

# **AF ABLATION**

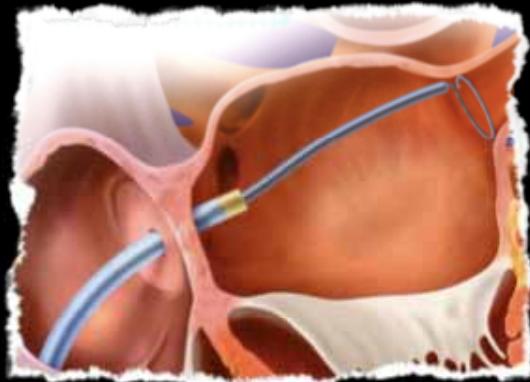
## **Patient Care & Monitoring to Prevent Procedural Complications**



**LI-FERN HSU  
Singapore**

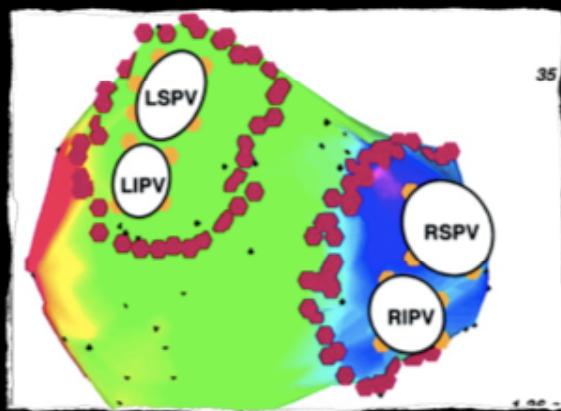
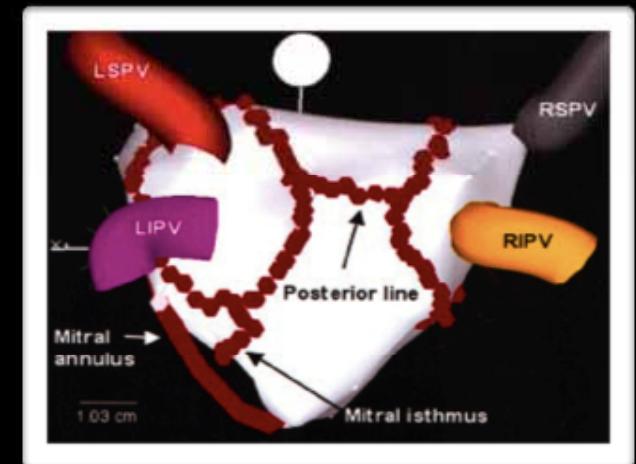


# PV ISOLATION TECHNIQUES



- Electrophysiologically-guided PV ostial ablation
- Now lesions moved towards PV-LA junction

- Wide encirclement of PVs without confirmation of electrical isolation
- Addition of LA linear lesions



- Wide encirclement of PVs with confirmation of electrical isolation
- Usually no additional linear lesions

