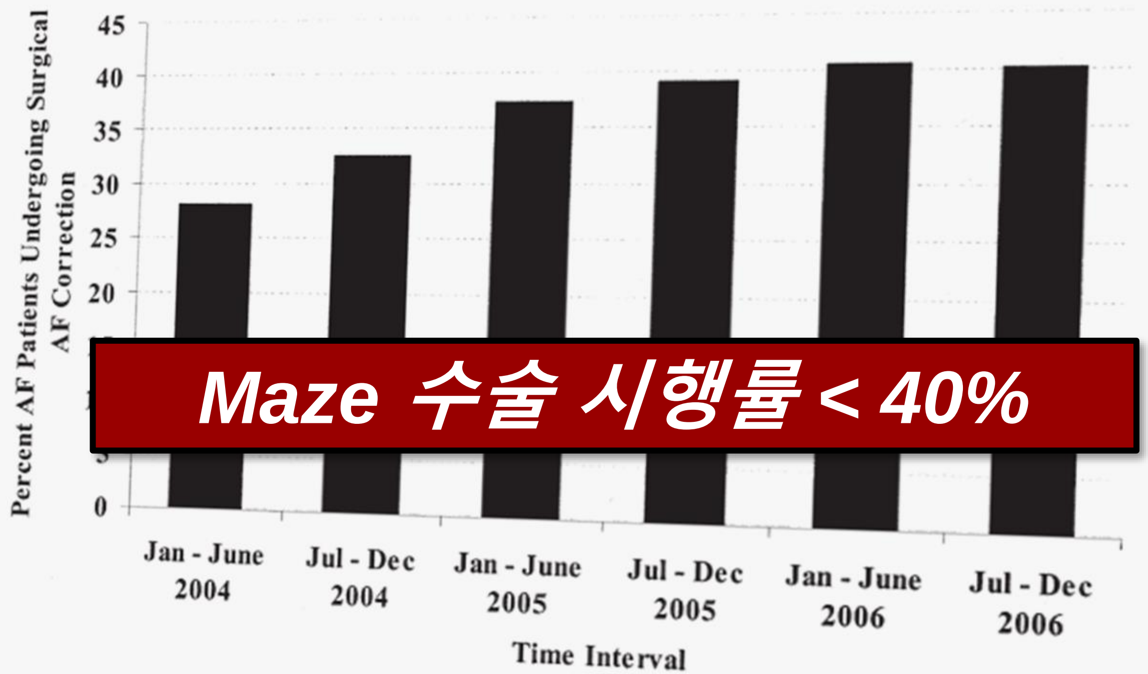

Fig 1. Prevalence of surgical atrial fibrillation (AF) correction procedures among patients with preoperative atrial fibrillation undergoing cardiac surgery. $p < 0.0001$, test for trend.

Gammie et al. Ann Thorac Surg 2008

Concomitant ablation of atrial fibrillation in rheumatic mitral valve surgery

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Wan Kee Kim, MD, Ho Jin Kim, MD, Joon Bum Kim, MD, PhD, Sung-Ho Jung, MD, PhD, Suk Jung Choo, MD, PhD, Cheol Hyun Chung, MD, PhD, and Jae Won Lee, MD, PhD

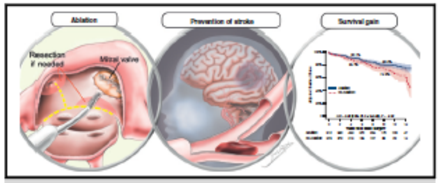
ABSTRACT

Objective: Efficacy of atrial fibrillation ablation in rheumatic mitral valve disease has been regarded inferior to that in nonrheumatic diseases. This study aimed to evaluate net clinical benefits by the addition of concomitant atrial fibrillation ablation in rheumatic mitral valve surgery.

Methods: Among 1229 consecutive patients with atrial fibrillation from 1997 to 2016 (54.4 ± 11.7 years; 68.2% were female), 812 (66.1%) received concomitant ablation of atrial fibrillation (ablation group), and 417 (33.9%) underwent valve surgery alone (no ablation group). Death and thromboembolic events were compared between these groups. Mortality was regarded as a competing risk to evaluate thromboembolic outcomes. To reduce selection bias, inverse probability of treatment weighting methods were performed.

