AntiAF Surgery

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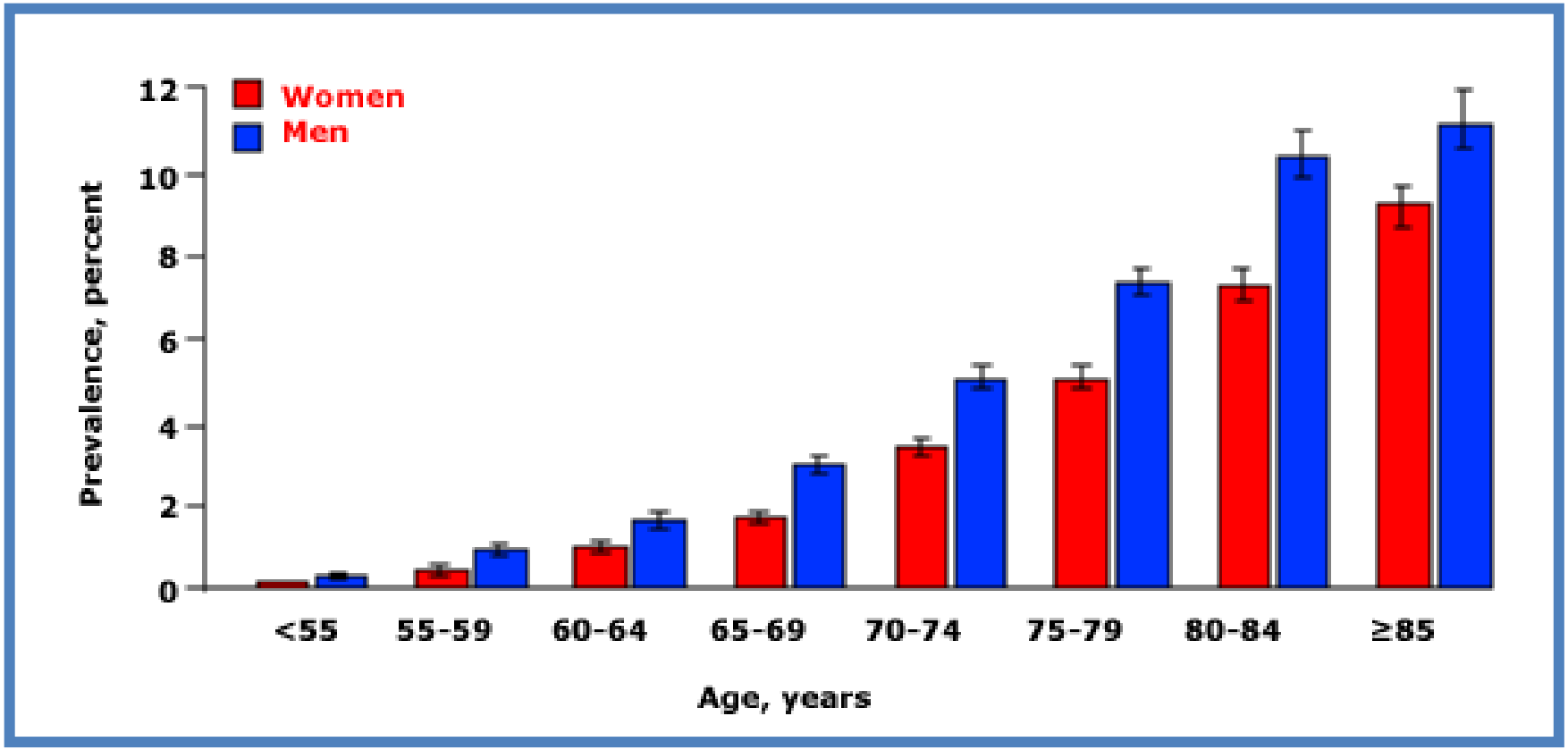
SMC TS

Prevalence of AF

- AF is the most common cardiac dysrhythmia treated in clinical practice:
  - 1~2% of all population
- Increasing with advancing age
  - from ,0.5% at 40–50 years, to 5–15% at 80 years
- Its prevalence continues to increase at a rapid rate
  - at least 2.5 folds in the next 50 years

Prevalence of AF



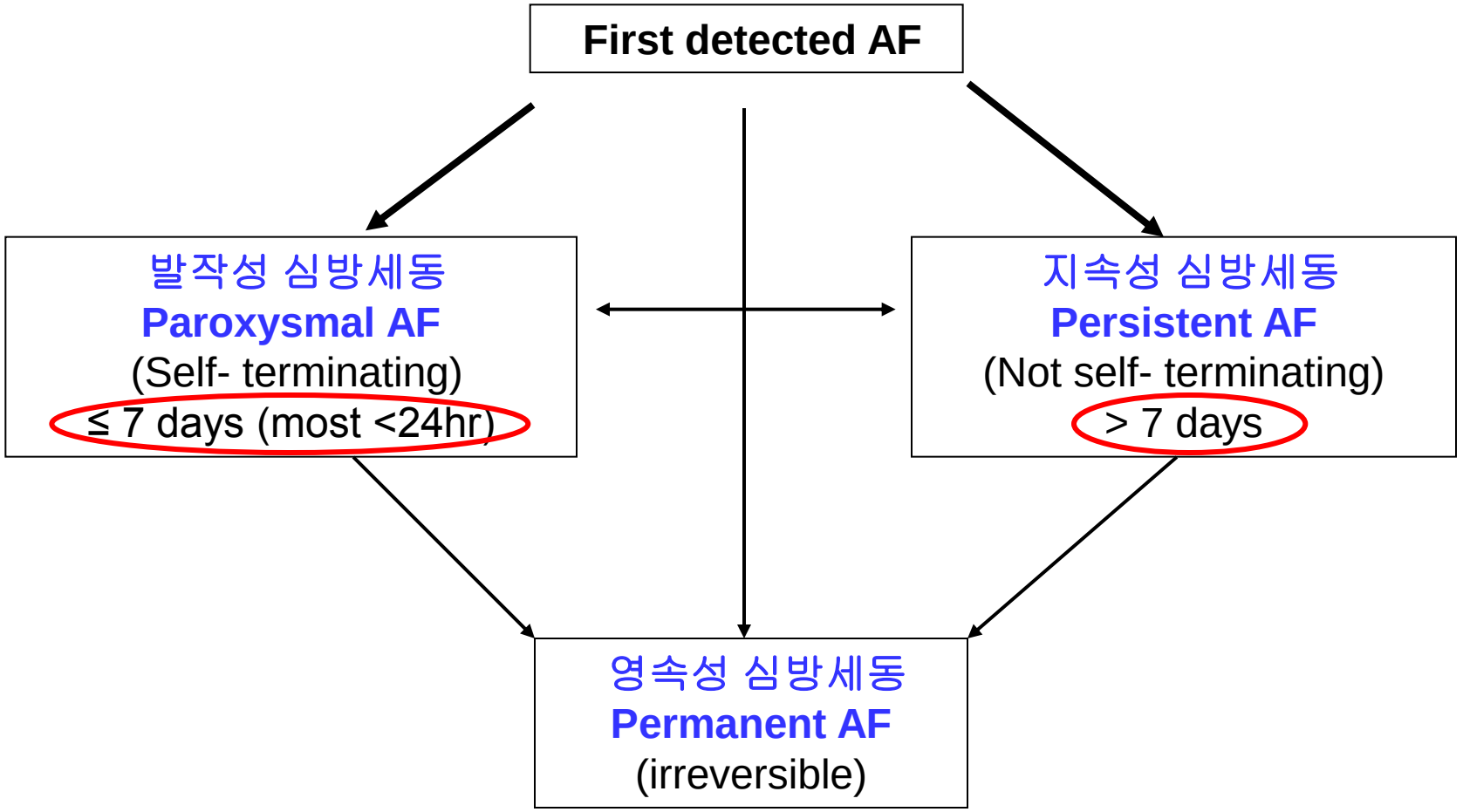
AF with Mitral Valve Disease

- Incidence: 50%
- MV surgery alone: remain 70 ~ 80%
- Survival benefit: JAMA 2005;294:2323-9
- Freedom from AF after Maze op: increase but sinus rhythm restoration rate:46-95%
- LA alone vs biatrial:
  - LA alone: paroxismal AF, no need for RA incision
  - Results ?

Consequences of AF

- Morbidity and Mortality
  - 2-fold increase in risk of mortality
  - 5-fold increase in risk of stroke
    associated with more severe stroke
  - increase hospitalization
  - promotes heart failure (due to LV dysfunction)
    worsen a patient's overall prognosis
- Quality of Life
  - QoL may be considerably impaired due to risk of exacerbation of symptoms

