Atrial Fibrillation and Anesthesia Considerations from an EP Perspective

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Disclosures

Speaker has no conflict of interest

I also hope that I don’t put you to sleep...

Because that’s your job!

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Objectives

1. Indications and special patient populations in atrial fibrillation ablation

2. Mechanisms of atrial fibrillation and evolving techniques and technologies in ablation

3. Anesthetic considerations and techniques during ablation
   - -Improved ablation lesion formation
   - -EP medications
   - -Esophageal considerations

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NEJM, 1998

SPONTANEOUS INITIATION OF ATRIAL FIBRILLATION BY ECTOPIC BEATS ORIGINATING IN THE PULMONARY VEINS

MICHEL HAÏSSAGUERRE, M.D., PIERRE JAÏS, M.D., DIPEN C. SHAH, M.D., ATSUSHI TAKAHASHI, M.D., MÉLÈZE HOCINI, M.D., GILLES QUINIOU, M.D., STÉPHANE GARRIGUE, M.D., ALAIN LE MOUROUX, M.D., PHILIPPE LE MÉTAYER, M.D., AND JACQUES CLÉMENTY, M.D.

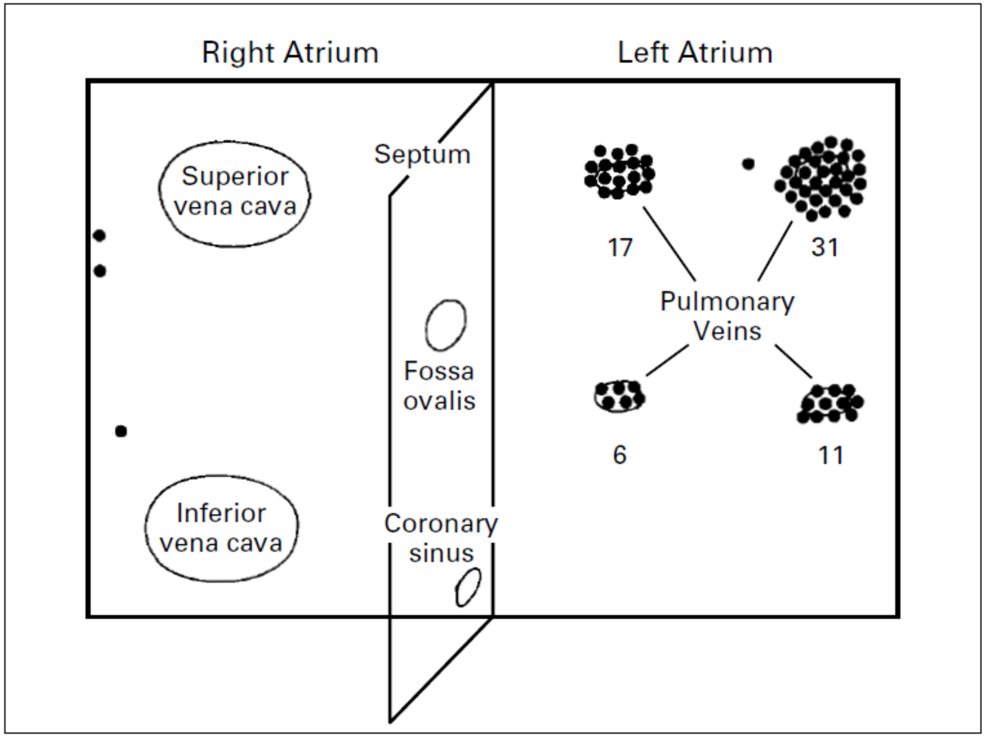


Figure 1. Diagram of the Sites of 69 Foci Triggering Atrial Fibrillation in 45 Patients.
Note the clustering in the pulmonary veins, particularly in both superior pulmonary veins. Numbers indicate the distribution of foci in the pulmonary veins.

In patients with paroxysmal AF, the vast majority of atrial premature beats **originate in the pulmonary veins** (94% of all triggers).

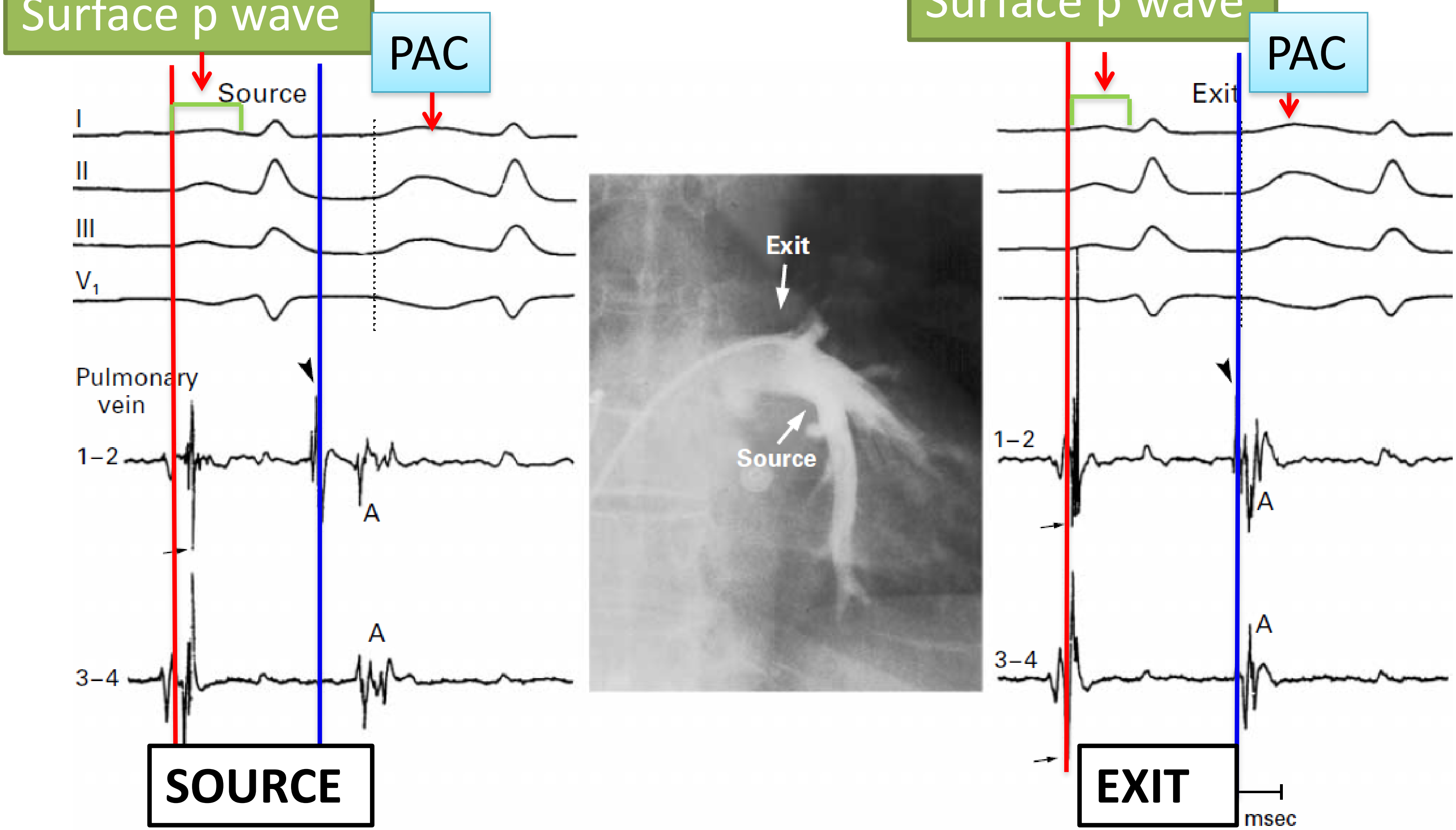


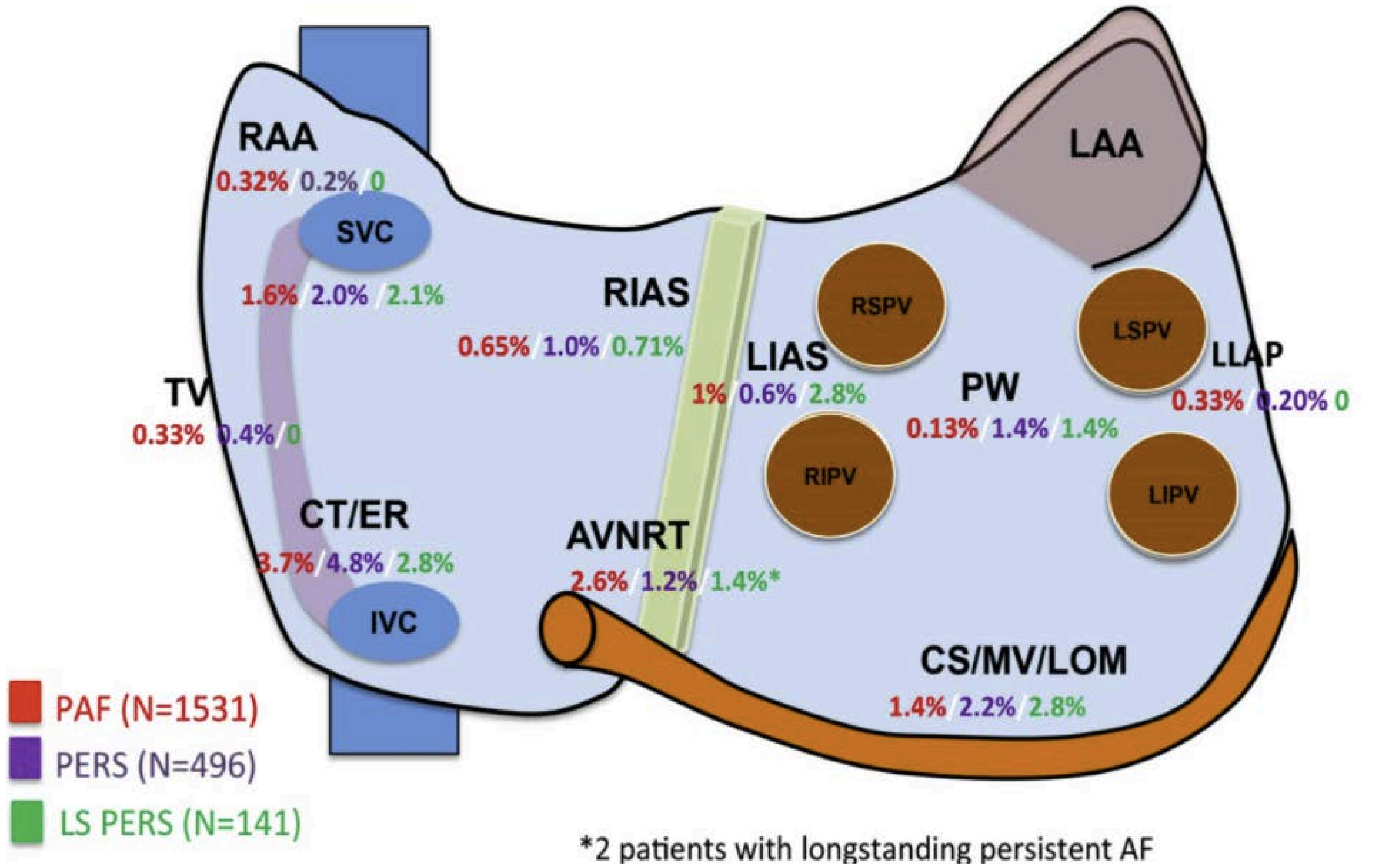
Figure 2. Angiogram of a Left Inferior Pulmonary Vein Depicting the Source and Exit of Ectopic Activity.

The electrogram showed characteristic changes in timing depending on the position of the recording catheter in the specific pulmonary vein. With an increasingly distal catheter position (toward the source), the spike was recorded progressively later during sinus rhythm (left-hand panel, arrows) and correspondingly earlier during ectopic activity (arrowhead). Conversely, in a proximal position at its exit into the left atrium (right-hand panel), the spike was not as delayed during sinus rhythm (arrows) nor as precocious during ectopic activity (arrowhead). The application of radio-frequency energy at the source of ectopic activity eliminated the local spike during sinus rhythm and ectopic beats and atrial fibrillation on a short-term basis. The dotted lines mark the onset of the ectopic P wave, and 1–2 and 3–4 are bipolar recordings from the distal and proximal poles of the mapping catheter. A indicates near-field atrial activity. The radiograph (center panel) shows the position of electrographic recordings inside the pulmonary vein at the source and exit.

Other AF triggers outside the pulmonary veins

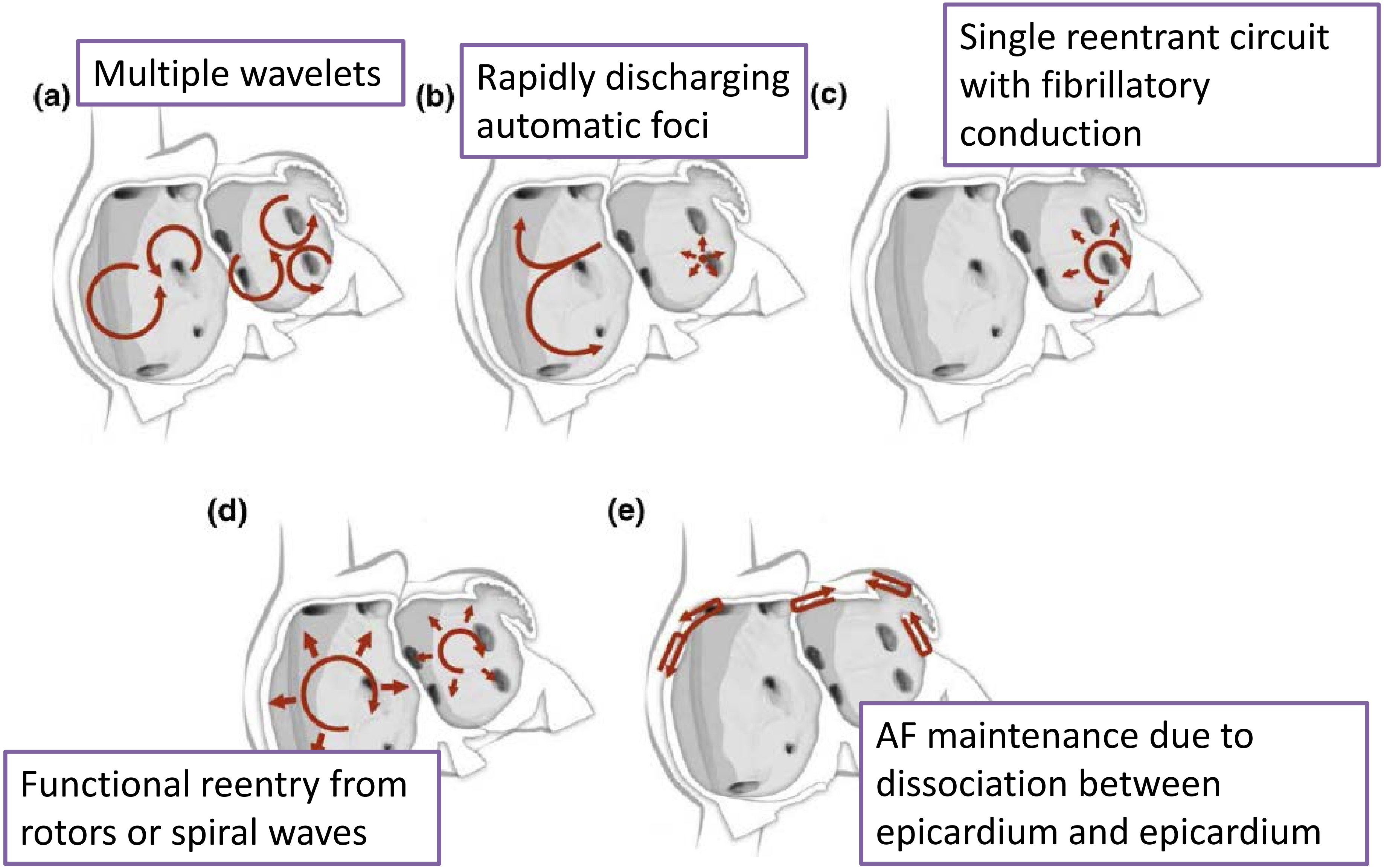
RAA=right atrial appendage
TV=tricuspid valve
CT=crista terminalis
ER=eustacian ridge
SVC=superior vena cava
AVNRT=AV node reentrant tachycardia