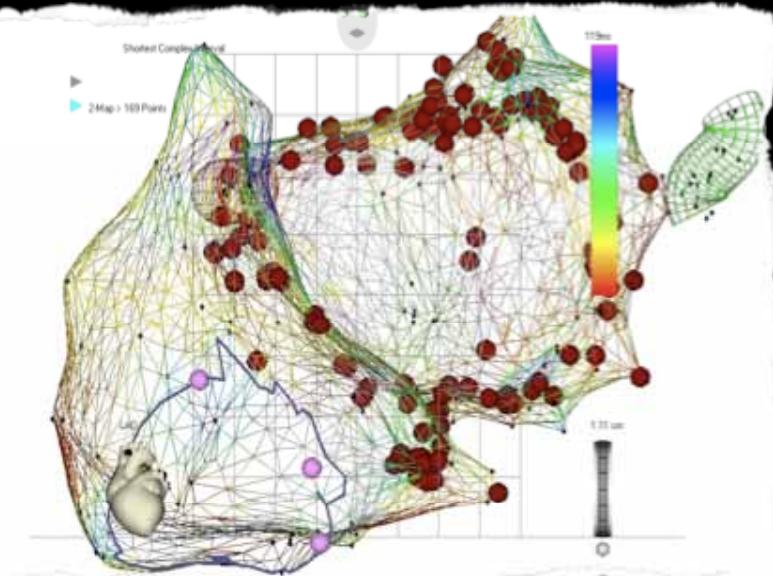
# SUBSTRATE-BASED TECHNIQUES

## A New Approach for Catheter Ablation of Atrial Fibrillation: Mapping of the Electrophysiologic Substrate

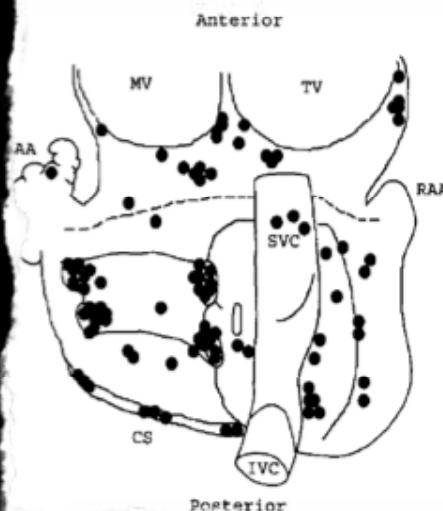
Koonlawee Nademanee, MD, FACC,\* John McKenzie, MD,\* Erol Kosar, MD,\* Mark Schwab, MD,\* Buncha Sunsanceewitayakul, MD,† Thaveekiat Vasavakul, MD,\* Chotikorn Khunnawat, MD,\* Tachapong Ngarmukos, MD‡  
*Inglewood, California; and Bangkok, Thailand*

Mapping & ablation of complex fractionated electrograms

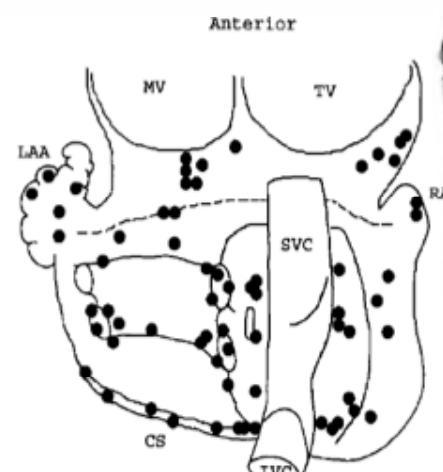
JACC 2004; 43:2044-2053



### Paroxysmal AF



### Permanent AF



## Spectral Analysis Identifies Sites of High-Frequency Activity Maintaining Atrial Fibrillation in Humans

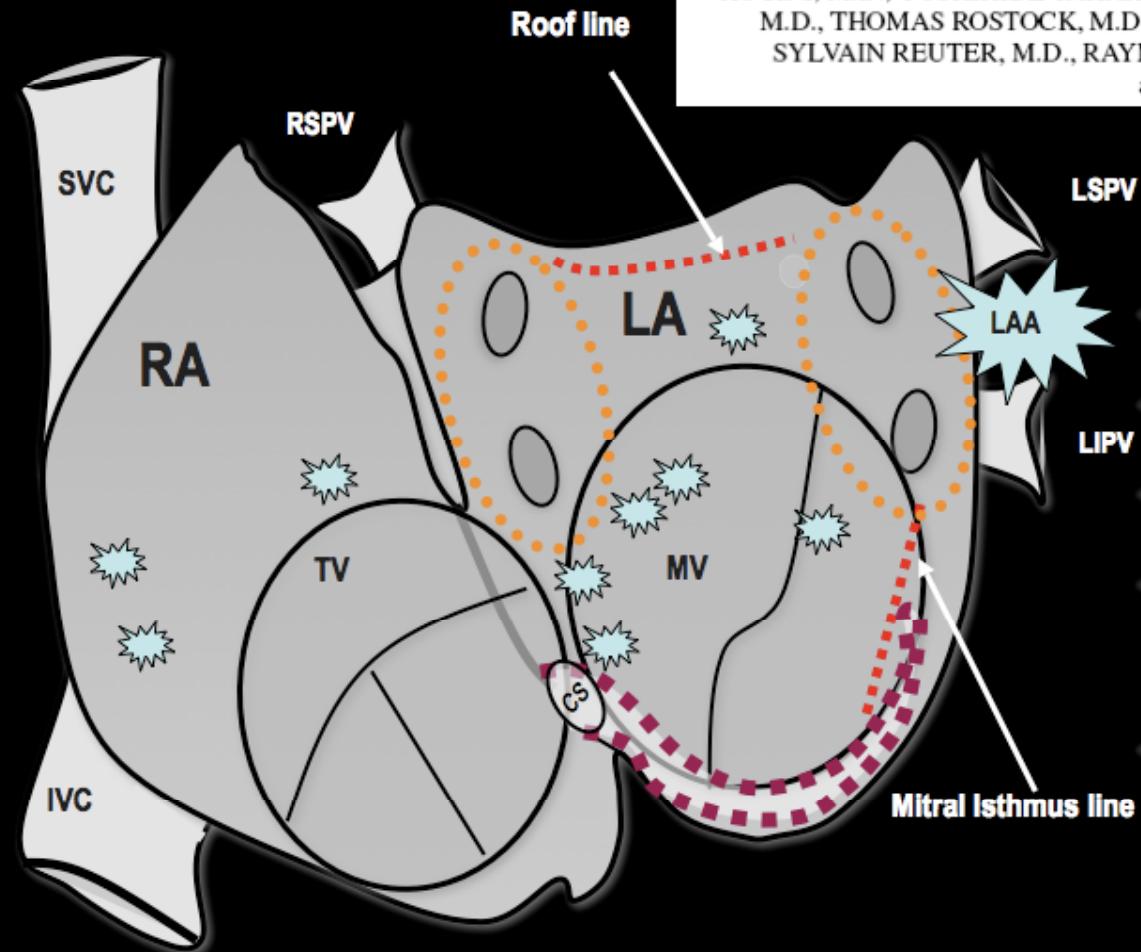
Prashanthan Sanders, MBBS, PhD\*; Omer Berenfeld, PhD\*; Mélèze Hocini, MD; Pierre Jaïs, MD; Ravi Vaidyanathan, BE; Li-Fern Hsu, MBBS; Stéphane Garrigue, MD, PhD; Yoshihide Takahashi, MD; Martin Rotter, MD; Frédéric Sacher, MD; Christophe Scavée, MD; Robert Ploutz-Snyder, PhD; José Jalife, MD; Michel Haïssaguerre, MD