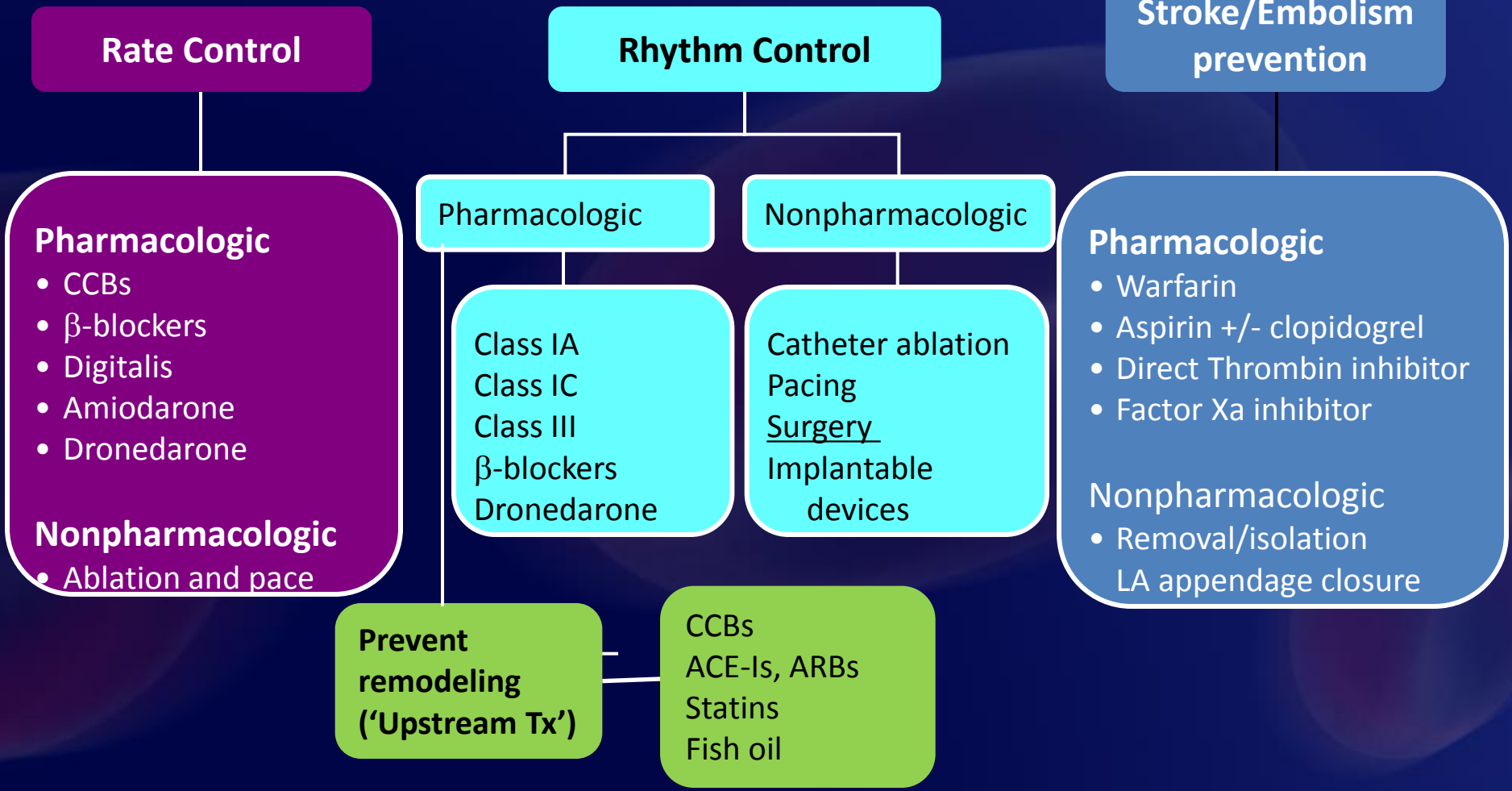
Classification of AF



Recurrent : two or more episode

Longstanding persistent AF: continuous AF of greater than one-year duration

Guideline-Based AF Treatment Options



Fuster V, et al. *J Am Coll Cardiol*. 2006;48(4):854-906.

Rate Control vs Rhythm Control

- AF-CHF trial: no difference

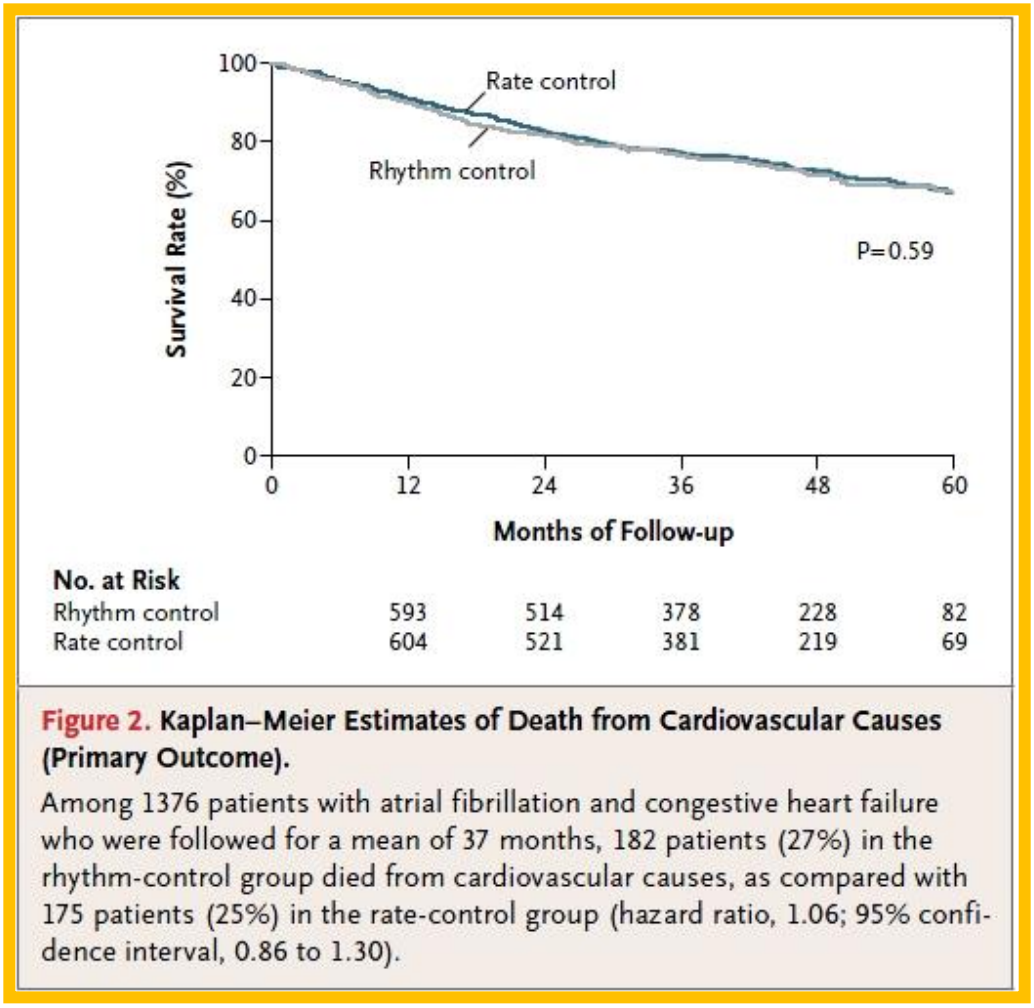
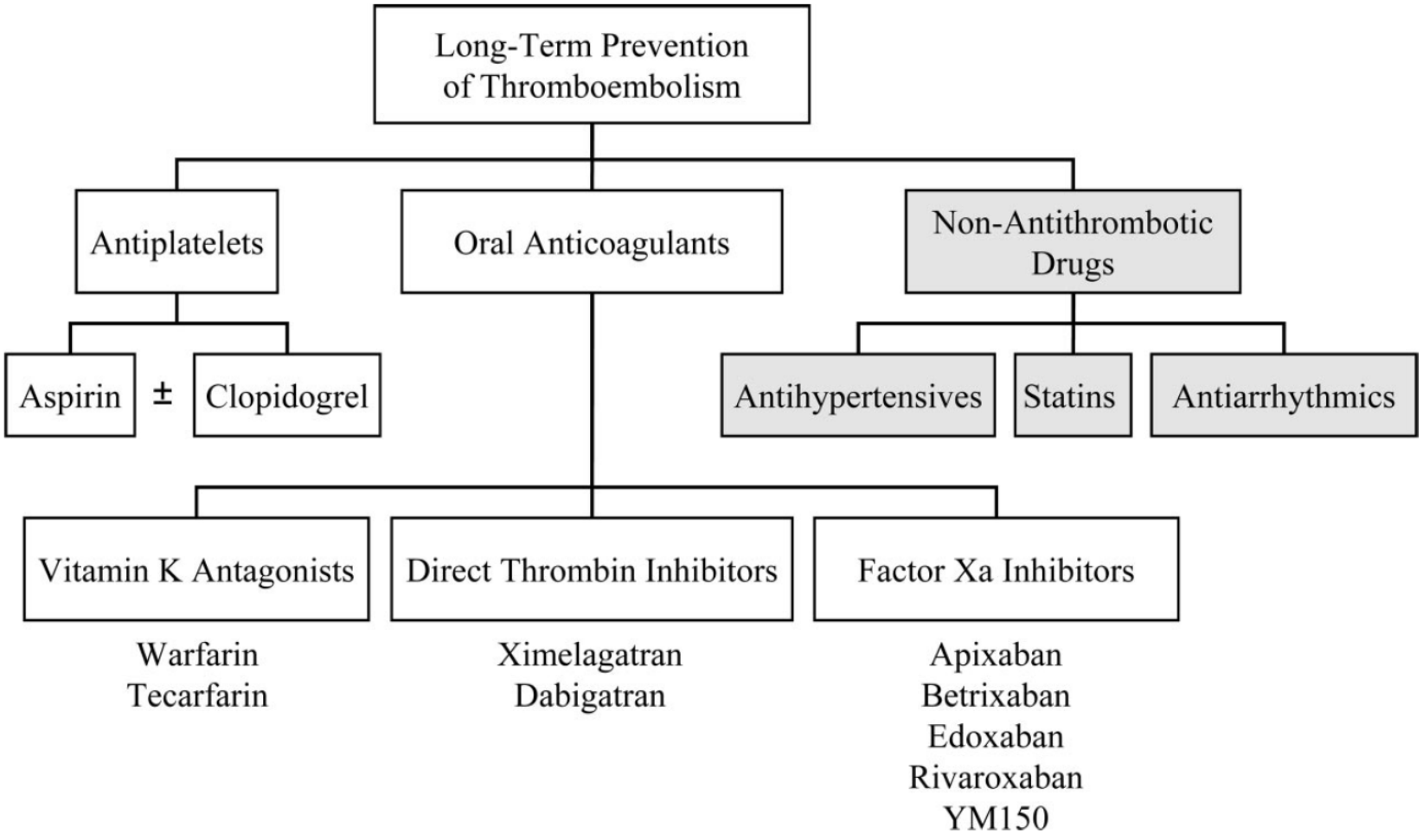


Figure 2. Kaplan–Meier Estimates of Death from Cardiovascular Causes (Primary Outcome).