Results: Freedom from atrial fibrillation occurrence at 5 years was 76.5% ± 1.8% and 5.3% ± 1.1% in the ablation and no ablation groups, respectively ($P < .001$). The ablation group had significantly lower risks for death (hazard ratio [HR], 0.69; 95% confidence interval [CI], 0.52-0.93) and thromboembolic events (HR, 0.49; 95% CI, 0.32-0.76) than the no ablation group. Time-varying Cox analysis revealed that the occurrence of stroke after surgery was significantly associated with death (HR, 3.97; 95% CI, 2.36-6.69). In subgroup analyses, the reduction in the composite risk of death and thromboembolic events was observed in all mechanical (n = 829; HR, 0.53; 95% CI, 0.39-0.73), bioprosthetic replacement (n = 239; HR, 0.67; 95% CI, 0.41-1.08), and repair (n = 161; HR, 0.17; 95% CI, 0.06-0.52) subgroups (P for interaction = .47).

Conclusions: Surgical atrial fibrillation ablation during rheumatic mitral valve surgery was associated with a lower risk of long-term mortality and thromboembolic events. Therefore, atrial fibrillation ablation for rheumatic mitral valve disease may be a reasonable option. (J Thorac Cardiovasc Surg 2019;157:1519-28)



Survival benefit by the addition of surgical AF ablation for rheumatic heart disease. Central Image was illustrated by Jinsoo Rhu.

Central Message

The addition of surgical AF ablation for patients undergoing rheumatic MV surgery may be a reasonable option.

Perspective

Although the efficacy of AF ablation in rheumatic MV disease has been reported to be inferior to that in nonrheumatic diseases in terms of the elimination of AF, whether there are net clinical benefits of concomitant AF ablation in rheumatic MV surgery has been debated.

See Commentaries on pages 1529 and pages 1531.

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Concomitant ablation of atrial fibrillation in rheumatic mitral valve surgery

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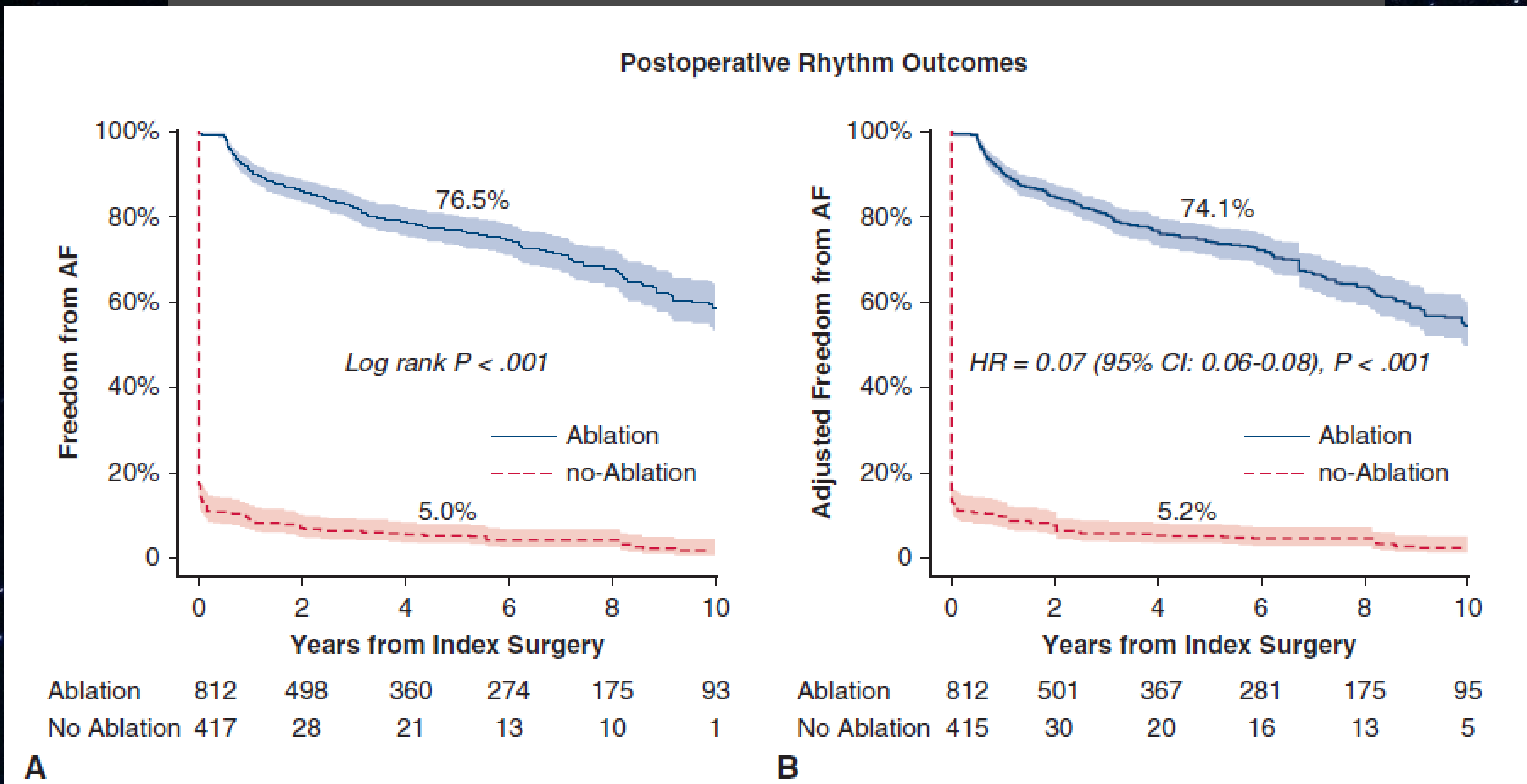