LAA=left atrial appendage
MV=mitral valve
CS=coronary sinus
LOM=ligament of Marshall
LLAP=left lateral accessory pathway
PW=posterior wall



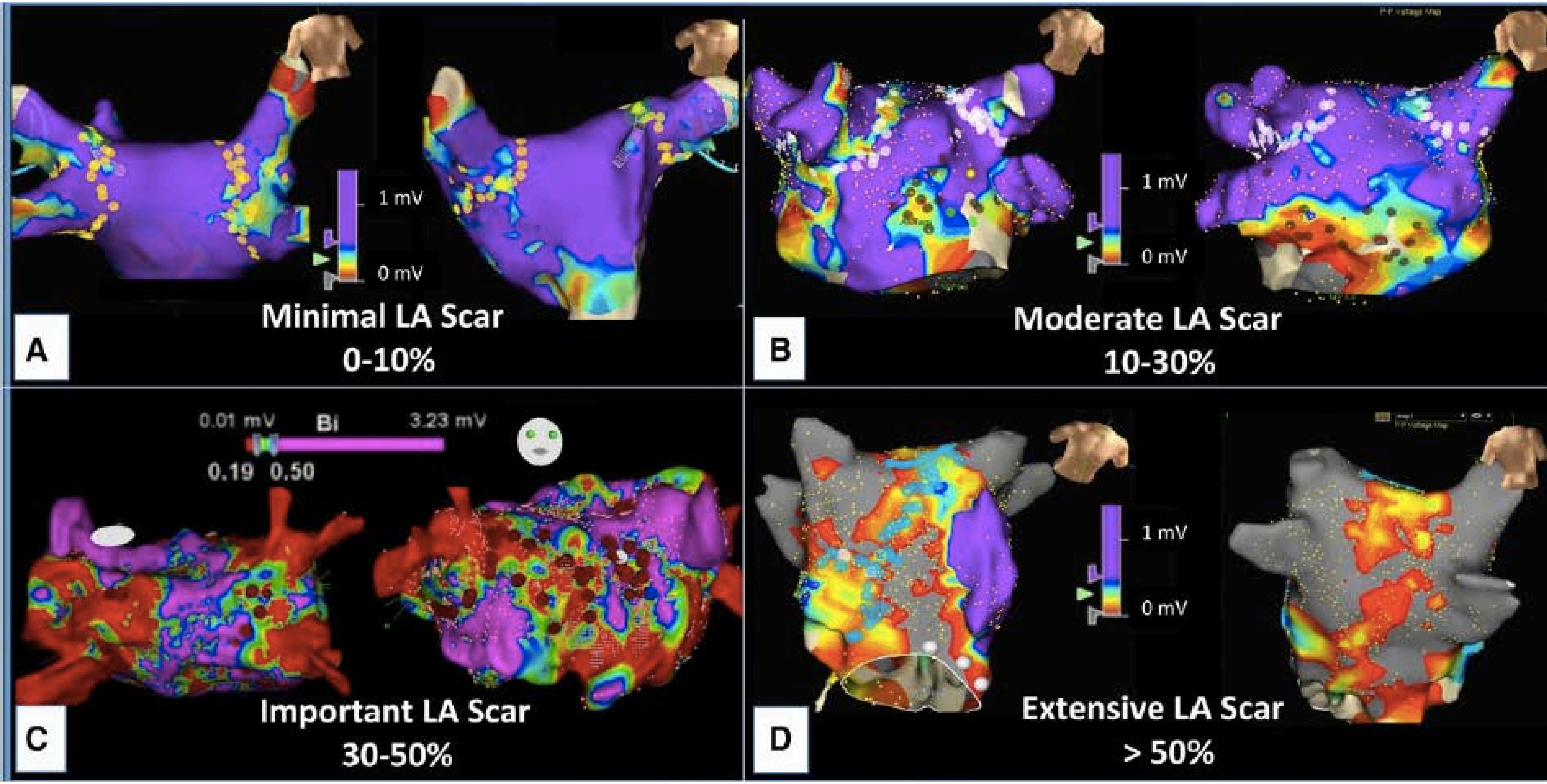
Santangeli et al. Heart rhythm July 2017. 14;7. 1087

Hypotheses regarding mechanisms of atrial fibrillation



2017 HRS expert consensus statement on catheter and surgical ablation of atrial fibrillation. J Interv Card Electrophysiol (2017) 50:1-55

Atrial Fibrosis: AF is a progressive disease

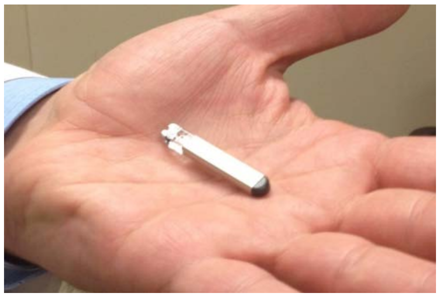


-Electroanatomic mapping allows direct contact with endocardial tissue and can reveal presence of scar (low voltage areas), not detectable by any imaging method
-In contrast to paroxysmal AF, an important proportion of patients with persistent AF have regional increase in atrial fibrosis that is associated with greater frequency of AF

Arentz, Circulation Arrhythmia and Electrophysiology. 2016.

Patient Populations: Who is at Risk for AF?

REVEAL-AF study: 385 patients with no history of AF ($CHADS_2$ score of ≥ 3 or 2 with 1 extra risk factor) underwent LINQ monitor implant



29% detection rate of AF lasting ≥ 6 min. AF would have gone undetected in most pts had monitoring been limited to 30 days. AF incidence was higher in older and more obese patients

Table 2. Predictive Value of Baseline Characteristics for Atrial Fibrillation Onset

Characteristic	Hazard Ratio (95% CI)[a]	P Value
Age, y	1.08 (1.05-1.11)	<.001
Body mass index	1.04 (1.01-1.08)	.02
Male sex	1.11 (0.77-1.61)	.56
Diabetes	1.09 (0.74-1.59)	.66
Heart failure	1.08 (0.69-1.69)	.73
Hypertension	1.23 (0.58-2.60)	.58
Renal impairment	0.92 (0.64-1.32)	.65
Chronic obstructive pulmonary disease	0.73 (0.45-1.20)	.22
Stroke	0.86 (0.54-1.38)	.53
Coronary artery disease	0.78 (0.53-1.15)	.21
Sleep apnea	0.72 (0.45-1.17)	.19
Family history of atrial fibrillation	1.97 (0.76-5.14)	.16
Vascular disease	0.89 (0.56-1.43)	.63

[a] Obtained from the Cox proportional hazards model.

Reiffel et al. *JAMA Cardiol*. 2017;2(10):1120-1127

Special Patient Populations Undergoing AF Ablation

CASTLE-AF: 398 heart failure pts with ICDs were enrolled
Randomized to medical therapy vs ablation

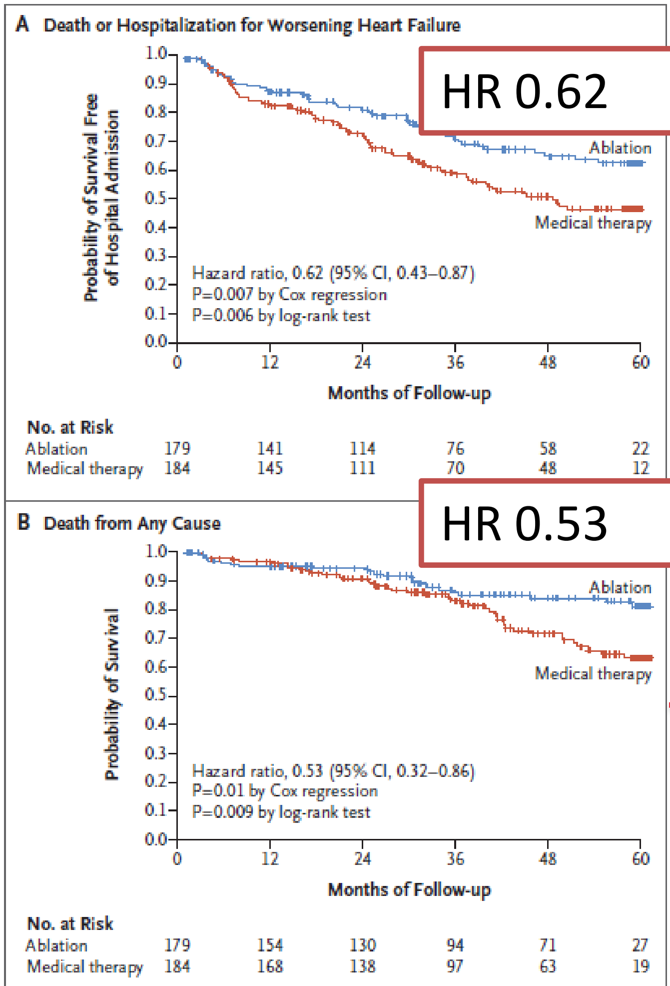


Table 1. Characteristics of the Patients at Baseline.*

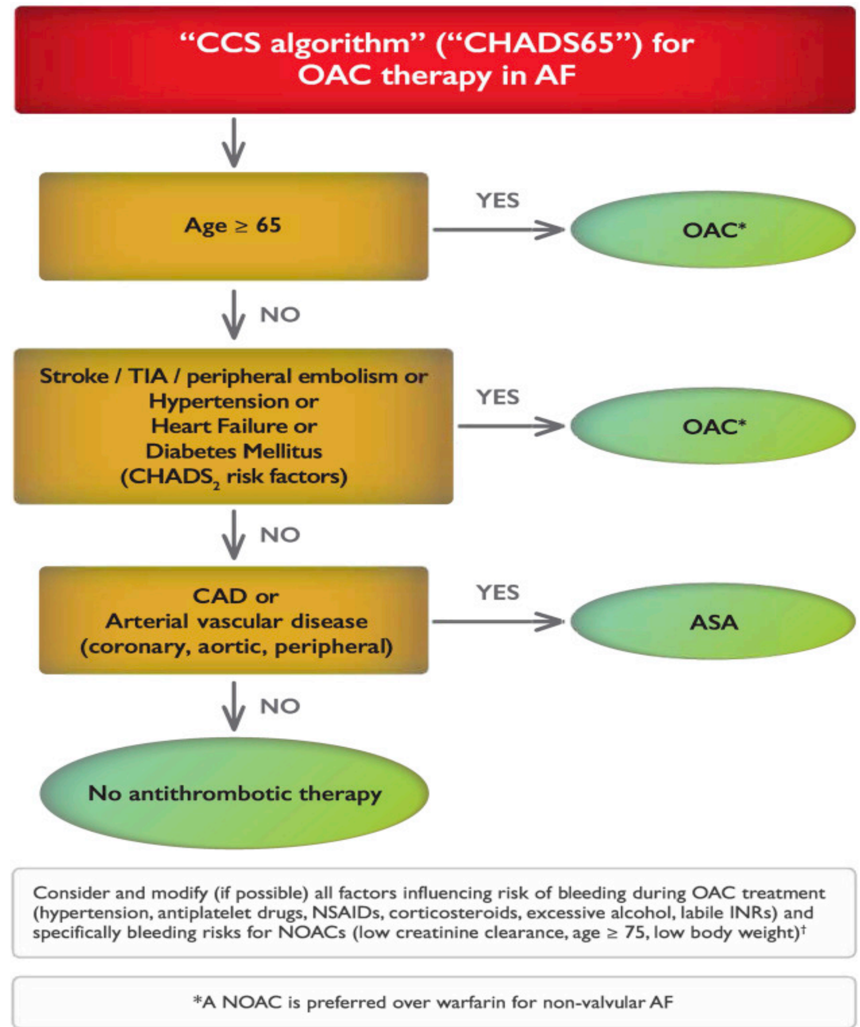
Characteristic	Treatment Type: Ablation (N=179)	Treatment Type: Medical Therapy (N=184)
Age — yr		
Median	64	64
Range	56–71	56–73.5
Male sex — no. (%)	156 (87)	155 (84)
Body-mass index†		
Median	29.0	29.1
Range	25.9–32.2	25.9–32.3
New York Heart Association class — no./total no. (%)		
I	20/174 (11)	19/179 (11)
II	101/174 (58)	109/179 (61)
III	50/174 (29)	49/179 (27)
IV	3/174 (2)	2/179 (1)
Cause of heart failure — no. (%)‡		
Ischemic	72 (40)	96 (52)
Nonischemic	107 (60)	88 (48)
Type of atrial fibrillation — no. (%)		
Paroxysmal	54 (30)	64 (35)
Persistent	125 (70)	120 (65)
Long-standing persistent (duration >1 year)	51 (28)	55 (30)
Left atrial diameter		
Total no. of patients evaluated	162	172
Median — mm	48.0	49.5
Interquartile range — mm	45.0–54.0	5.0–55.0
Left ventricular ejection fraction		
Total no. of patients evaluated	164	172
Median — %	32.5	31.5
Interquartile range — %	25.0–38.0	27.0–37.0
CRT-D implanted — no. (%)§	48 (27)	52 (28)
ICD implanted — no. (%)§	131 (73)	132 (72)
D		7)
Si		)
Indica		
Pr		9)
Se		1)
Histo		
Fa		(47)
U		(14)
N		(40)

Significant reduction in composite outcome of death and hospitalization for heart failure and in all-cause mortality alone

4 Pillars of AF Management

1. Risk Factor Modification
2. Rate control: resting HR < 100bpm
3. Anticoagulation
4. Rhythm Control

-Flecainide/propafenone: class Ic (Na channel blockers)
-Sotalol: class III (K+ ch blocker + BB)
-Amiodarone: class III – reserved for pts with significant HF/systolic dysf’n EF <35%
-Dronedarone: class III



2016 Focused Update of the Canadian Cardiovascular Society Guidelines for the Management of Atrial Fibrillation. CJC 32 (2016) 1170-1185

Risk of Thromboembolism

Table 2. Event rates (95% CI) and hazard ratios for hospital admission and death due to thromboembolism according to components of CHA2DS2-VASc score at 5-years follow-up

Risk Factor	Annual Risk (95% CI)	Hazard Ratio (95% CI)	*P*
CHA_2DS_2-VASc = 0	0.69 (0.59-0.81)	1.0	
CHA_2DS_2-VASc = 1			
- **Heart failure**	2.35 (1.30-4.24)	3.39 (1.84-6.26)	< 0.0001
- **Diabetes mellitus**	2.28 (1.42-3.66)	3.31 (2.00-5.46)	< 0.0001
- **Hypertension**	1.60 (1.26-2.01)	2.32 (1.75-3.07)	< 0.0001
- **Age 65-74**	2.13 (1.85-2.46)	3.07 (2.48-3.80)	< 0.0001
- **Vascular disease**	1.40 (0.91-2.15)	2.04 (1.29-3.22)	0.002
- **Female sex**	0.86 (0.70-1.06)	1.25 (0.96-1.63)	0.10