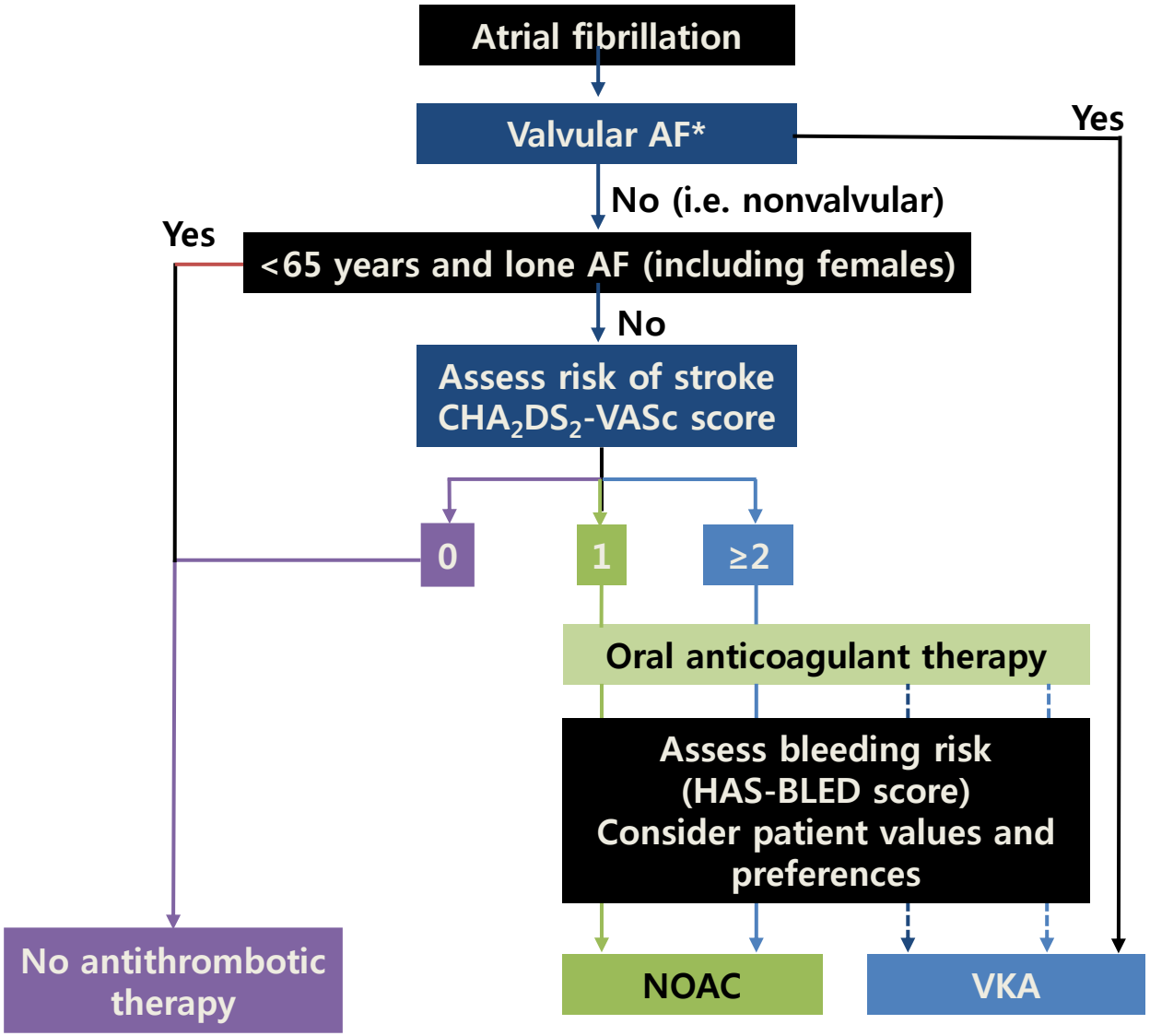
Among 1376 patients with atrial fibrillation and congestive heart failure who were followed for a mean of 37 months, 182 patients (27%) in the rhythm-control group died from cardiovascular causes, as compared with 175 patients (25%) in the rate-control group (hazard ratio, 1.06; 95% confidence interval, 0.86 to 1.30).

N Engl J Med. 2008;358(25):2667.

Prevention of Thromboembolism



Choice of Anticoagulant



ESC guideline, 2012

CHA_2DS_2VASc score for further refinement

'Major' risk factors	'Clinically relevant non-major' risk factors
Previous stroke, TIA, or systemic embolism Age ≥75 years	Heart failure or moderate to severe LV systolic dysfunction (e.g. LV EF ≤40%) Hypertension - Diabetes mellitus Female sex - Age 65–74 years Vascular disease[a]

CHA_2DS_2-VASc score	Patients (n=7329)	Adjusted stroke rate (%/year)[b]
0	1	0%
1	422	1.3%
2	1230	2.2%
3	1730	3.2%
4	1718	4.0%
5	1159	6.7%
6	679	9.8%
7	294	9.6%
8	82	6.7%
9	14	15.2%

Risk factor	Score
Congestive heart failure/LV dysfunction	1
Hypertension	1
Age ≥75	2
Diabetes mellitus	1
Stroke/TIA/thrombo-embolism	2
Vascular disease[a]	1
Age 65–74	1
Sex category (i.e. female sex)	1
Maximum score	**9**

CHA_2DS_2VASc score and antithrombotics

Risk category	CHA_2DS_2-VASc score	Recommended antithrombotic therapy
One 'major' risk factor or ≥2 'clinically relevant non-major' risk factors	≥ 2	OAC[a]
One 'clinically relevant non-major' risk factor	1	Either OAC[a] or aspirin 75–325 mg daily. Preferred: OAC rather than aspirin.
No risk factors	0	Either aspirin 75–325 mg daily or no antithrombotic therapy. Preferred: no antithrombotic therapy rather than aspirin.

HAS-BLED bleeding risk score

Letter	Clinical characteristic	Points awarded
H	Hypertension	1
A	Abnormal renal and liver function (1 point each)	1 or 2
S	Stroke	1
B	Bleeding	1
L	Labile INRs	1
E	Elderly (e.g. age >65 years)	1
D	Drugs or alcohol (1 point each)	1 or 2
		Maximum 9 points

* a score of ≥3 indicates 'high risk

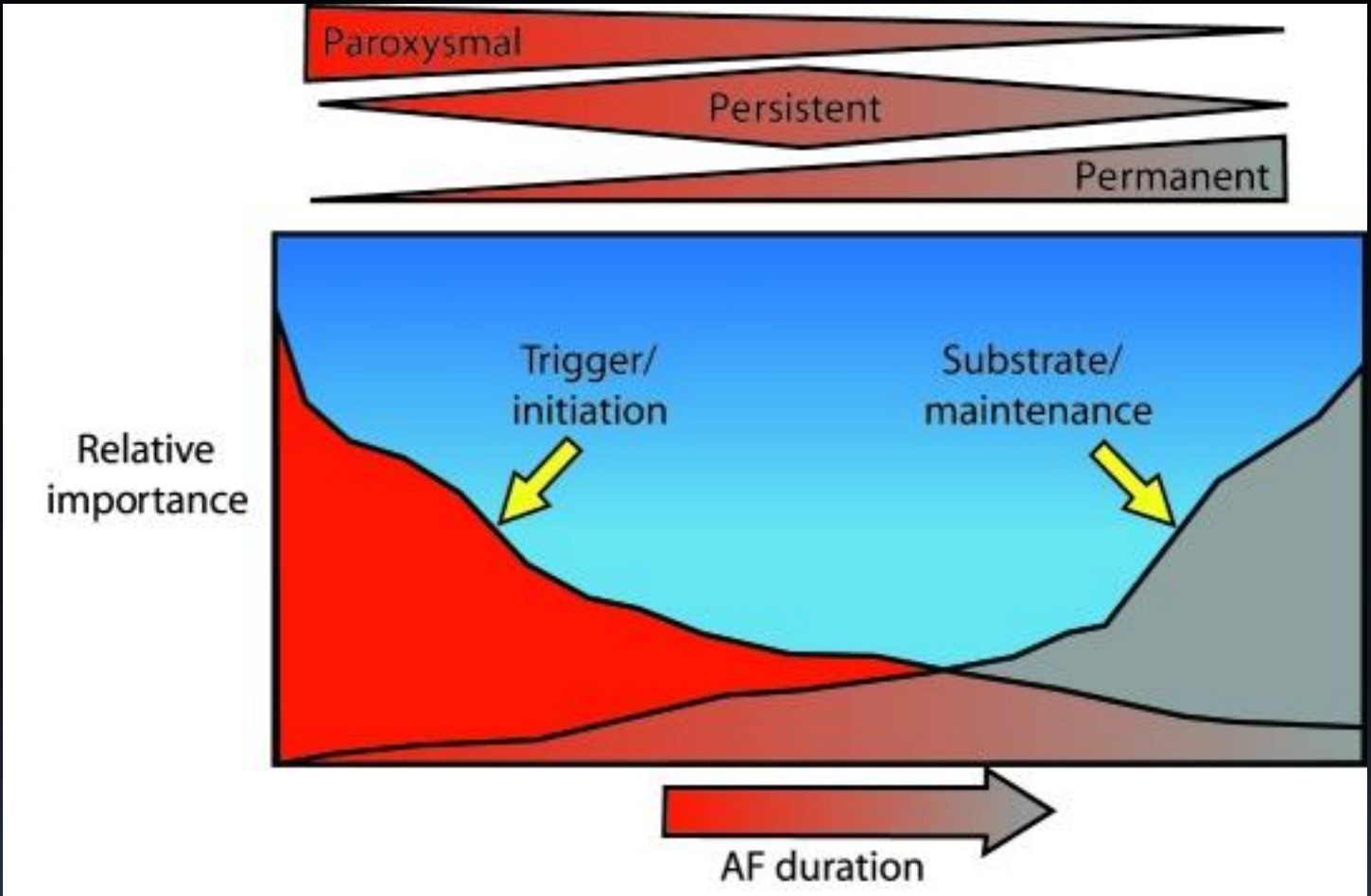
Pathophysiology 1

- Triggers: initiation of AF
  - Pulmonary veins and left atrium
    - 94% of paroxymal Af (Haissaguerre et al.)
    - Two types with different electric properties are juxtaposed.
  - Posterior wall of left atrium
  - SVC, Marshall vein and coronary sinus