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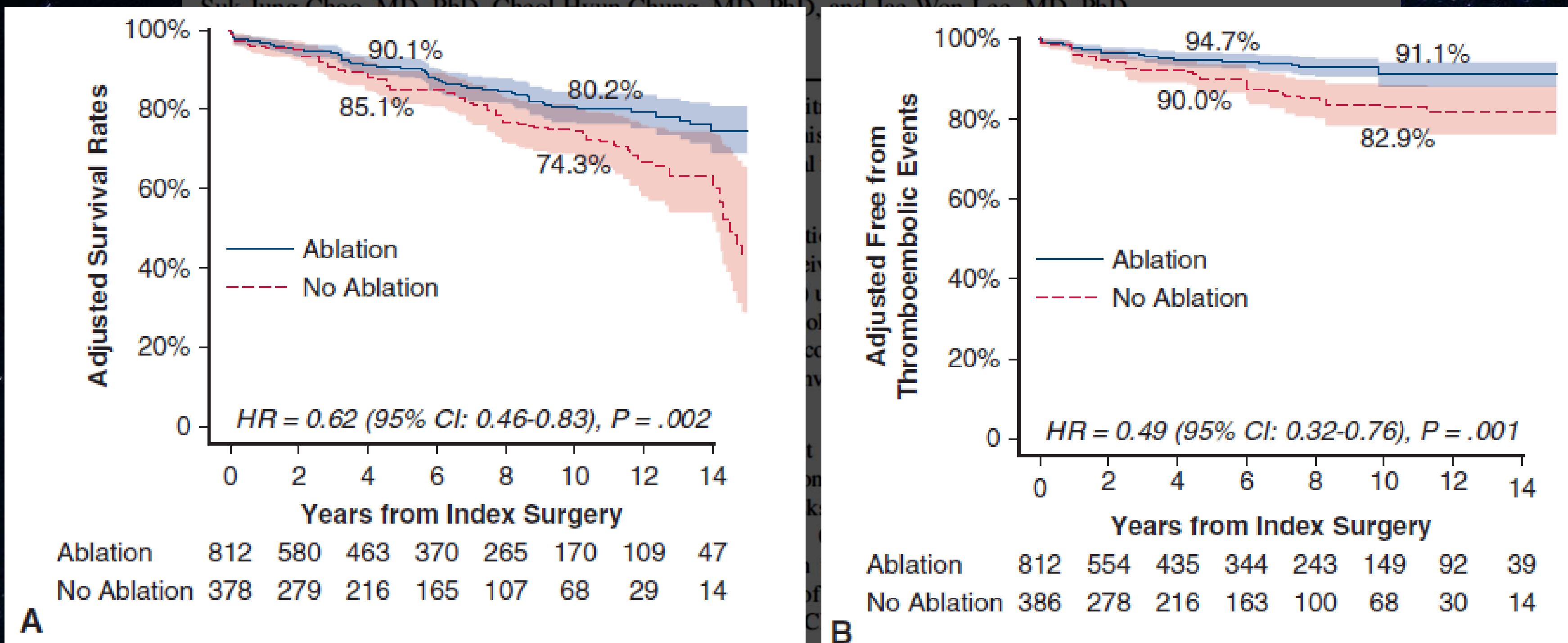

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Long-Term Outcomes of Mechanical Valve Replacement in Patients With Atrial Fibrillation

Impact of the Maze Procedure

Joon Bum Kim, MD; Joon Suk Moon; Sung-Cheol Yun, PhD; Wan Kee Kim, MD; Sung-Ho Jung, MD; Suk Jung Choo, MD, PhD; Hyun Song, MD, PhD; Cheol Hyun Chung, MD, PhD; Jae Won Lee, MD, PhD

Background**—**The long-term benefits of the maze procedure in patients with chronic atrial fibrillation undergoing mechanical valve replacement who already require lifelong anticoagulation remain unclear.