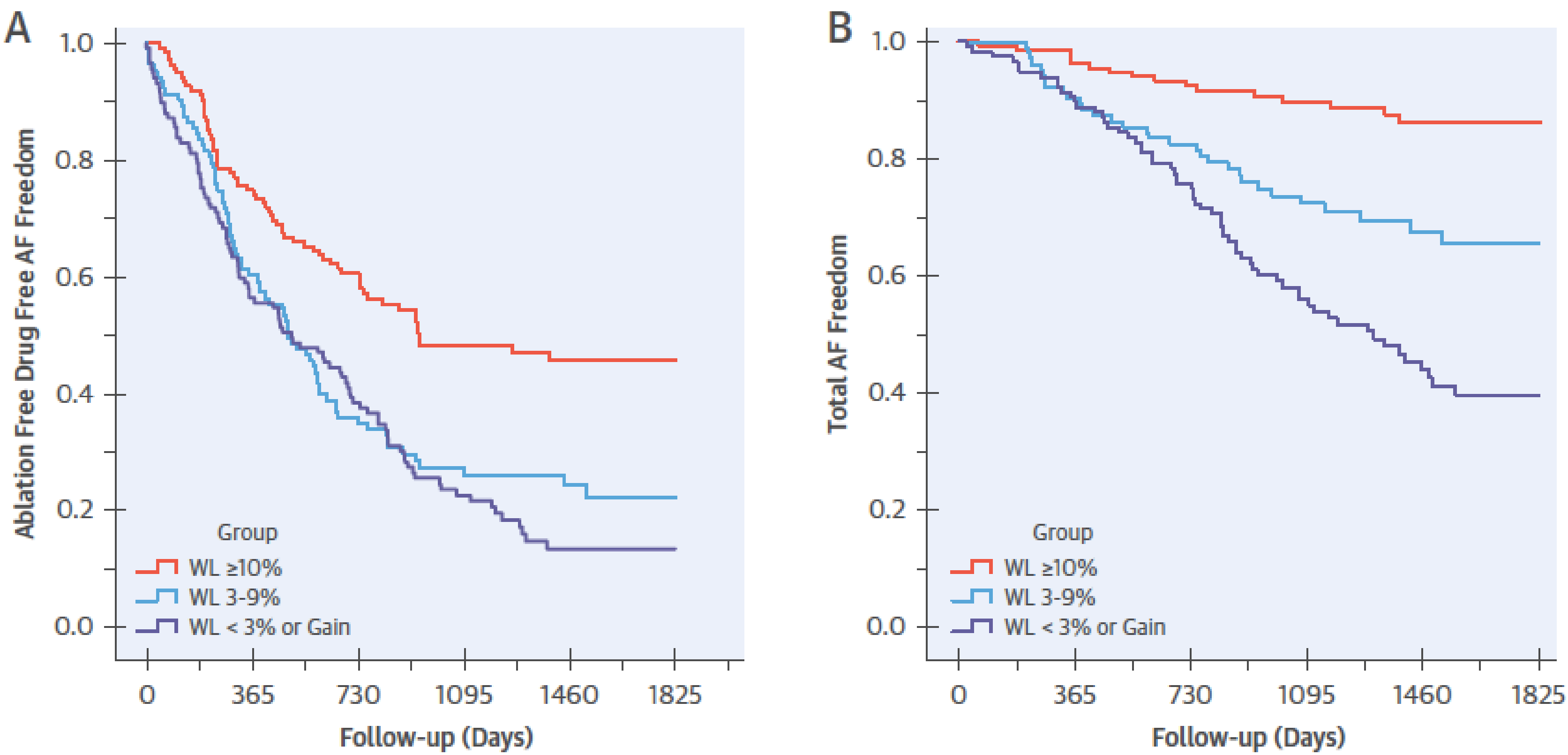
CHA_2DS_2-VASc, Congestive Heart Failure, Hypertension, Age (≥75 years), Diabetes, Stroke/Transient Ischemic Attack, Vascular Disease, Age (65-74 years), Sex (Female); CI, confidence interval. Modified from Olesen et al.[22] with permission from BMJ Publishing Group Ltd.

Oral anticoagulant therapy is justified when the annual risk of stroke exceeds 1.5%
OAC for patients age ≥ 65 (even without other criteria)
ASA for patients with vascular disease (? questions remain)

2016 Focused Update of the Canadian Cardiovascular Society Guidelines for the Management of Atrial Fibrillation. CJC 32 (2016) 1170-1185

Modifiable Risk Factors: Weight loss

FIGURE 2 **Atrial Fibrillation Freedom Outcome According to Group**

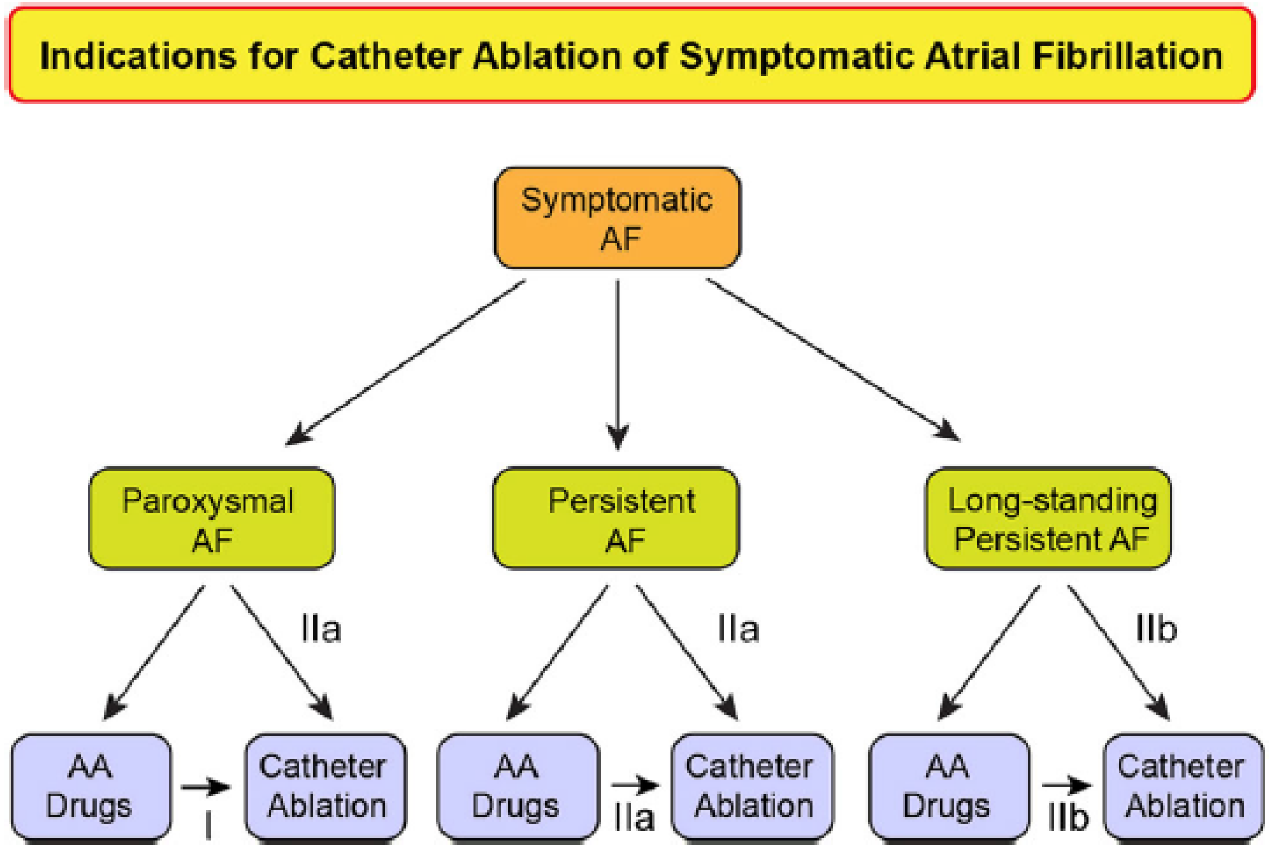


Time (Days)	0	365	730	1095	1460	1825	0	365	730	1095	1460	1825
≥10 WL	135	101	72	42	31	18	135	130	114	86	67	36
3-9% WL	103	62	36	22	13	7	103	93	83	57	35	22
<3% WL or gain	117	66	44	22	11	9	117	105	85	53	32	22

(A) Kaplan-Meier curve for AF-free survival without the use of rhythm control strategies. **(B)** Kaplan-Meier curve for AF-free survival for total AF-free survival (multiple ablation procedures with and without drugs). Abbreviations as in Figure 1.

Pathak et al. Weight management and AF. JACC Vol. 65, No 20. 2015.

Indications for AF ablation



<u>Paroxysmal</u>:
AF terminates with intervention or spontaneously within 7 days of onset

<u>Persistent</u>:
AF that is sustained beyond 7 days but < 3 months

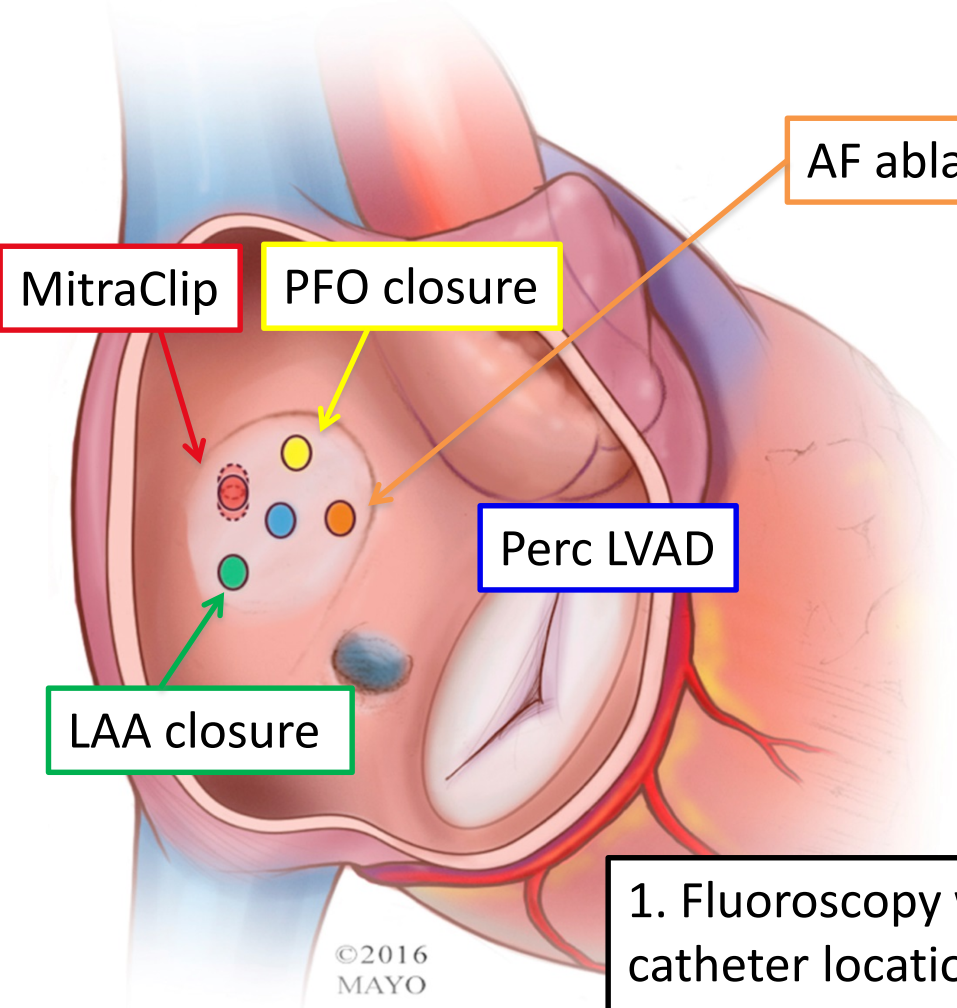
<u>Longstanding persistent:</u>
Continuous AF > 12 months duration

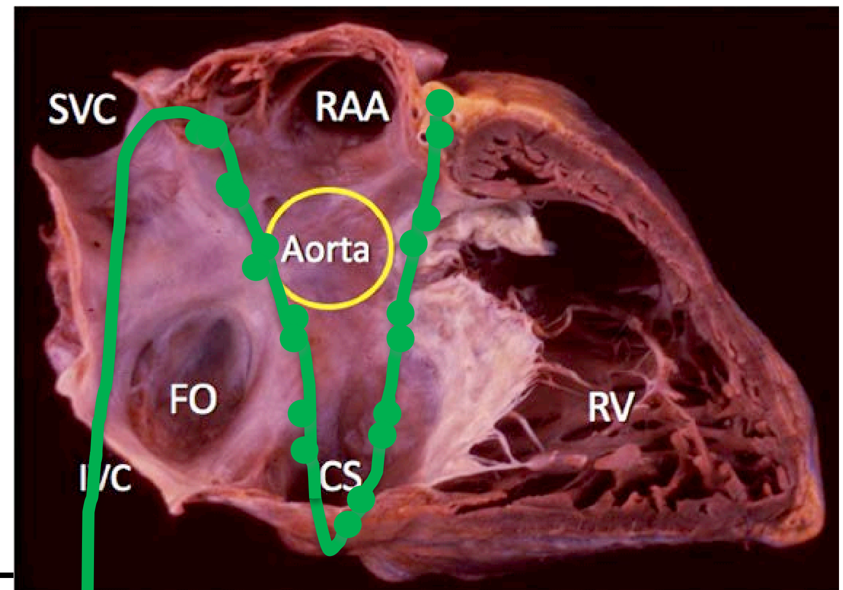
Success rate in maintaining sinus rhythm:
catheter ablation: 66-89%
antiarrhythmics: 9-58%

2017 HRS expert consensus statement on catheter and surgical ablation of atrial fibrillation. J Interv Card Electrophysiol (2017) 50:1-55
Contemporary AF managemenet. Andrade et al. CJC 33 (2017) 965-976