Pathophysiology 2

- Substrate: maintenance of AF
  - Structural abnormalities
    - Atrial dilatation
    - Lower mean atrial voltage
  - Conduction abnormalities
    - Prolongation of conduction times
    - Longer P wave duration and slow conduction
  - Impaired sinus node

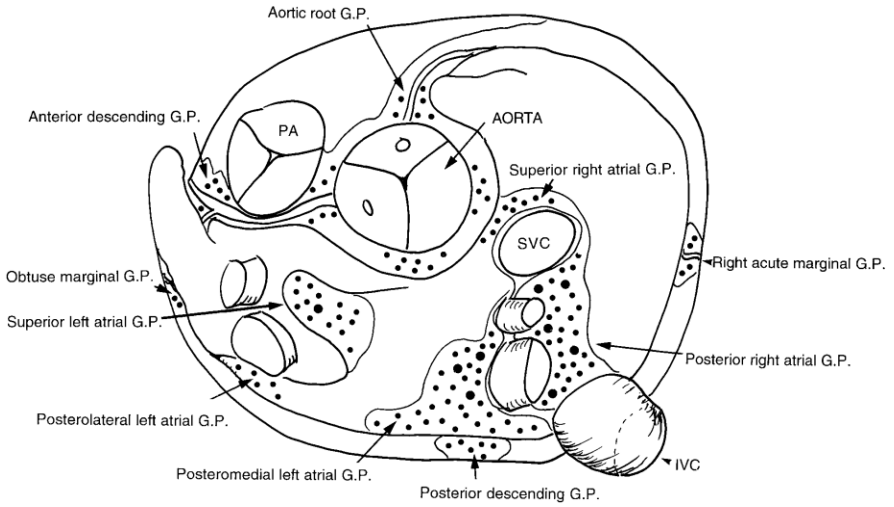
Persistent AF: Different disease from PAF



Mayo Clin Proc. 2009 July;84(7):643-662.

Pathophysiology 3

- Modulating factors
  - Inflammation
    - C-reactive protein (CRP)
    - Equivocal and limited
  - Parasympathetic nerves
  - Sympathetic nerves
    - Pulmonary veins are primary location for entry of vagal nerves into the LA
  - Ganglionated plexus

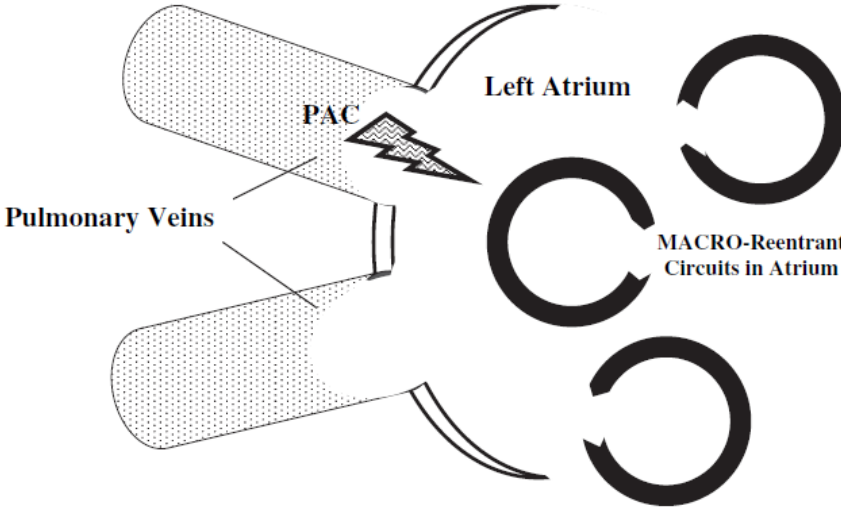


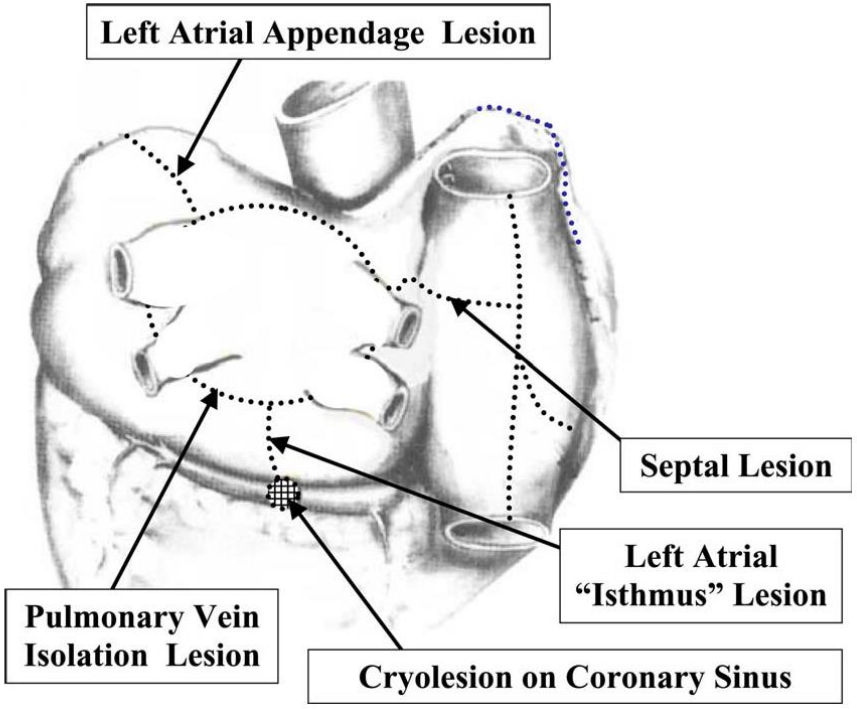
Surgical vs Catheter

- Controversial
- Surgical >> Catheter ?
- Surgical indication
  - Symptomatic AF patients undergoing cardiac surgery (IIA-A)
  - Asymptomatic AF patients undergoing cardiac surgery in whom the ablation can be performed with minimal risk (IIB-C)
  - Stand-alone AF who have failed catheter ablation in whom minimally invasive surgical ablation is feasible (IIB-C)
  - Adult congenital reoperation for TGA
  - MV disease

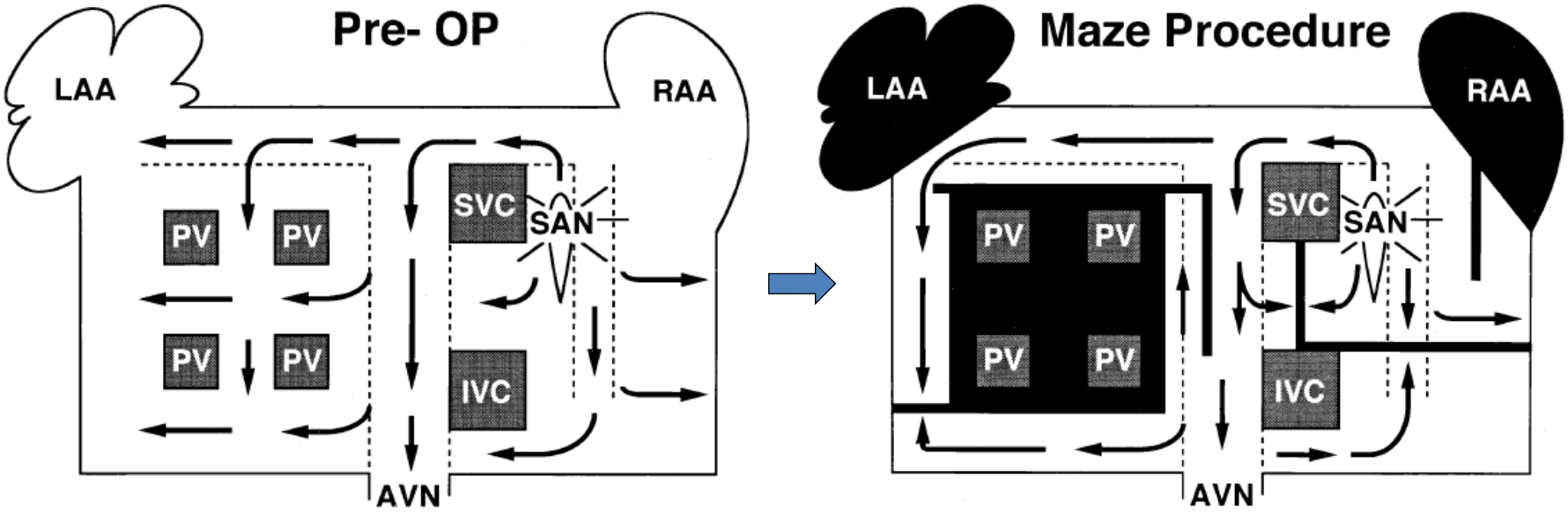
Maze Operation

- The first curative approach to AF
- Atrial segmentation impeding deployment of reentant waves