Methods and Results**—**We evaluated adverse outcomes (death; thromboembolic events; composite of death, heart failure, or valve-related complications) in 569 patients with atrial fibrillation–associated valvular heart disease who underwent mechanical valve replacement with (n=317) or without (n=252) a concomitant maze procedure between 1999 and 2010. After adjustment for differences in baseline risk profiles, patients who had undergone the maze procedure were at similar risks of death (hazard ratio, 1.15; 95% confidence interval, 0.65–2.03; *P*=0.63) and the composite outcomes (hazard ratio, 0.82; 95% confidence interval, 0.50–1.34; *P*=0.42) but a significantly lower risk of thromboembolic events (hazard ratio, 0.29; 95% confidence interval, 0.12–0.73; *P*=0.008) compared with those who underwent valve replacement alone at a median follow-up of 63.6 months (range, 0.2–149.9 months). The effect of superior event-free survival by the concomitant maze procedure was notable in a low-risk EuroSCORE (0–3) subgroup (*P*=0.049), but it was insignificant in a high-risk EuroSCORE (≥4) subgroup (*P*=0.65). Furthermore, the combination of the maze procedure resulted in superior left ventricular (*P*<0.001) and tricuspid valvular functions (*P*<0.001) compared with valve replacement alone on echocardiographic assessments performed at a median of 52.7 months (range, 6.0–146.8 months) after surgery.

Conclusion**—**Compared with valve replacement alone, the addition of the maze procedure was associated with a reduction in thromboembolic complications and improvements in hemodynamic performance in patients undergoing mechanical valve replacement, particularly in those with low risk of surgery. **(*Circulation*. 2012;125:2071-2080.)**

Adjusted Hazard Ratios for Clinical Outcomes: Maze vs. Control

Outcomes		HR	95% CI	*P* value
Death	Crude	0.91	0.53-1.56	0.73
	Propensity score	1.13	0.63-2.01	0.69
	IPTW	1.15	0.65-2.03	0.63
Thromboembolism	Crude	0.42	0.17-1.03	0.059
	Propensity score	0.28	0.10-0.77	0.014
	IPTW	0.29	0.12-0.73	0.008
Composite outcome	Crude	0.83	0.59-1.16	0.27
	Propensity score	0.80	0.55-1.16	0.24
	IPTW	0.82	0.50-1.34	0.42