AF Ablation Procedure

Site-Specific Transseptal Puncture for Various Intracardiac Interventions

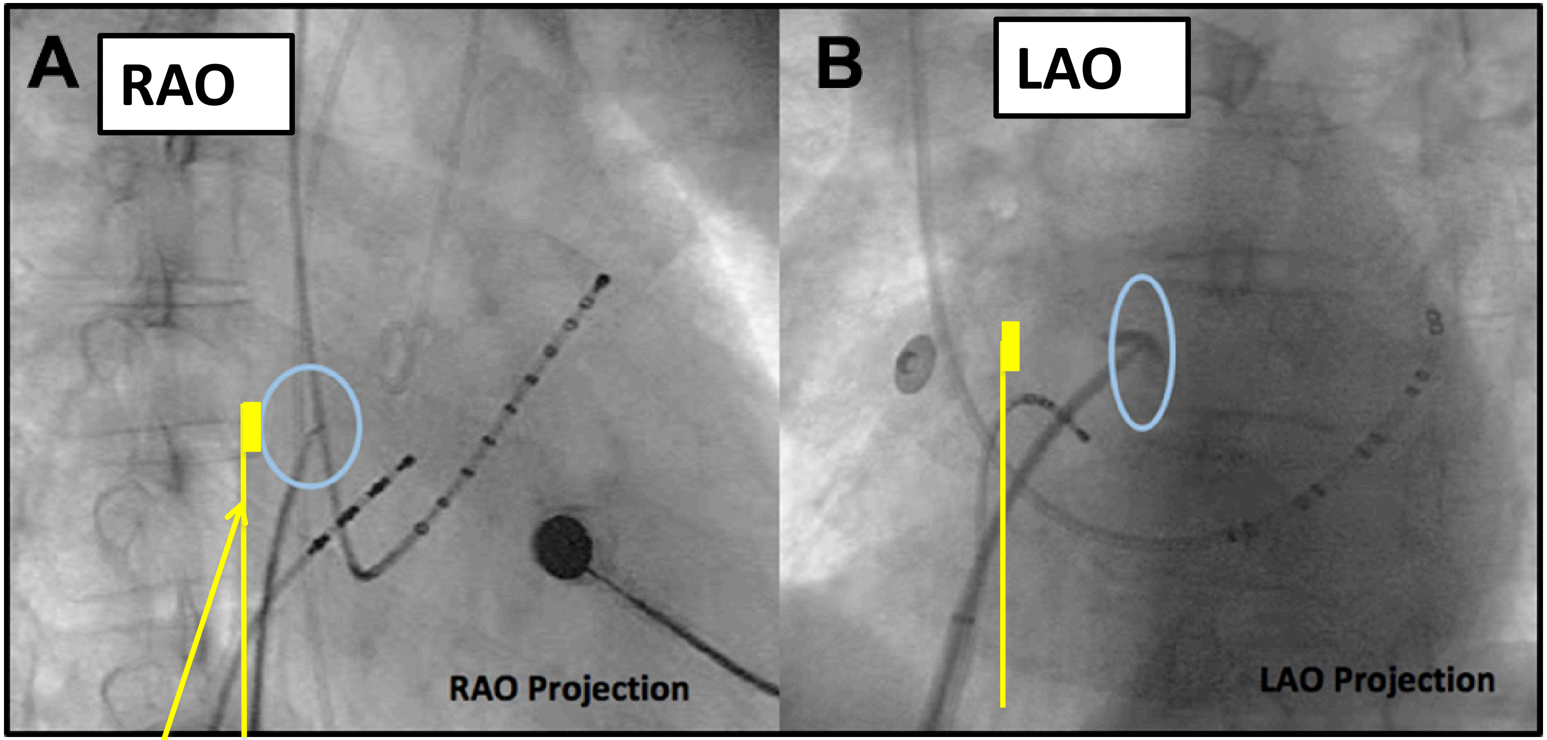


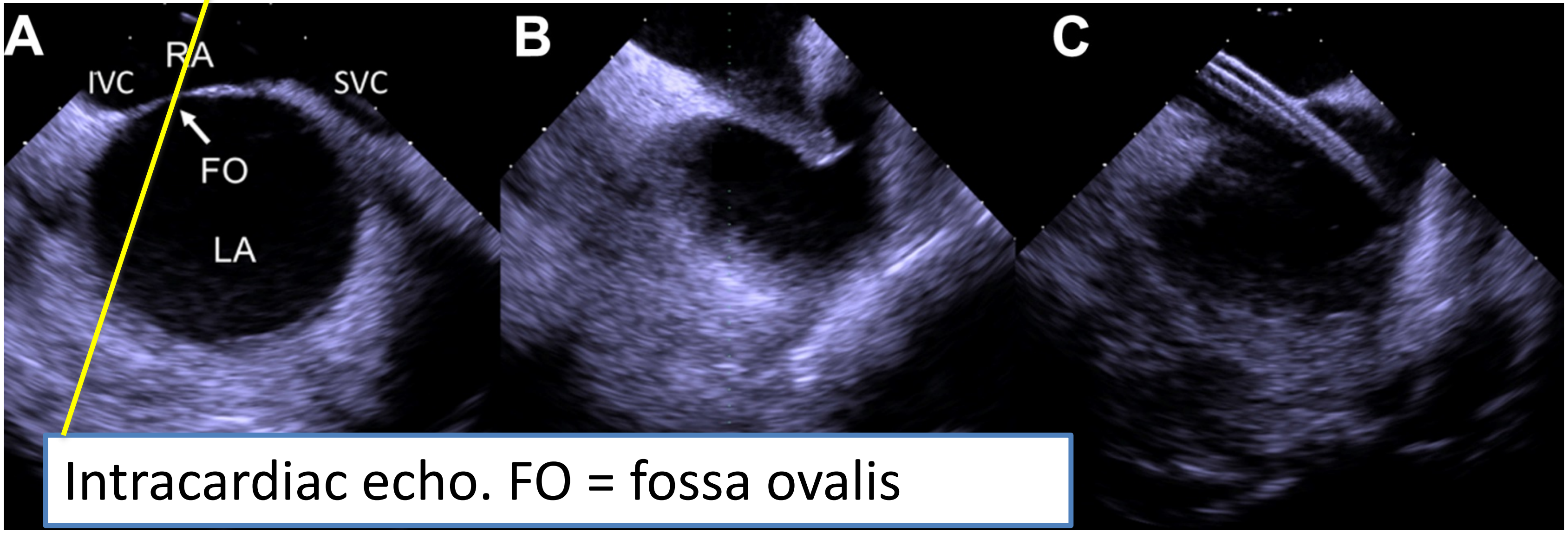


Coronary sinus catheter

1. Fluoroscopy with catheter location
2. Hemodynamics
3. TEE
4. Intracardiac echo (ICE)

Alkhouli et al. JACC Volume 9, 24 (2016), 2465-2480





Intracardiac echo. FO = fossa ovalis

Alkhouli et al. JACC Cardiovascular Interventions. Volume 9, 24 (2016), 2465-2480

Intraprocedural Anticoagulation

Typically 5-10,000 units of heparin is bolused before transseptal

ACT during procedure = target 300-350 seconds

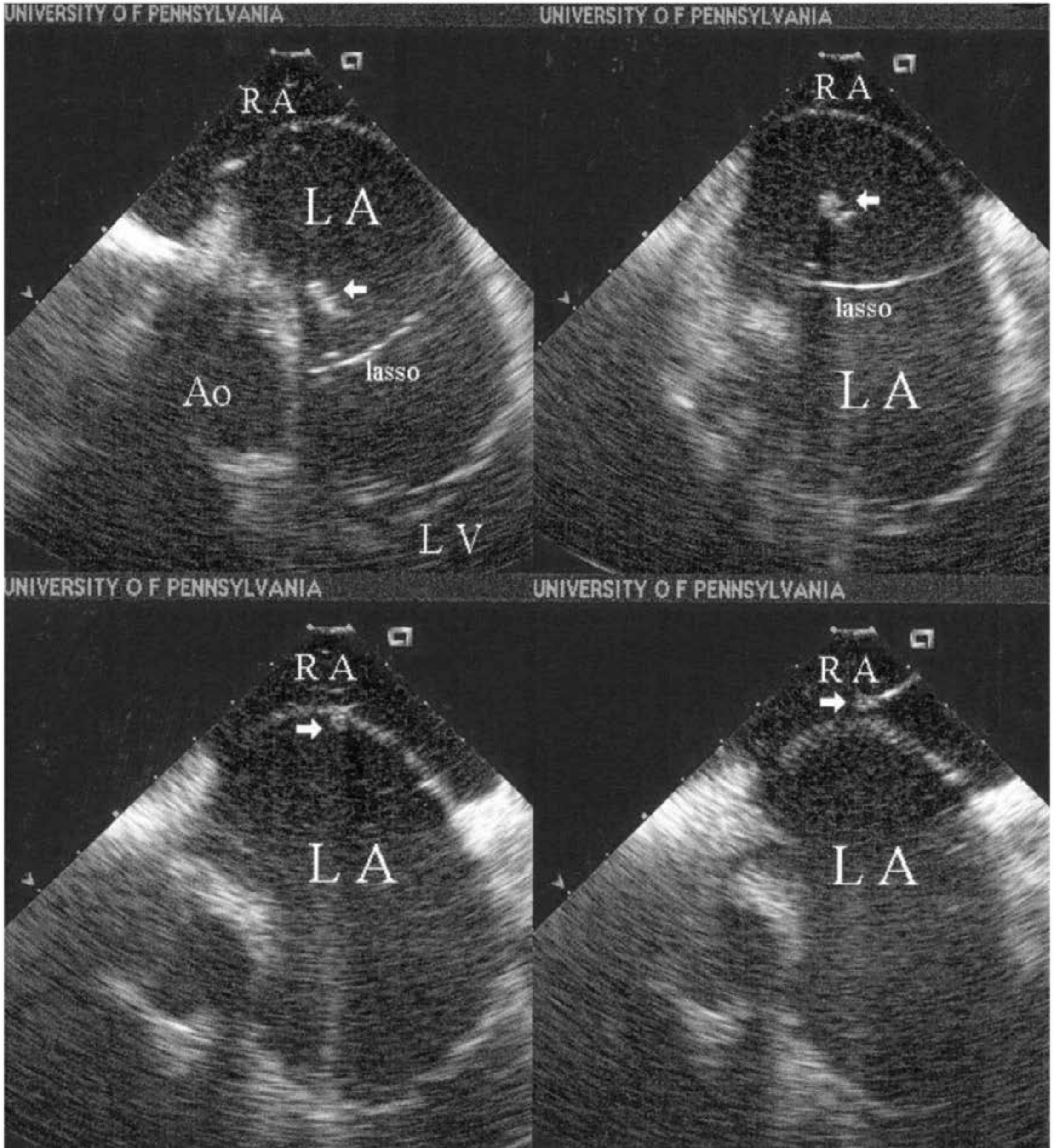
Heparin given in boluses or continuously IV

Protamine may be given at termination of procedure

Periprocedural OAC varies between operator.
-coumadin will typically not be stopped
-NOAC held for 1 or 2 doses, and heparin IV or a NOAC will be restarted 6 hours post sheath removal

Why is Anticoagulation Given Even Prior to Transseptal Puncture?

and restarted so soon post procedure?



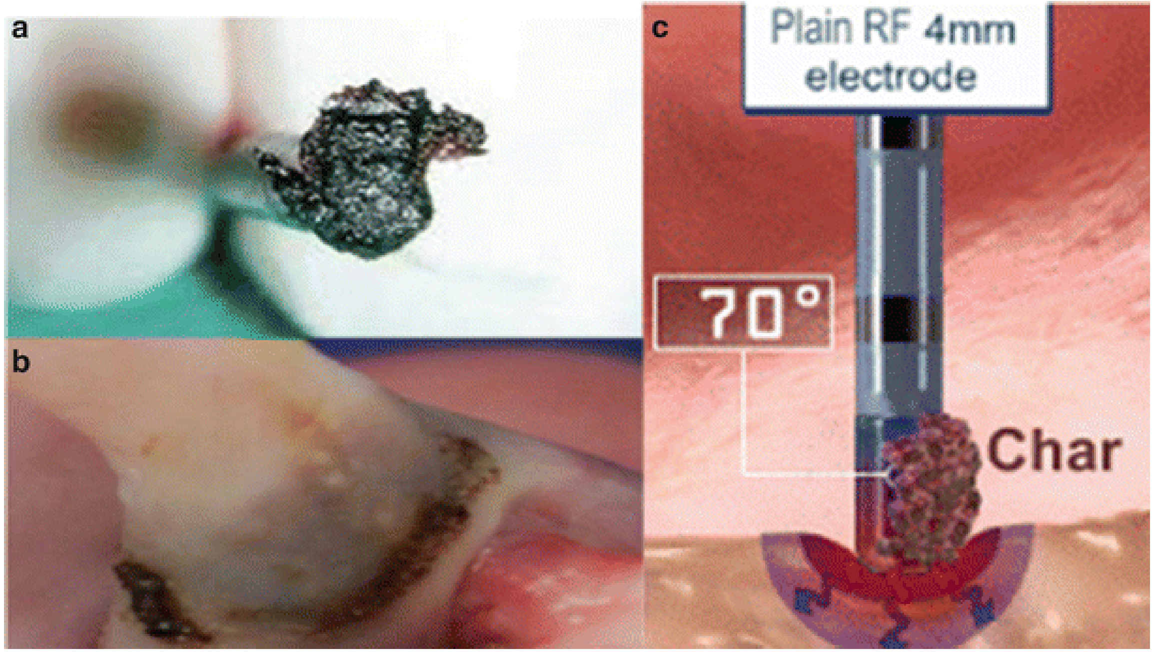
Intracardiac echo

A single linear mobile thrombus (8x4mm) attached at the sheath of the lasso catheter, pulling the sheath/lasso with thrombus back into the right atrium.

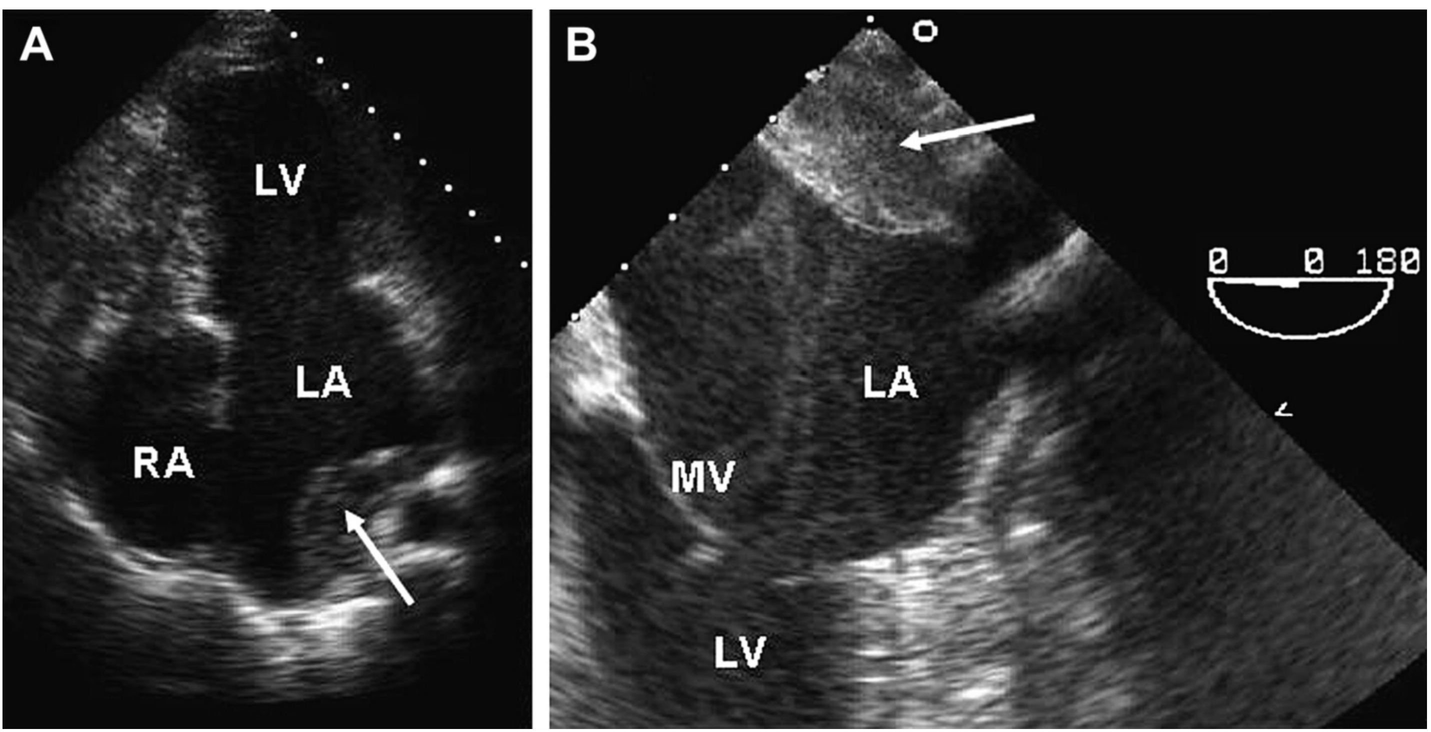
In 50%, LA thrombi occurred before RF energy application.