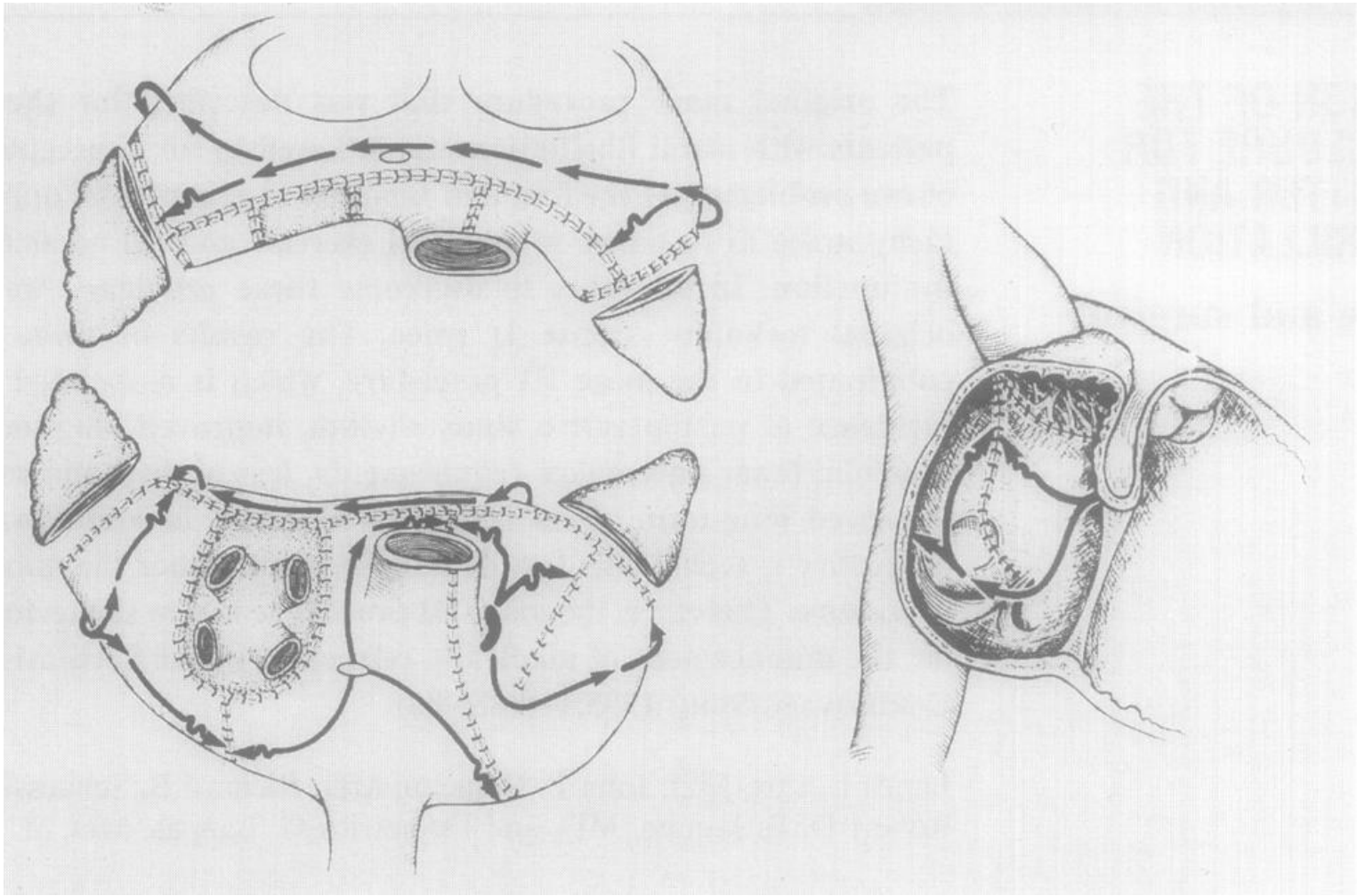


Concept of Maze Op.