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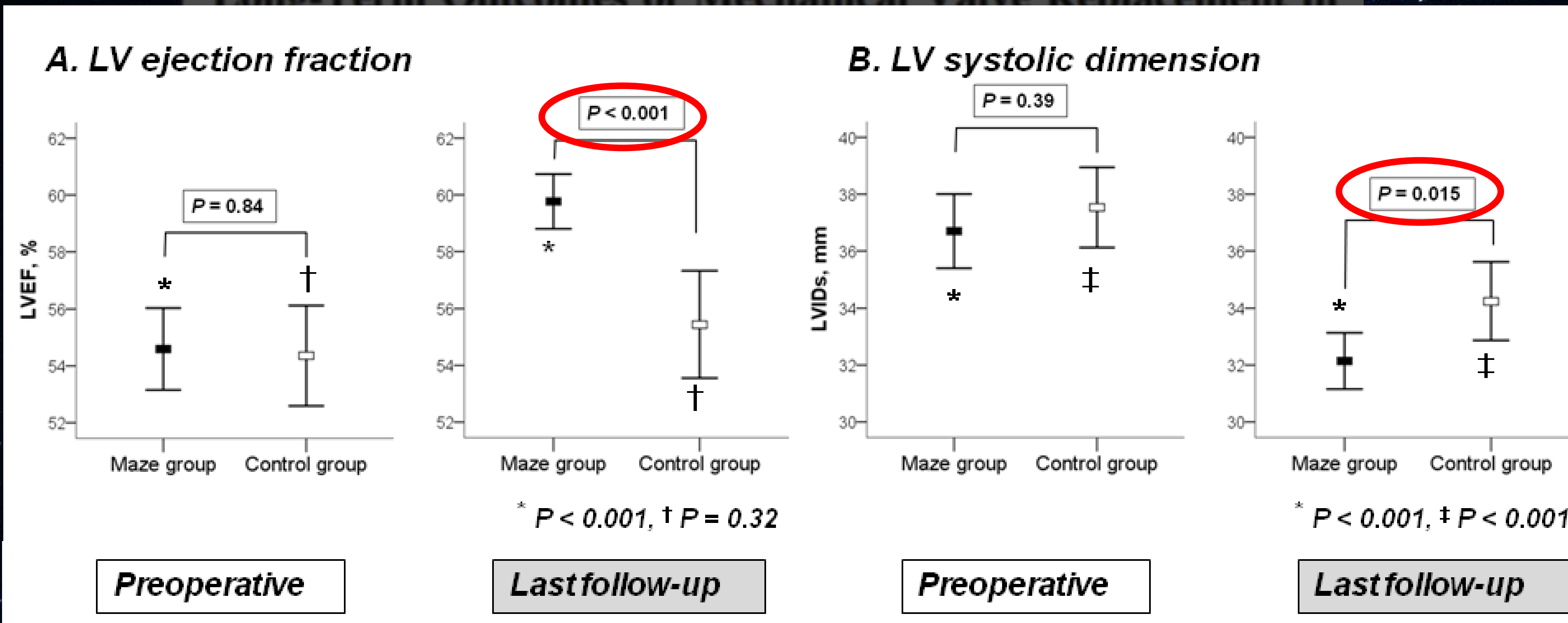
Echocardiographic Outcomes



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Postoperative TV Function

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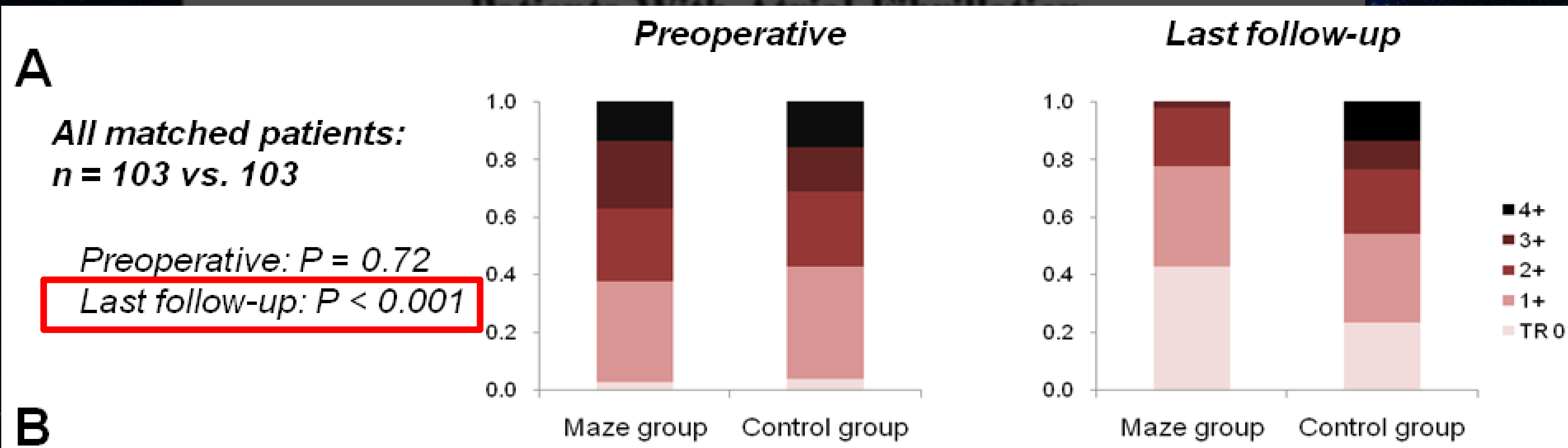

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Summary

- Pathophysiology of AF:
  - Multifactorial
  - Trigger from PV-major focus
- Essential part of surgical AF ablation
  - PV isolation
- Alternative energy sources
  - Cryoablation
  - Radiofrequency ablation
- Proven benefits of AF ablation?
  - Positive based on observational studies


Thank you