JACC

Jian-Fang Ren et al. JACC 2004;43:1861-1867



Char formation on the tip of the radiofrequency ablation catheter

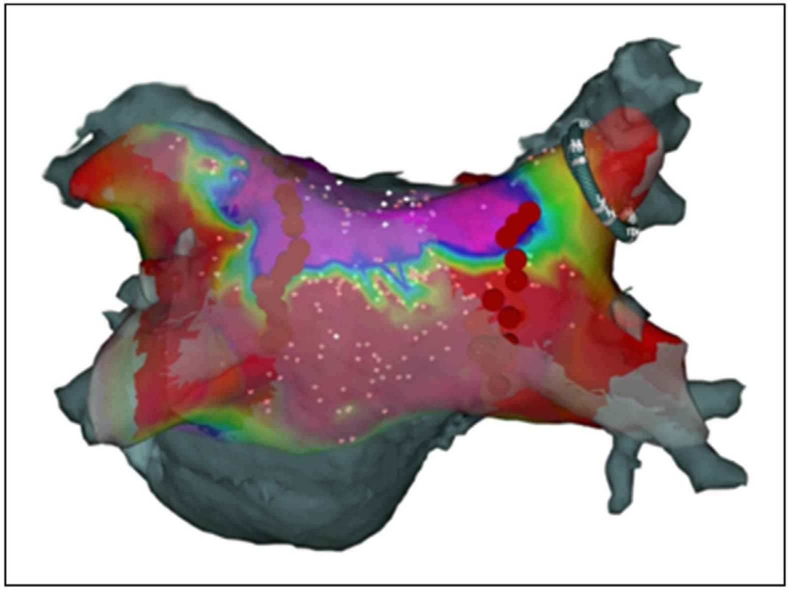


A. Transthoracic echo (apical 4-ch) demonstrating posterior LA thrombus 3 days post AF ablation
B. TEE

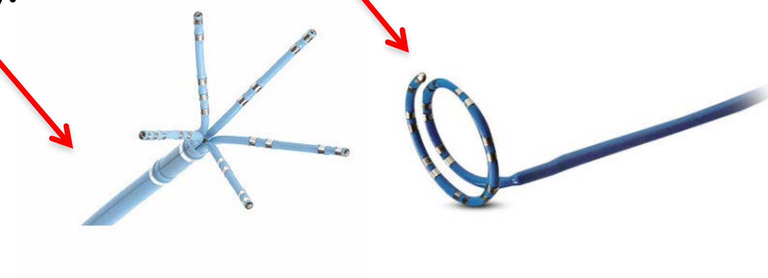
Thrombogenic milieu post abl with increased D-dimers and slow flow due to stunning

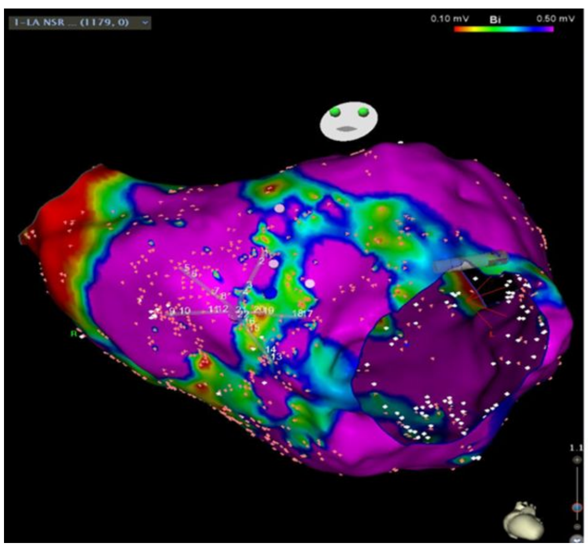
European Journal of Echocardiography, Volume 7, Issue 5, 1 October 2006, Pages 383–

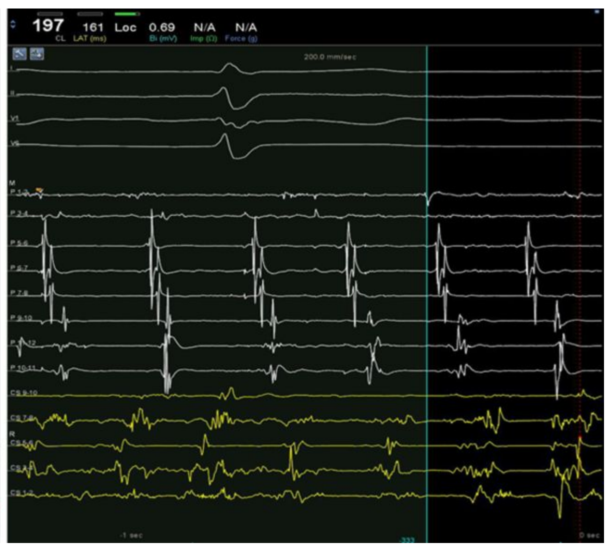
AF Ablation Procedure: Mapping

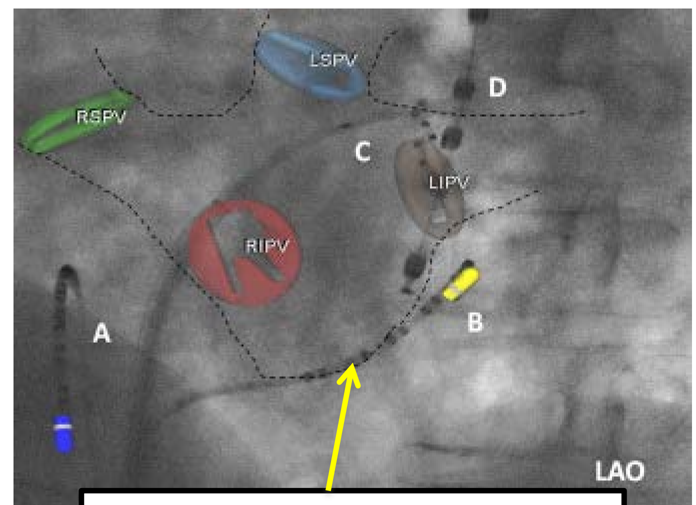


A left atrial electroanatomic map is created using a multielectrode mapping catheter (lasso or pentaray).



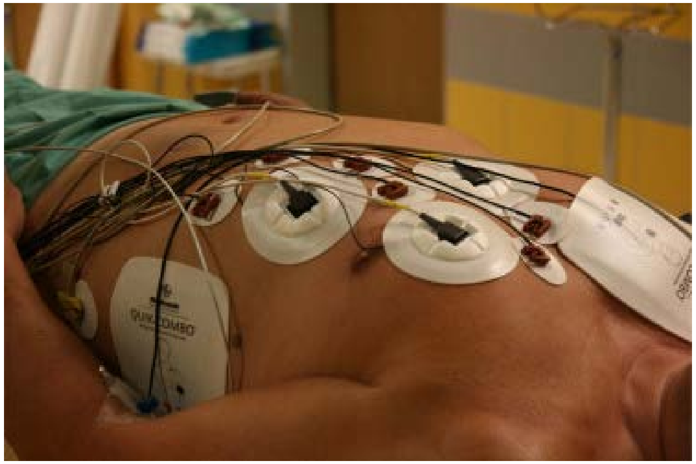


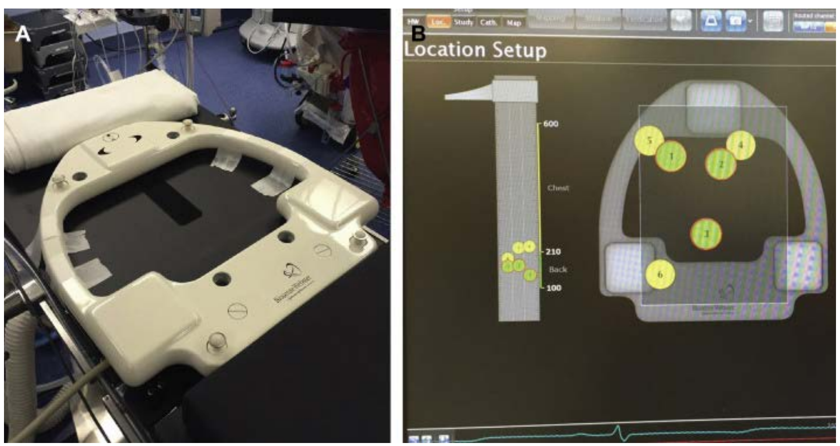




Coronary sinus catheter

AF Ablation Procedure: importance of being still



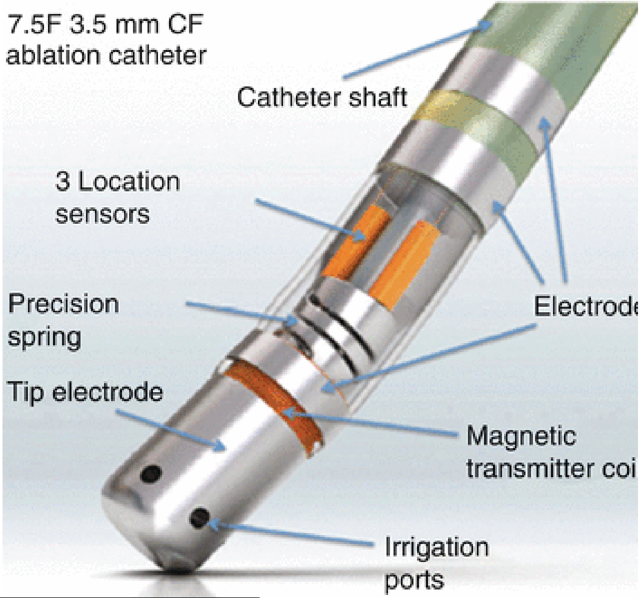


Once the mapping catheters have been introduced into the LA after transseptal, and the electroanatomic map has been started, it is essential that the patient does not move.

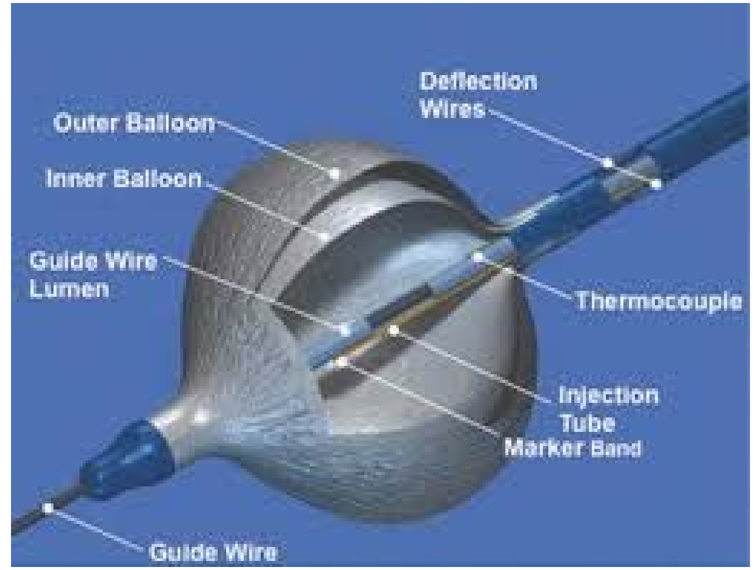
The mapping and ablation catheters have magnetic sensors that link to patches on the patient’s front and back with a reference under the table/at torso level.

Mapping is usually started 30 minutes after achieving femoral access… typically at times when induction paralytic agent starts to wear off.

Radiofrequency

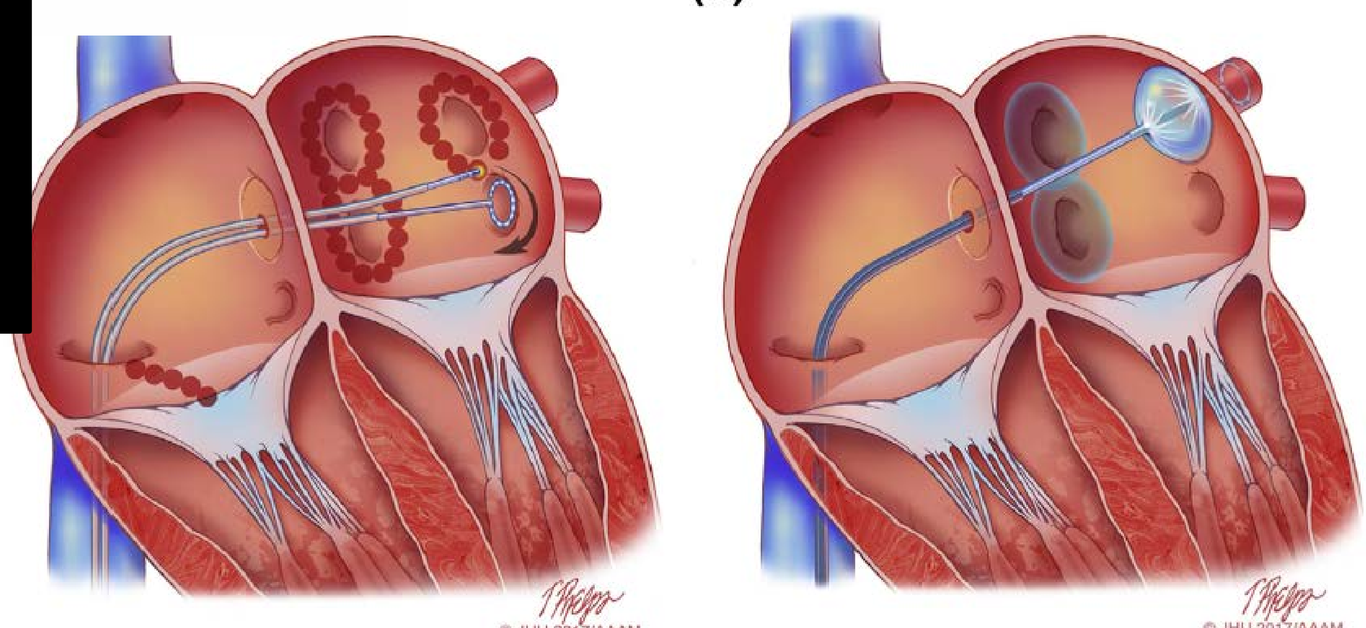


Cryoablation

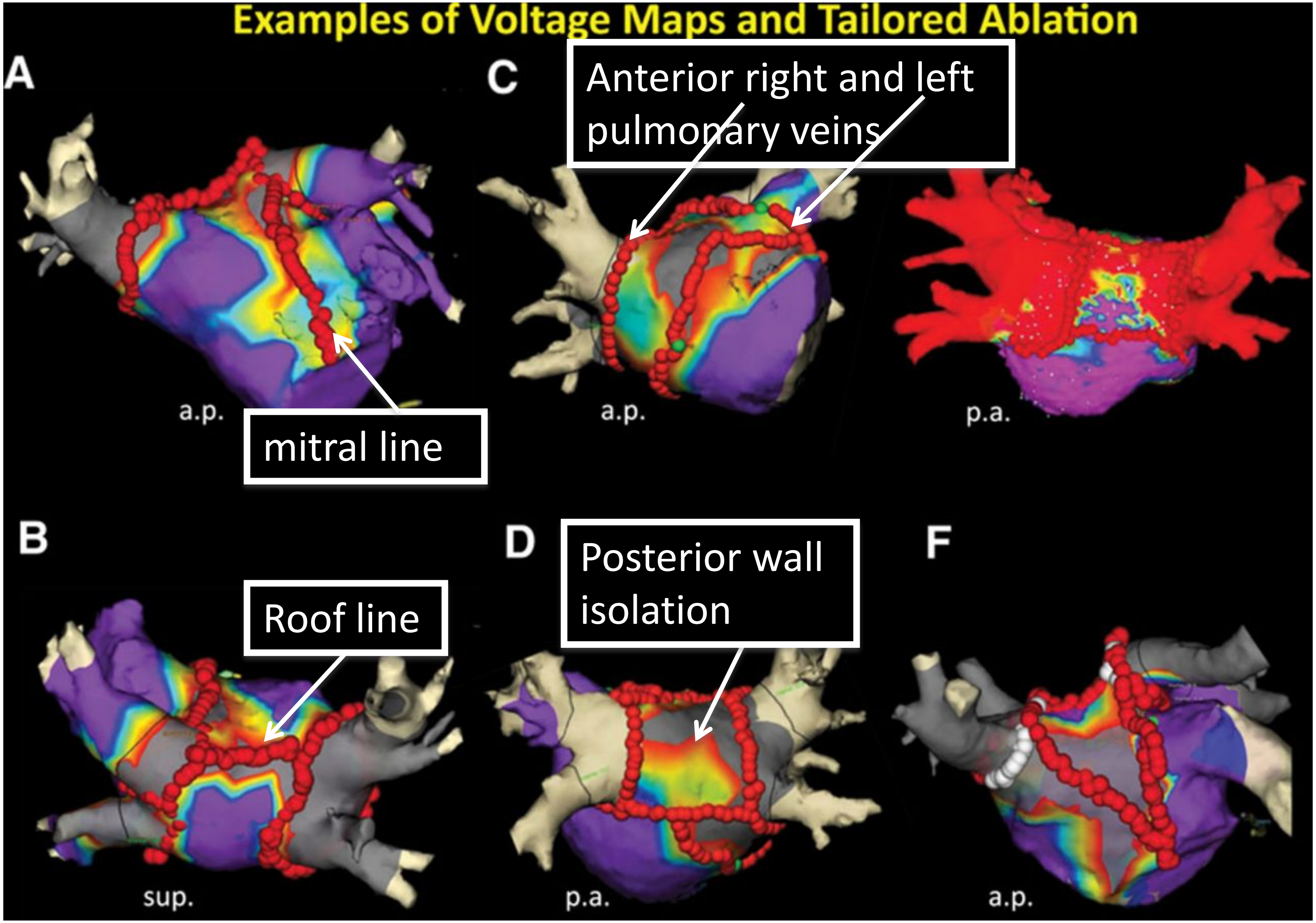


Contact Sensing RF catheters since 2014 = more efficacious lesions and safer procedure