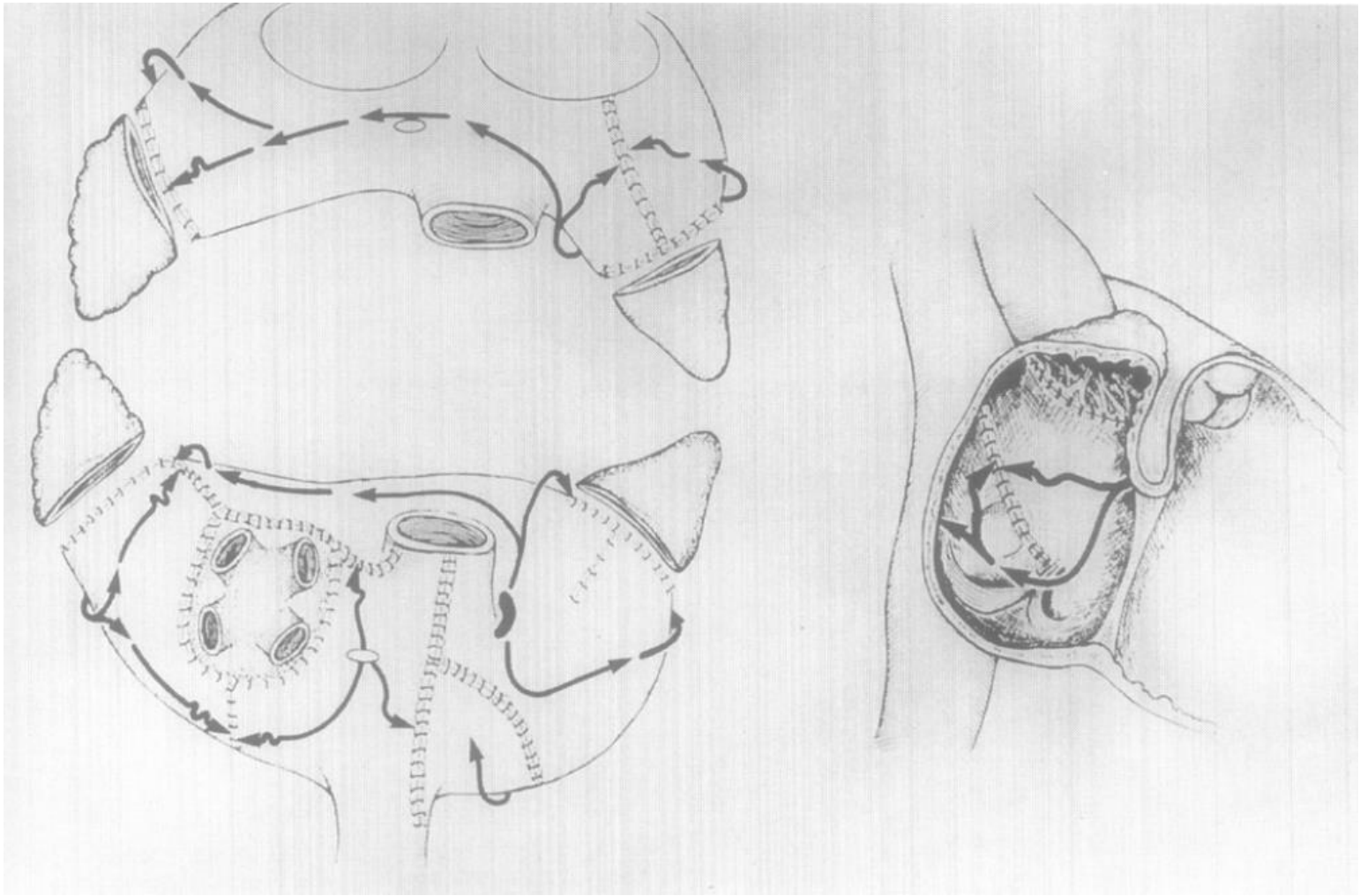
Maze I

- Sinus node dysfunction



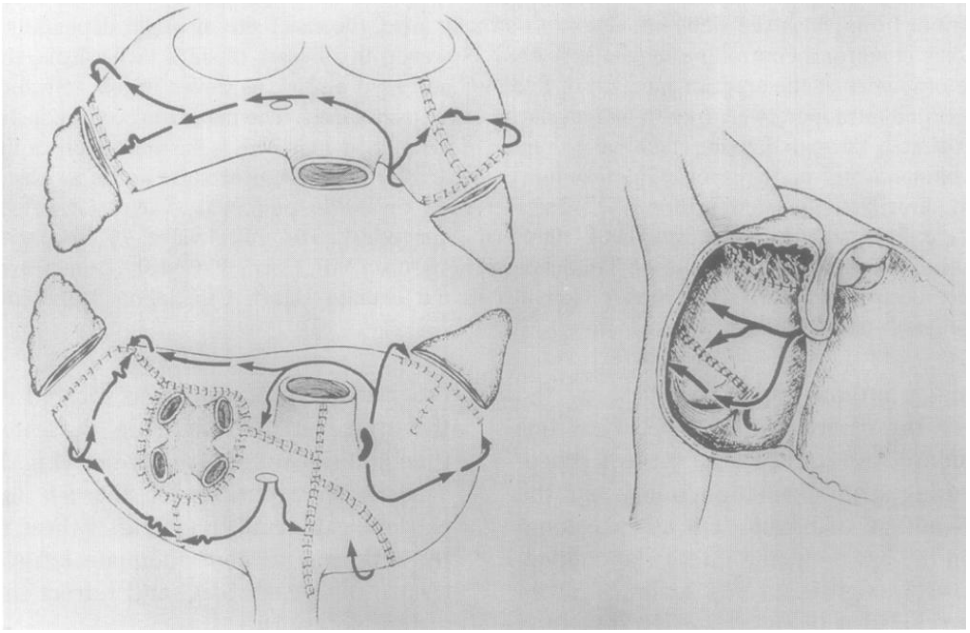
Maze II

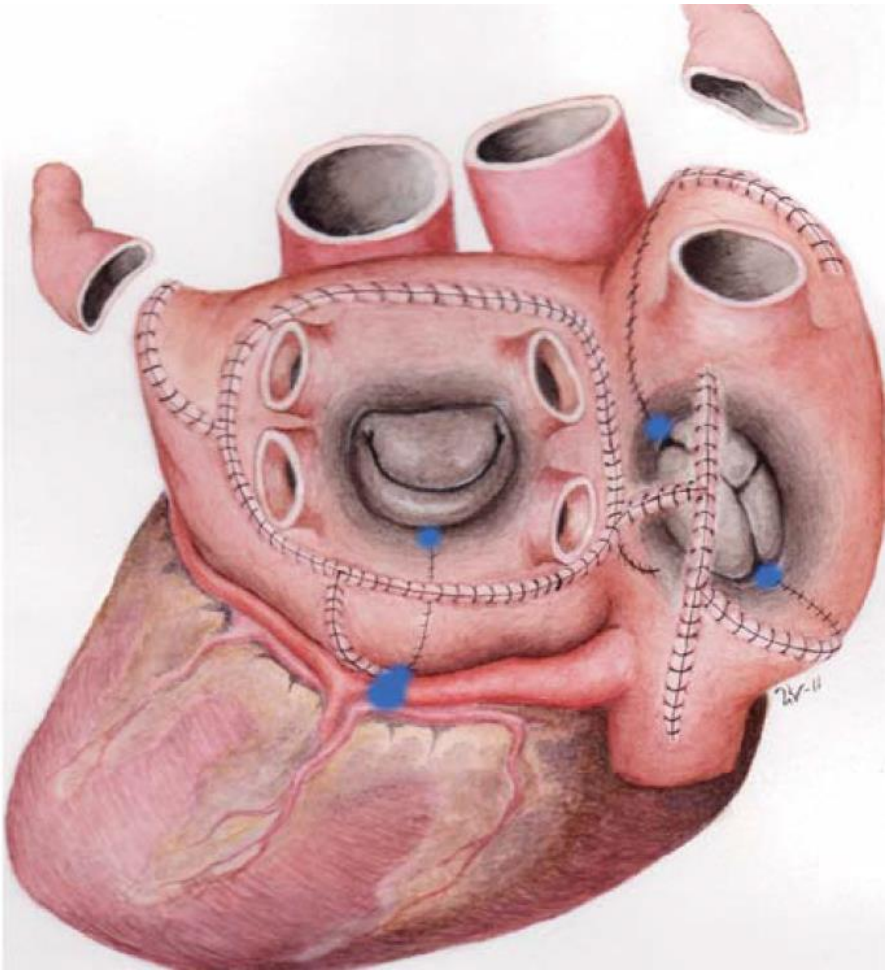
- SVC transsection



Maze III

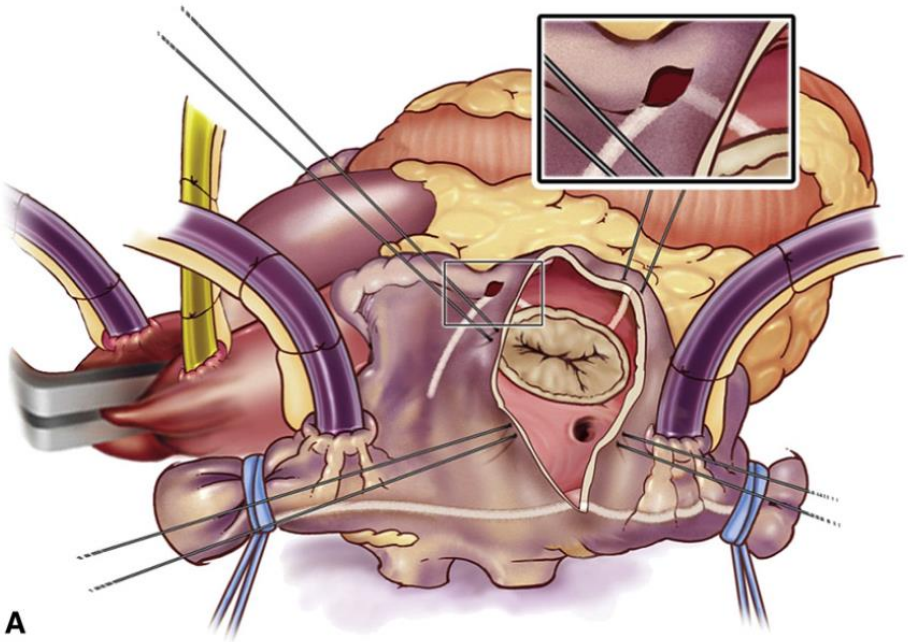
- Gold standard, cut-and-saw

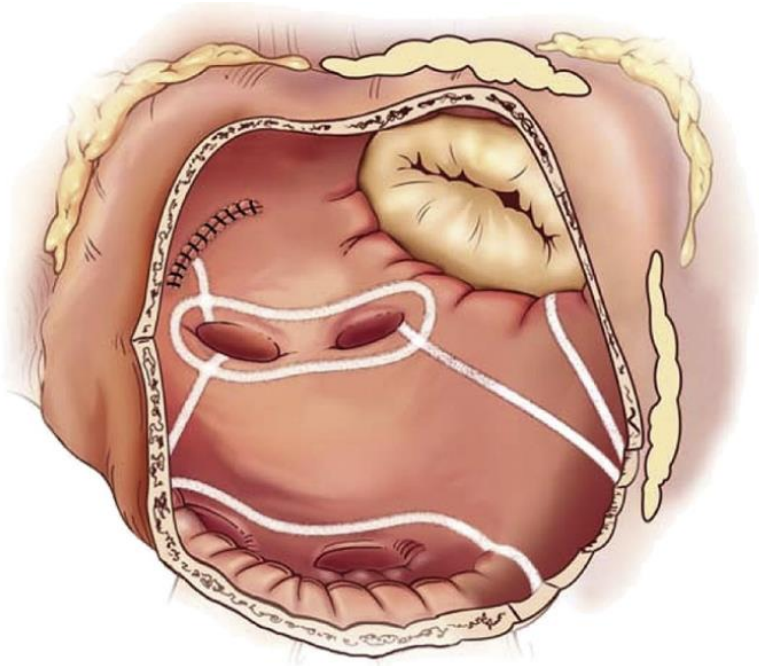


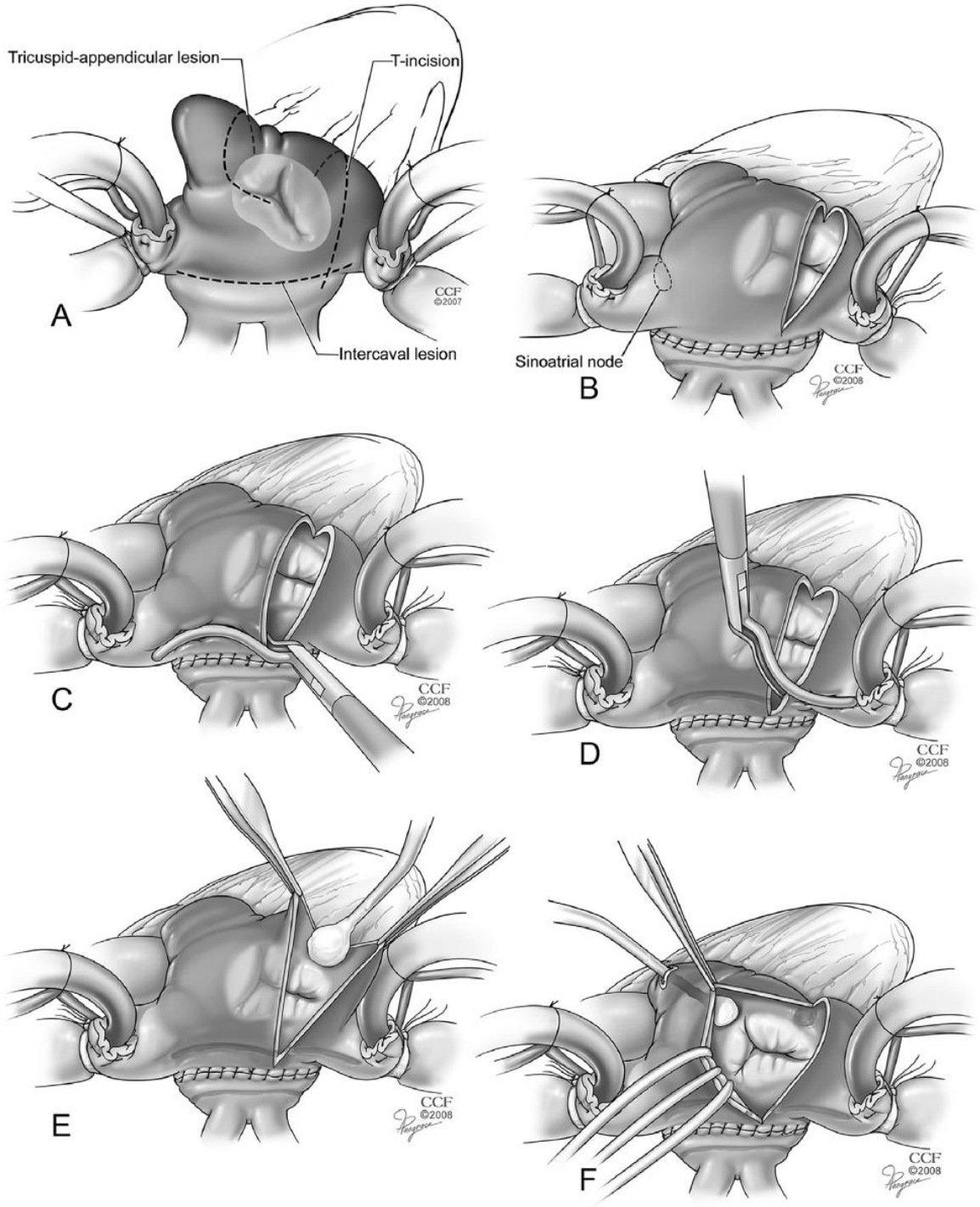


Maze IV

- Simplified ablation assisted procedure






Tricuspid-appendicular lesion
T-incision
Intercaval lesion
A
CCF ©2007
Sinoatrial node
B
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C
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D
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E
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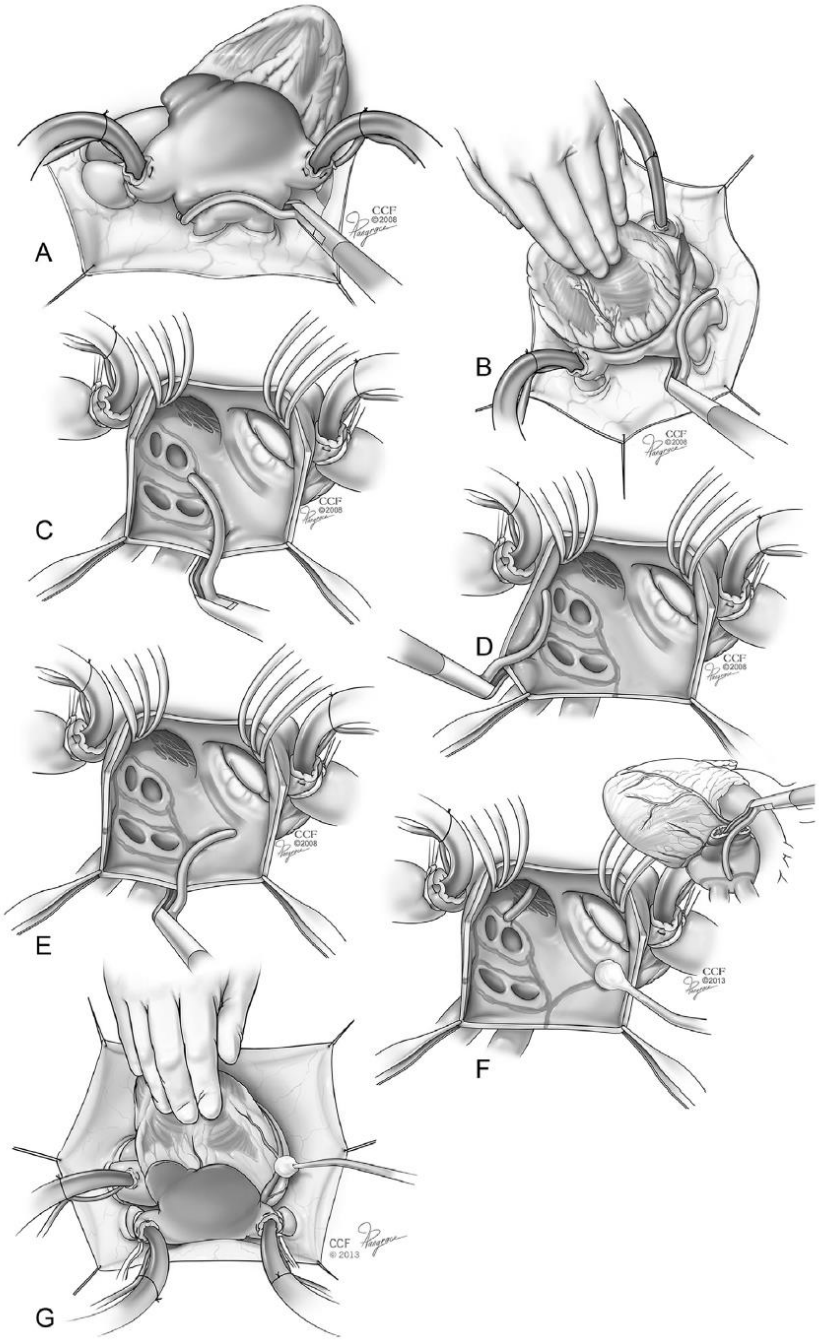
2015 Arrhythmia Surger

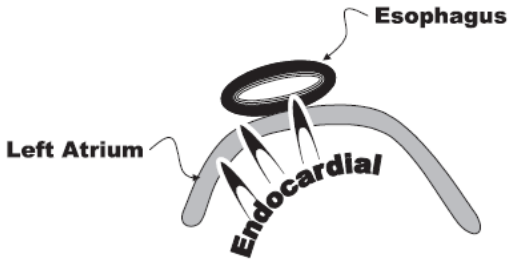


Choice of Lesion Set

Type of surgery	Paroxysmal AF	Nonparoxysmal AF
Aortic valve surgery	Left sided ablation (1 or 2)	Biatrial ablation (1 + 3 or 2 + 3)
Coronary artery surgery		
Other open heart surgery without left atriotomy		
Mitral valve surgery	Left sided ablation (1)	Biatrial ablation (1 + 3)
Atrial septal defect surgery	Biatrial ablation (1 + 3)	Biatrial ablation (1 + 3)

Alternative Energy source

- Transmurality vs collateral injury
  - Heat sink or cooling sink
- Cryo
- Radiofrequency
  - Uni
  - Bi
  - Irrigated
- Microwave
- Laser
- Focused US



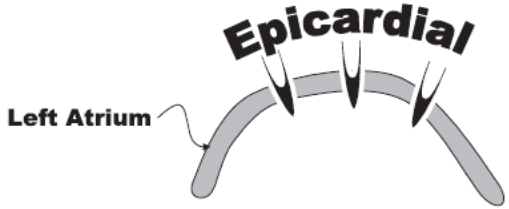


Table 2: Energy sources

Source Type	Cryoablation Unipolar	Microwave Unipolar	Laser Unipolar	HIFU unipolar	Radiofrequency Unipolar dry/irrigated	Bipolar dry/irrigated
Characteristics	Tissue destruction through the formation of intra- and extra-cellular ice.	Dielectric heating created by electromagnetic waves emitted from an antenna (300 MHz–300 GHz).	Produces high-energy optical waves via an optical coupling fibre and radiating fibre tip.	It involves propagation of sound waves from a transducer vibrating at a fixed frequency between 2 and 20 MHz.	Radiofrequency energy uses an alternating current in the range of 100–1000 Hz.	Alternating current is driven between two closely approximated electrodes, which results in a focused ablation.
	Three phases: (1) Freeze/thaw. (2) Inflammation. (3) Fibrosis.	Microwave probes allow for rapid heat penetration. Thermal damage leads to subsequent scar formation.	Tissue is ablated by direct heating and also by mechanical damage for cellular lysis caused by shock waves.	Tissue injury is created through a combination of thermal energy (tissue absorption and acoustic energy) and mechanical energy (oscillation and collapse of gas bubbles or microcavitation.	The energy is dispersed between the electrode tip and a different electrode, usually the grounding pad applied to the patient.	Results in discrete, transmural lesions with no evidence of contraction or scarring.
			The laser creates well demarcated and narrow ablation lines because the light beam is collimated and heats the tissue directly without dispersion.		The tissue within 2–3 mm from the probe is heated to 50–60 °C with permanent destruction of cell structures and collagen.	
Advantages						
	(1) It preserves the architectural integrity of tissue collagen. (2) Excellent source for ablation close to valvular tissue or the fibrous skeleton of the heart. (3) Low risk of bleeding, perforation, or collateral damage. (4) Absence of cicatrization and lack of endocardial thrombus formation. (5) Ease of use.	(1) MW probes can create linear lesion easily and complete transmural ablation epicardially. (2) It can penetrate tissue more deeply than RF energy sources. (3) The lesion is more likely transmural with a grater volume of heated tissue for the same tissue surface temperature. (4) It releases unidirectional focused energy and avoids collateral damage because excess energy is absorbed by blood elements, not anatomical structures. (5) It can accomplish long linear lesions with few applications. (6) Thermal damage and the subsequent scar result in a deep lesion without endocardial char. (7) Lower risk of thromboembolism. (8) Less sensitive to electrode positioning.	(1) Ablation safe and effective. (2) Focused energy and unaffected by overlying fat. (3) It uses flexible fiber optics to deliver energy to tissue. (4) Deep uniform lesion can be created at low tissue temperature (50°C). (5) Rapid tissue heating facilitates both endocardial and epicardial approaches, especially with a beating heart. (6) A single application is enough to create a long lesion during a single application. (7) The Laser lesions are deep (up to 7 mm) and narrow. (8) The reduced area of ablated tissue preserves atrial contractility, reduces the risks of thromboembolism, and minimizes perforation. (9) Scattering of the energy when contacting blood offers a potential safety factor in beating-heart epicardial ablation.	(1) Focused precise lesions. (2) Capability to ablate without direct contact with tissue. (3) Creation of a transmural lesion is possible from epicardial approach, unimpeded by epicardial fat, in less than 2 seconds. (4) Ability to cause injury to myocardial of fat tissue on both sides of a coronary artery without causing injury to the artery itself. (5) A combined device could theoretically visualize the atrium, quantitate the wall thickness and simultaneously confirm the transmurality of the lesion.	(1) Well controlled lesions. (2) Saline irrigation at the electrode tip maintains a low electrode-tissue interface temperature and allows a low impedance path for energy to penetrate deeper into the target tissue. This focuses the energy further and prevents disruptive and insulating char formation and over-heating.	(1) Focused and discrete lesion that can be made in a fraction of the time of unipolar ablation. (2) It is capable of creating reliable transmural lesion, both on arrested and the beating heart. (3) No collateral cardiac or extracardiac injury. (4) Shorter ablation times when compared with unipolar devices.