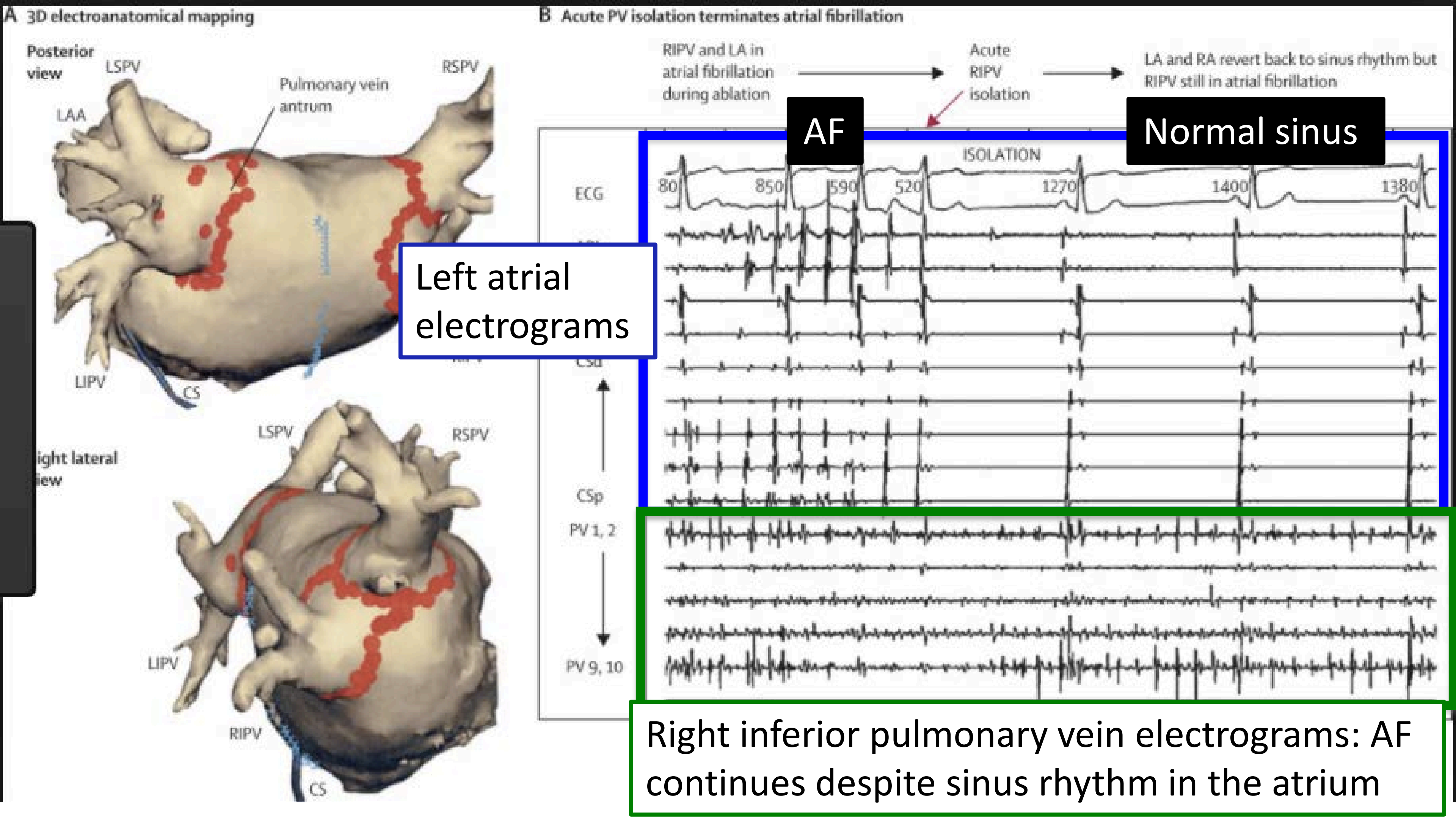
(b)



Radiofrequency Lesion Sets



Different lesion sets are created depending on location of scar, persistent vs paroxysmal AF, recurrent atrial tachycardias/flutters (red=scar, purple=healthy)


A 3D electroanatomical mapping
Posterior view
LSPV
RSPV
Pulmonary vein antrum
LAA
LIPV
CS
LSPV
RSPV
ight lateral
iew
LIPV
RIPV
CS
B Acute PV isolation terminates atrial fibrillation
RIPV and LA in atrial fibrillation during ablation
Acute RIPV isolation
LA and RA revert back to sinus rhythm but RIPV still in atrial fibrillation
AF
Normal sinus
ISOLATION
ECG
80
850
590
520
1270
1400
1380
CSd
CSp
PV 1, 2
PV 9, 10
Left atrial electrograms
Right inferior pulmonary vein electrograms: AF continues despite sinus rhythm in the atrium

Lesion Creation and Stability

Achieving durable pulmonary vein isolation **necessitates the creation of transmural, contiguous ablation lesions** encircling the veins

Requires the ablation catheter to maintain adequate contact with the endocardial surface to have **sufficient contact force and time-duration** to create a transmural lesion

3 things have been demonstrated to improve AF ablation outcomes:

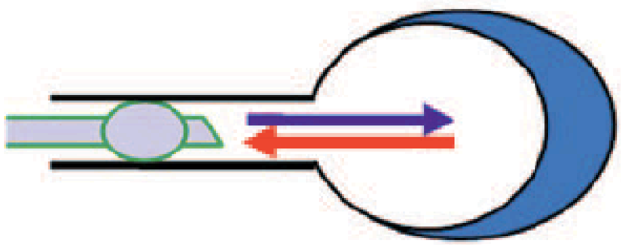
1. Incorporation of cardiac imaging (CT or MRI)
2. Use of a steerable sheath
3. ….

Hutchinson Heart Rhythm, Vol 10, No 3, March 2013

Anesthesia saves the day!

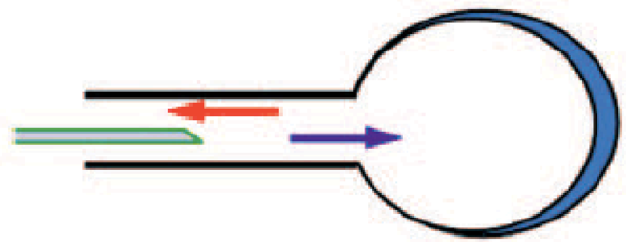
Jet Ventilation

Conventional Ventilation



- Gas flow is slow, bidirectional, and sequential.
- Dead space can be an issue.
- Airway sealing is mandatory.

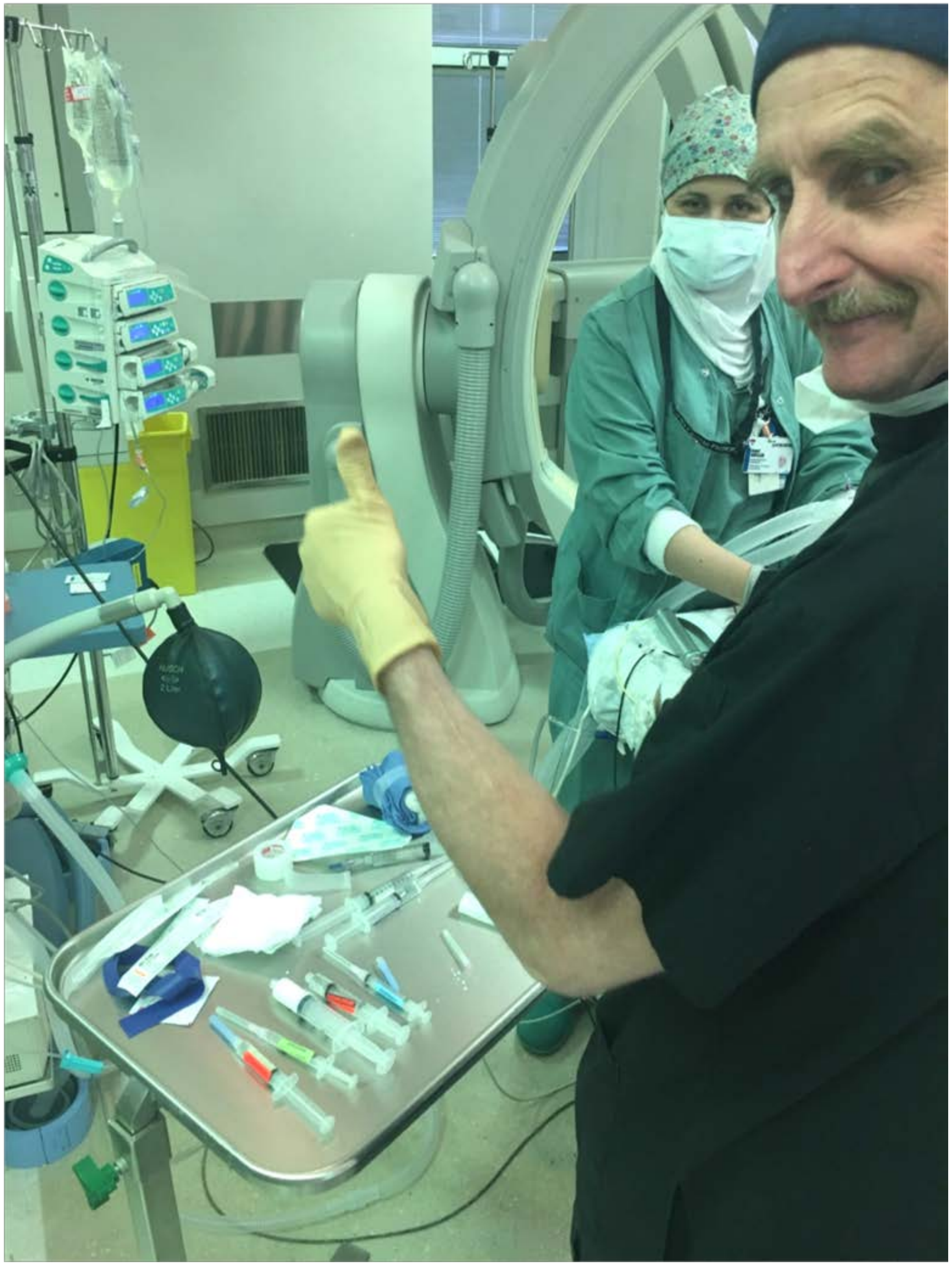
High Frequency Jet Ventilation



- High velocity insufflation of gas through a narrow nozzle into the open airway.
- Gas flow is fast, coaxial, partially simultaneous, inward only.
- Dead space is less relevant.
- Airway sealing contraindicated.

Thumbs up for Jet

-Dr. David Bracco



Efforts to enhance catheter stability improve atrial fibrillation ablation outcome

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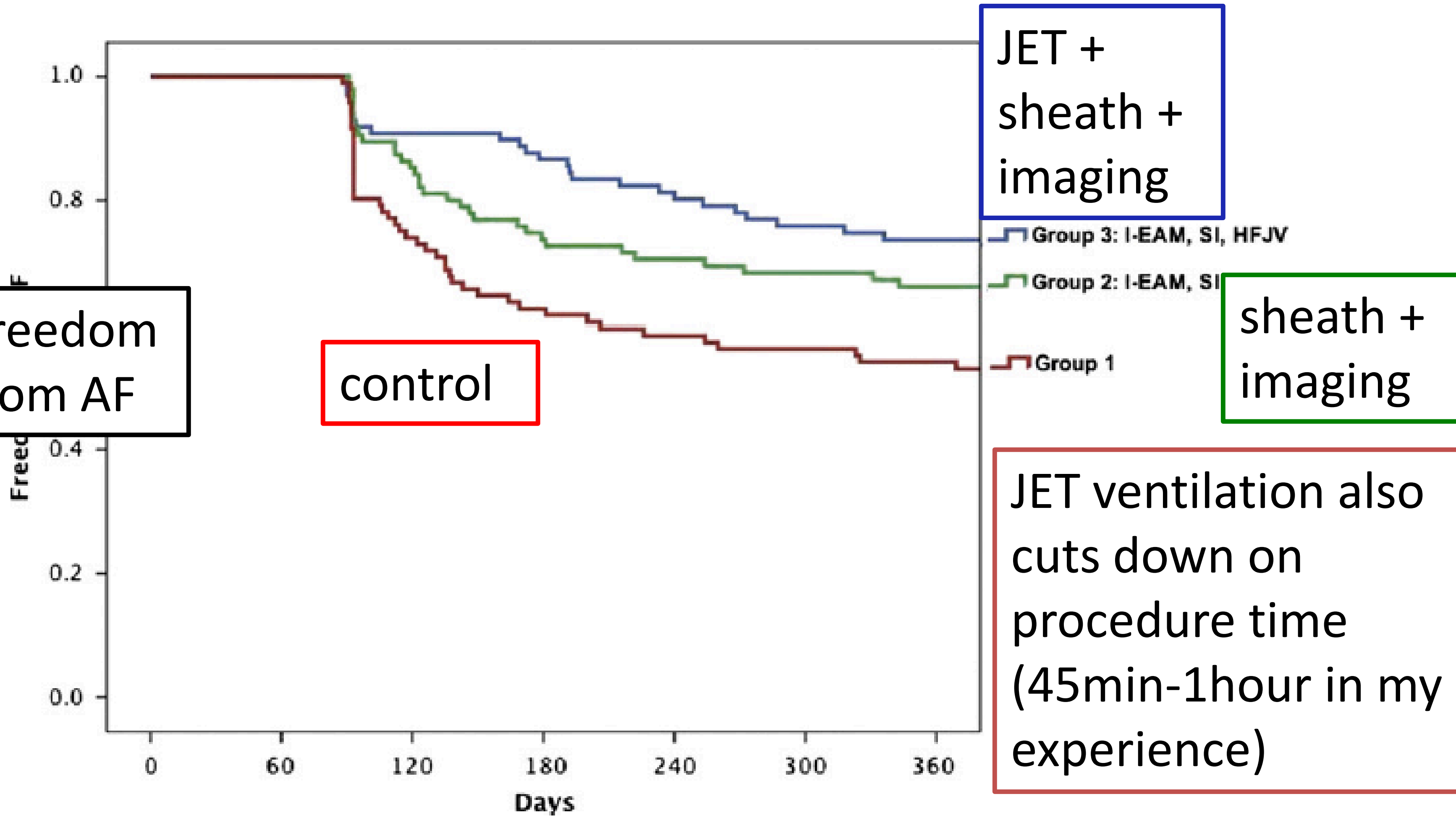
Table 1 Demographic data