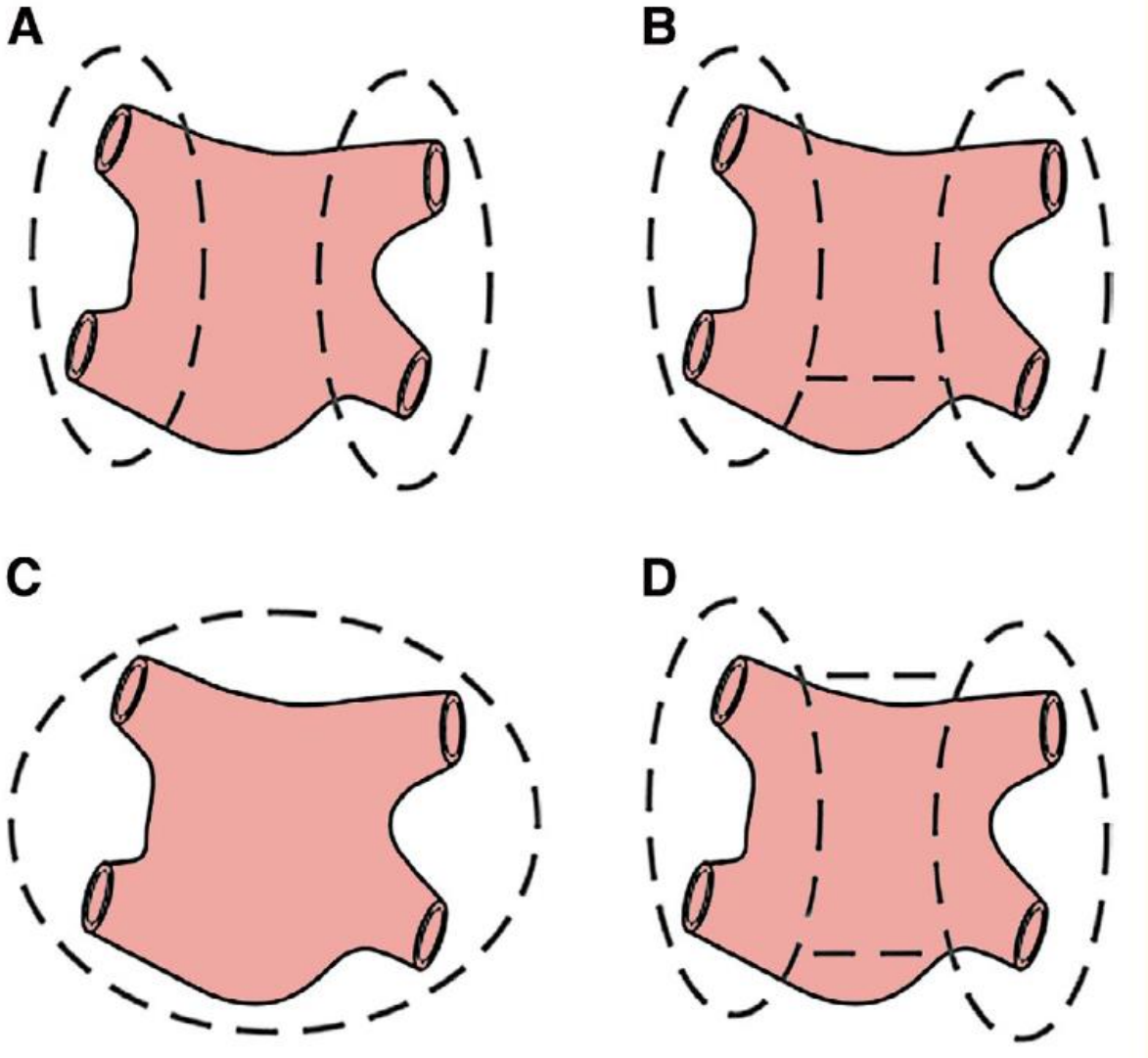
Table 2: Continued

Source Type	Cryoablation Unipolar	Microwave Unipolar	Laser Unipolar	HIFU unipolar	Radiofrequency Unipolar dry/irrigated	Bipolar dry/irrigated
Disadvantages						
	(1) Long time necessary to create an ablation (2–3 min). (2) Probes rigid and large-not suitable for minimally invasive procedures. (3) Difficulty in creating lesions in the beating heart because of the heat sink of the circulating blood volume. (4) Coronary artery stenosis. (5) Oesophageal lesions.	(1) It is unfocused heat energy. (2) There is no way to judge transmurality of ablation during surgery. (3) Potential collateral injury (circumflex artery. (4) It is not capable of creating epicardial lesions on the beating heart.	(1) The deliver is unconfined and thus could cause collateral damage. (2) There is no way to judge transmurality of ablation during procedures. (3) Crater formation and even perforation at high energy can occur[a]. (4) Poor visualization can make precise application difficult.	(1) If the power of the source is too high, excessive mechanical shear can disrupt adjacent tissue and cause collateral or target tissue damage. (2) Its safety profile needs to be clarified. (3) Fixed depth of penetration, which may be problematic because of the pathological variability in atrial wall thickness.	(1) It is incapable of creating epicardial transmural lesion on the beating heart. (2) It radiates unfocused heat, and this may cause collateral injury if not used carefully. (3) It is thrombogenic. (4) Pulmonary vein stenosis. (5) Damage to the circumflex coronary artery. (6) Atrio-esophageal fistula.	(1) Difficult to maintain constant and firm tissue-electrode surface contact on beating heart. (2) Limited maneuverability can hamper the orientation of the probe and constrain the variety of achievable lesion set. (3) It can only ablate tissue that can be clamped within the jaws of the device.

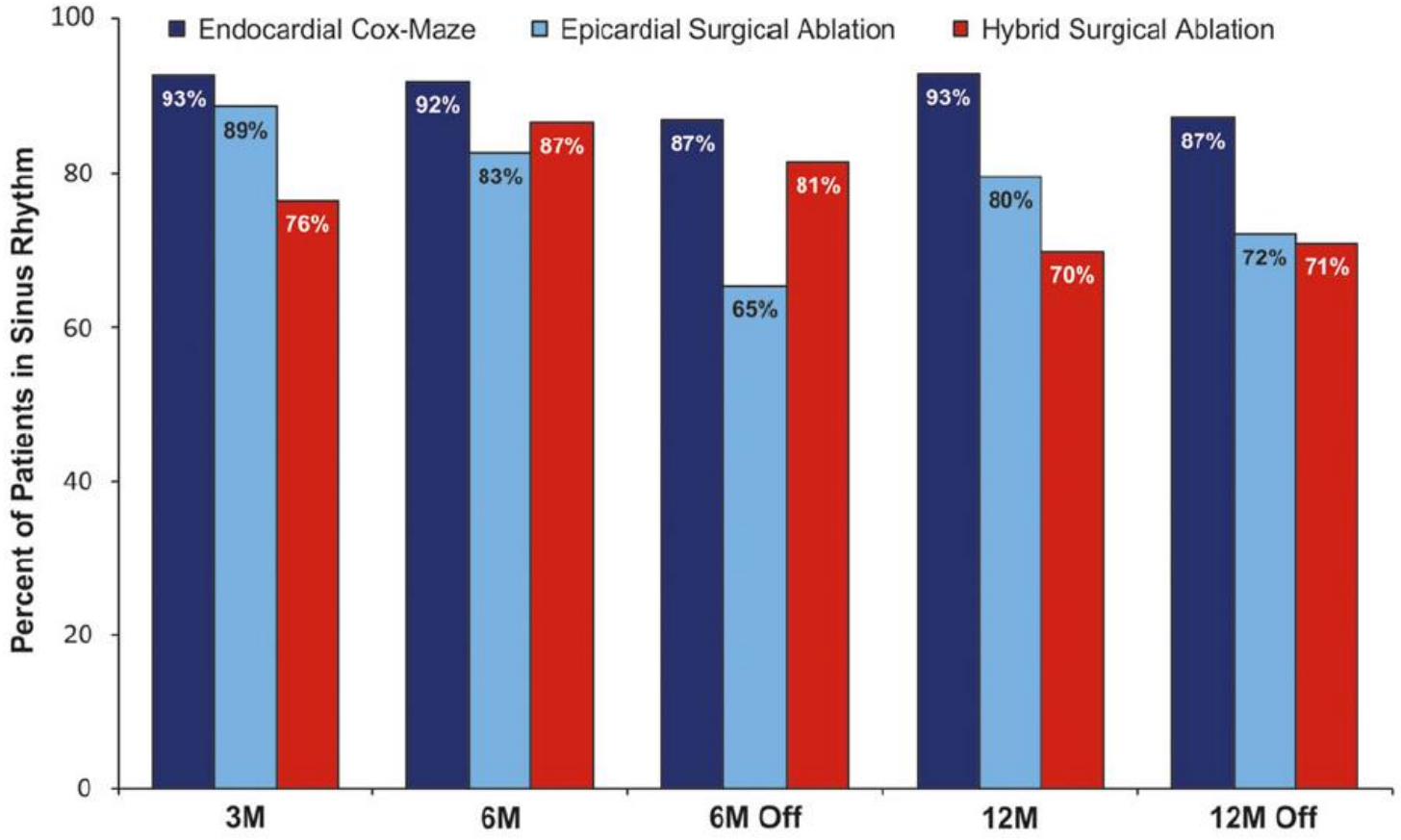
Minimally Invasive Technique

- Beating heart (without CPB), epicardial
  - Robotic
  - Throacoscopic
  - Mini-thoracotomy
- Hybrid: epicardial surgcial ablation + endocardial catheter ablation
- Mini-maze:
  - PVI + LA isthmus & coronary sinus + RA isthmus
- PVI, LA appendage resection

PVI



Freedom From AF



Other AF Surgery

- Historical
  - Left atrial isolation: 1980, Williams et al
  - Corrido technique: 1985, Guiraudon et al
  - Mini-maze:
  - PVI
  - Radial approach: experimental

Results

- Success rate: about 90%

- When ?
  - Last rhythm
  - At 6m, 1yr, etc
  - Time related event
- With AAD or not
- Without AF or resortration of sinus rhythm
- 24hr holter or long-term monitoring or EKG only

Risk Factors for Recurrence

- Huge LA
- Fine fibrillation wave
- Duration of AF
- Old age
- Fibrosis
- Recurrence of MV disease

Comments

- Without AF ≠ restoration of atrial activity

- Survival benefit ?
- Risk of thromboembolism ?