	Control	sheath + imaging	JET + sheath + imaging	
	Group 1	Group 2 (I-EAM, SI)	Group 3 (I-EAM, SI, HFJV)	*P*
Sex: Man	66%	85%	75%	.008
Age (y)	57 ± 11	60 ± 10	59 ± 10	.03
BMI (kg/m^2)	28.5 ± 5.8	29.1 ± 4.8	31.2 ± 5.4	<.001
CAD	13%	16%	16%	.79
Hypertension	48%	64%	64%	.03
Diabetes mellitus	9%	10%	15%	.36
TIA/CVA	5%	3%	4%	.78
MR (≥moderate)	1%	4%	6%	.17
CM	6%	14%	15%	.09
CHF	2%	2%	6%	.19
OSA	12%	16%	20%	.30
LVEF (%)	62 ± 8	60 ± 10	59 ± 10	.22
LA diameter (cm)	4.2 ± 0.8	4.4 ± 0.7	4.5 ± 0.8	.002
AF type				.002
Paroxysmal	83	70	61	
Persistent	6	26	28	
Permanent	11	4	11	

AF = atrial fibrillation; BMI = body mass index; CAD = coronary artery disease; CHF = congestive heart failure; HFJV = high-frequency jet ventilation; I-EAM = 3-dimensional image integration; LA = left atrium; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; OSA = obstructive sleep apnea; SI = steerable introducer; TIA/CVA = transient ischemic attack/cerebrovascular accident.

300 patients undergoing AF ablation

Despite a sicker population, Jet ventilation added significant improvement to 1-year freedom from AF (52% vs 66% vs 74%)



JET ventilation also cuts down on procedure time (45min-1hour in my experience)

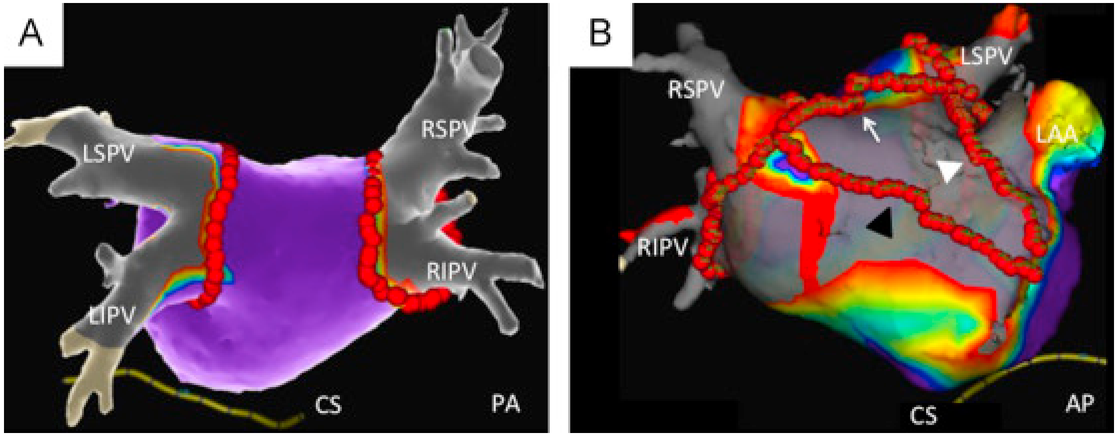
Hutchinson Heart Rhythm, Vol 10, No 3, March 2013

Apnea

EP may request apnea be performed **where difficulty with catheter stability is encountered:**

-typically left atrial roof, Marshall ridge (anterior to the left pulmonary veins), and at the anterior aspect of the right superior pulmonary vein

-apnea significantly improves catheter stability and lesion formation



During Ablation: Fluctuations in HR and BP

Adenosine is frequently given post pulmonary vein isolation to confirm isolation

Adenosine acts to hyperpolarize cells, thereby increasing conduction times and uncovering potentially dormant conduction/Afib

A brief period of bradycardia and heart block is observed with resultant brief period of hypotension.

Isoproterenol (non-selective β adrenoreceptor agonist) is given post ablation in attempts to induce atrial tachycardias or atrial fibrillation.

Hypotension may be caused with isoproterenol alone or when atrial pacing is performed at the same time

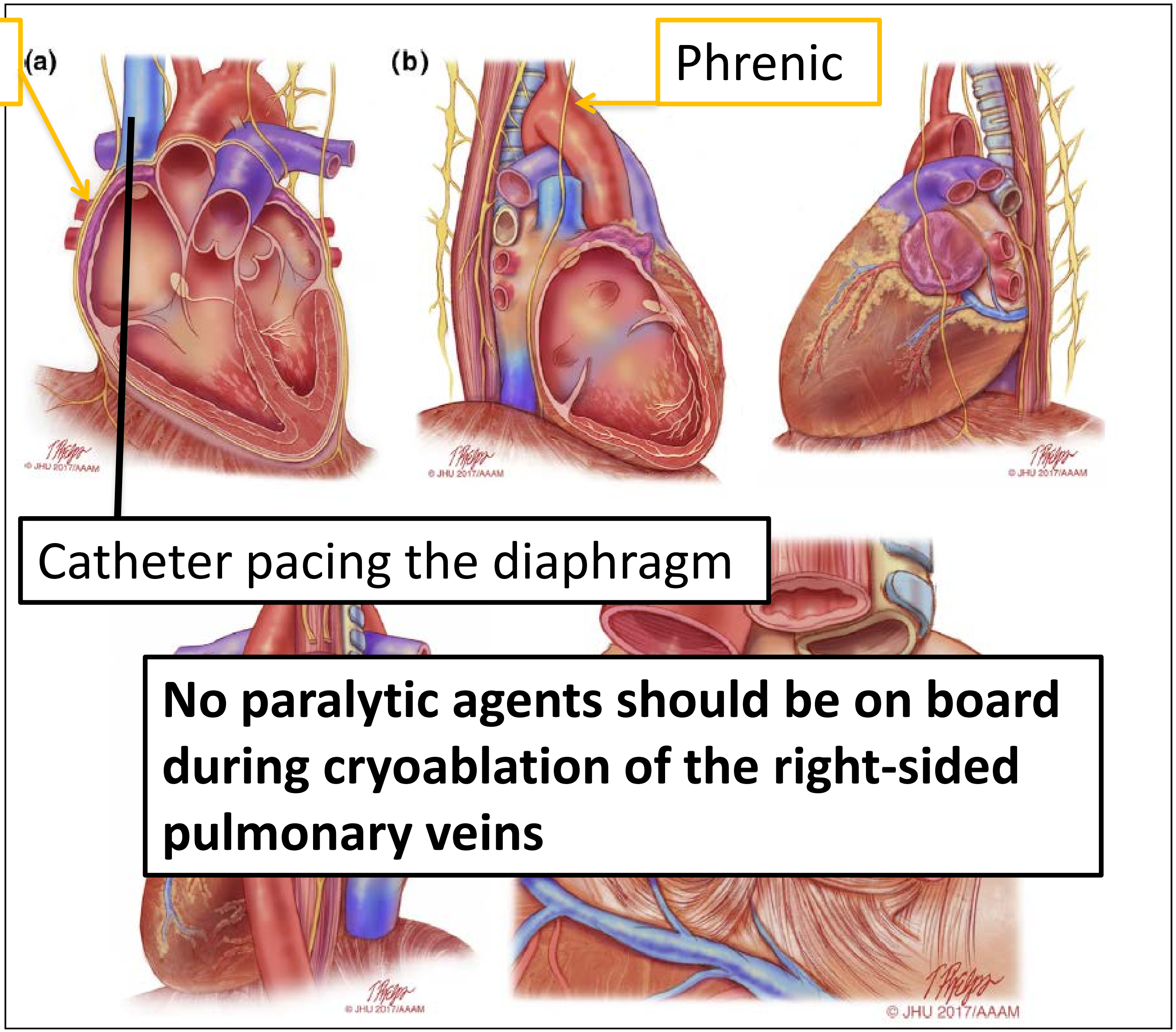
Potential Complications of AF Ablation

Signs and symptoms of complications within a month postablation	
Back pain	Musculoskeletal, retroperitoneal hematoma
Chest pain	Pericarditis, pericardial effusion, coronary stenosis (ablation related), pulmonary vein stenosis, musculoskeletal (after cardioversion), worsening reflux
Cough	Infectious process, bronchial irritation (mechanical, cryoballoon), pulmonary vein stenosis
Dysphagia	Esophageal irritation (related to transesophageal echocardiography), atrioesophageal fistula
Early satiety, nausea	Gastric denervation
Fever	Infectious process, pericarditis, atrioesophageal fistula
Fever, dysphagia, neurological symptoms	Atrial esophageal fistula
Groin pain at site of access	Pseudoaneurysm, AV fistula, hematoma
Headache	Migraine (related to anesthesia or transseptal access, hemorrhagic stroke), effect of general anesthetic
Hypotension	Pericardial effusion/tamponade, bleeding, sepsis, persistent vagal reaction
Hemoptysis	PV stenosis or occlusion, pneumonia
Neurological symptoms	Cerebral embolic event, atrial esophageal fistula
Shortness of breath	Volume overload, pneumonia, pulmonary vein stenosis, phrenic nerve injury
Signs and symptoms of complications more than a month postablation	
Fever, dysphagia, neurological symptoms	Atrial esophageal fistula
Persistent cough, atypical chest pain	Infectious process, pulmonary vein stenosis
Neurological symptoms	Cerebral embolic event, atrial esophageal fistula
Hemoptysis	PV stenosis or occlusion, pneumonia

Phrenic nerve paralysis:

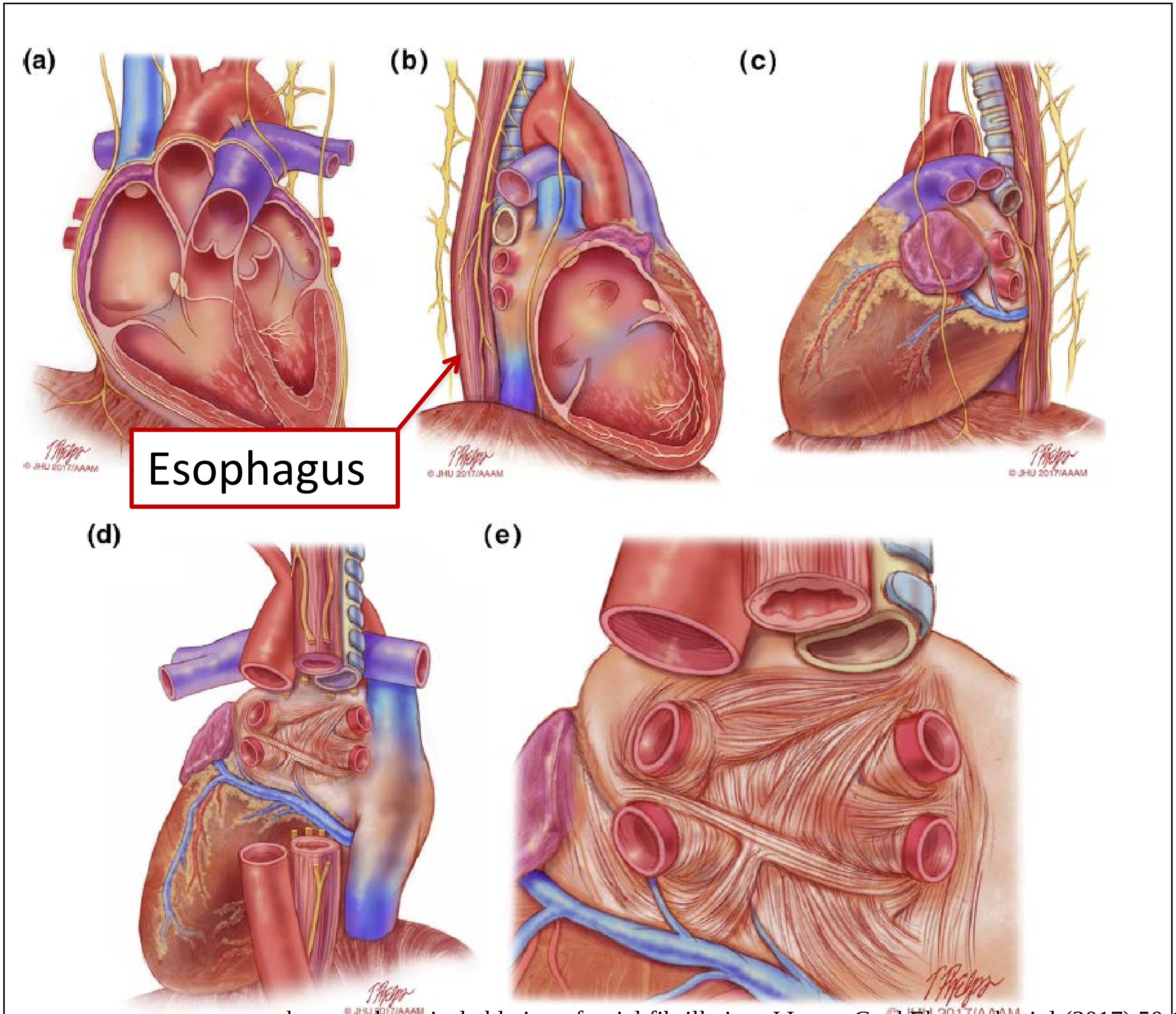
Typically resolves but may be permanent. Occurs during radiofrequency ablation at the right superior pulmonary vein and during cryoablation of the right-sided veins.

Diaphragmatic pacing is performed with a catheter at the SVC/RA



2017 HRS expert consensus statement on catheter and surgical ablation of atrial fibrillation. J Interv Card Electrophysiol (2017) 50:1-55

Esophageal Injury:



2017 HRS expert consensus statement on catheter and surgical ablation of atrial fibrillation. J Interv Card Electrophysiol (2017) 50:1-55

Not only does the esophagus have a variable position within the thoracic cavity, but can also vary temporally and based on patient position

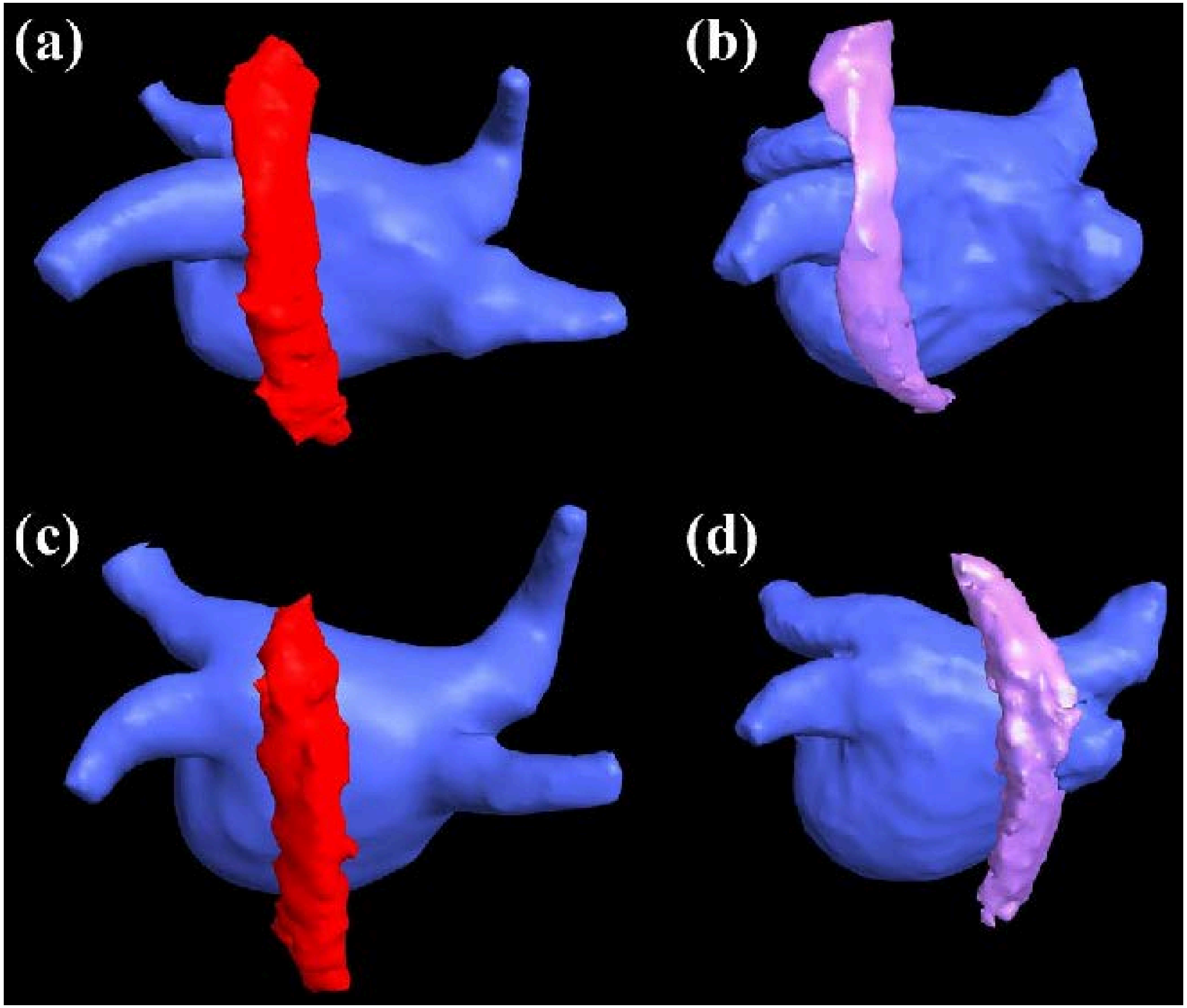
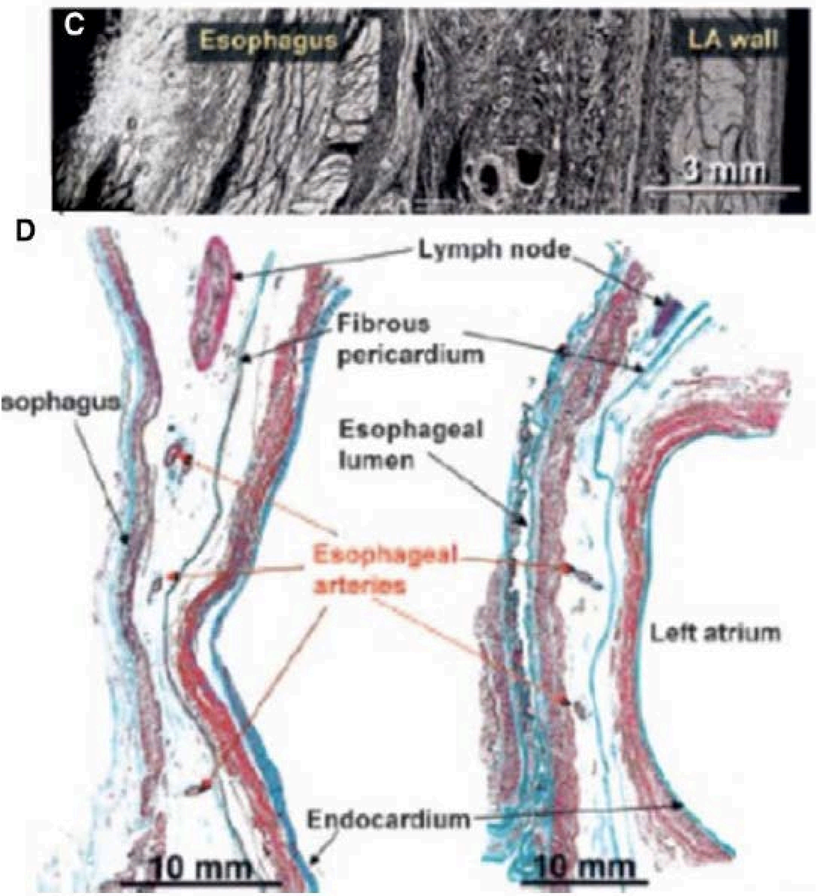


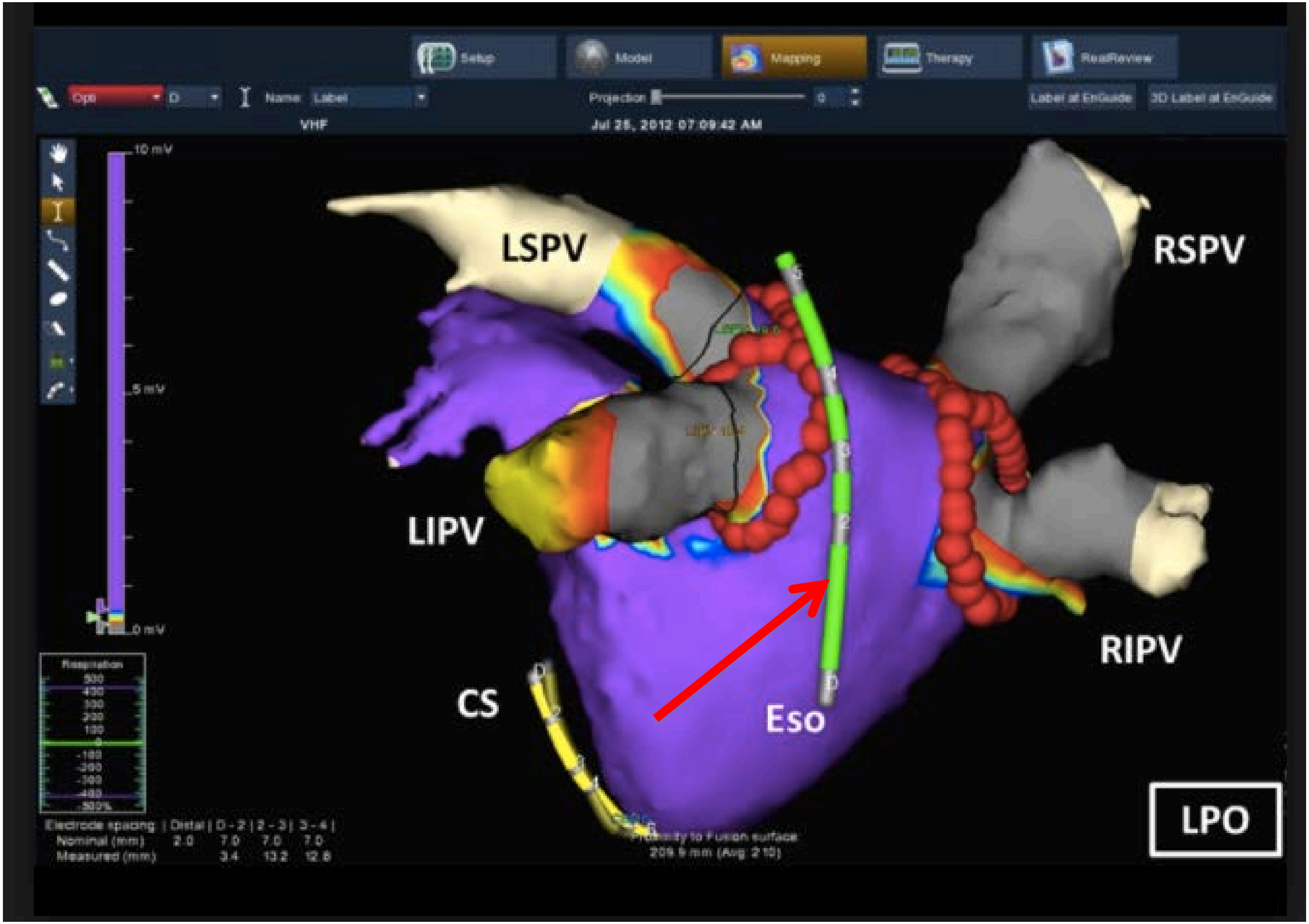
Figure 2. Different aspects of esophageal thermal lesions related to atrial fibrillation ablation as seen on upper endoscopy.
A, Erythema without disruption of the esophageal mucosa. **B**, Esophageal ulcer showing mucosal disruption and injury. **C**, Necrotizing esophageal ulcer.



Esophageal heating is a mechanism for injury, but fistulas do occur in cryoablation as well

Can an esophageal temperature probe help to prevent fistulas?

Kapur et al. Circulation. 2017;136:1247–1255.


Setup
Model
Mapping
Therapy
RealReview
Name
Label
Projection
Label at EnGuide
3D Label at EnGuide
VHF
Jul 25, 2012 07:09:42 AM
10 mV
5 mV
0 mV
LSPV
RSPV
LIPV
RIPV
CS
Eso
LPO
Respiration
Electrode spacing | Distal | D - 2 | 2 - 3 | 3 - 4 |
Nominal (mm) 2.0 7.0 7.0 7.0
Measured (mm) 3.4 13.2 12.8

lesions occurred in pts with esophageal temp > 41° C (every 1° C increase in esophageal temperature = 1.36 increased odds of esophageal lesion)

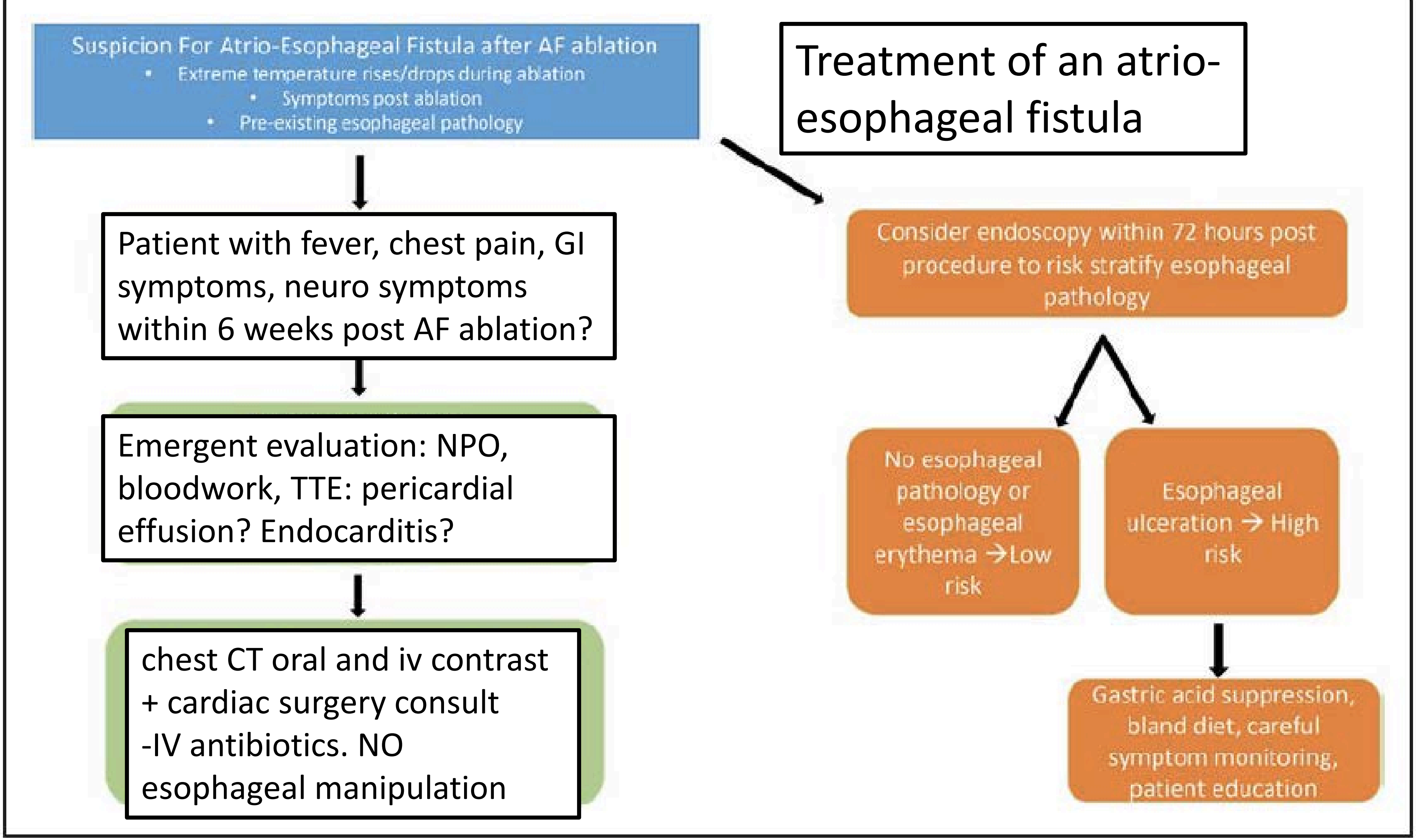
<u>Is there harm associated with temperature probes?</u>

30% vs 2.5% incidence of esophageal injury in the temperature probe group (n=80 patients)

-Some harm has been associated with the type of temperature probe**: temp probes with noninsulated metal thermistors may function as lightning rods**, attracting electric current form the ablation catheter and potentiating heat transfer to the esophagus.

-Others suggest that use of a temp probe with insulated thermocouples was as safe compared with ablations performed without a temperature probe

Kapur et al. Circulation. 2017;136:1247–1255



If a patient presents with fever, chest pain, GI or neuro sx within 6 weeks of AF ablation: NO TEE, NO ENDOSCOPY. DO CT SCAN, DIAGNOSE ESOPHAGEAL FISTULA AND SURGERY (NOT STENTING)

Kapur et al. Circulation. 2017;136:1247–1255.

Pericarditis

Most patients experience pleuritic chest pain post procedure as a result of transmural ablation lesions, lasting up to 48-72 hours

Significant improvement with Ketorolac given at time of procedure, prior to leaving the operating room

Conclusions

1. Early atrial fibrillation originates at the muscular sleeves of the pulmonary veins. With time, scarring in the left atrium can occur resulting in a more complex ablation procedure

2. New techniques in atrial fibrillation, including contact force sensing catheters, new-generation cryo-balloons, and mapping software have translated into higher success rates with reduced complications. Sicker patients are being ablated

3. Importance of Anesthesia and EP communication during ablation: issues with paralysis, patient movement, improved catheter stability (JET ventilation/apnea)

4. Esophageal considerations to reduce complications

5. Specific EP medications used during ablation

6. And…

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