Mapping & ablation of areas of dominant frequency activity

Circulation 2005; 112:789-797

# CHRONIC AF

Extensive ablation



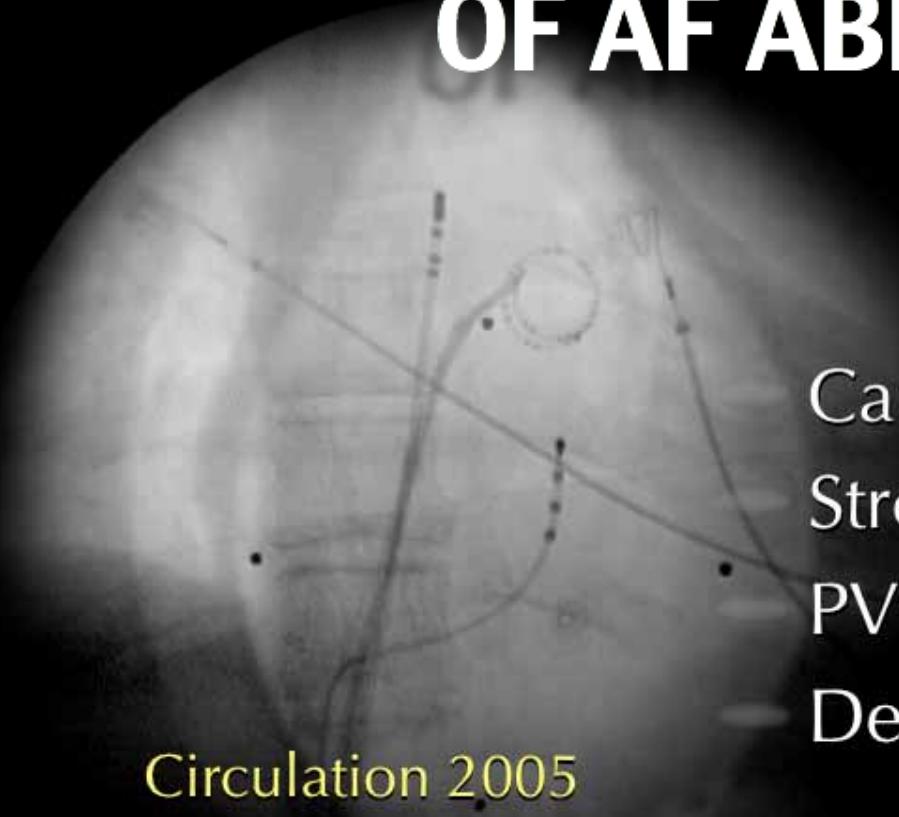
## Catheter Ablation of Long-Lasting Persistent Atrial Fibrillation: Critical Structures for Termination

MICHEL HAÏSSAGUERRE, M.D., PRASHANTHAN SANDERS, M.B.B.S., Ph.D., MÉLÈZE HOCINI, M.D., YOSHIHIDE TAKAHASHI, M.D., MARTIN ROTTER, M.D., FREDERIC SACHER, M.D., THOMAS ROSTOCK, M.D., LI-FERN HSU, M.B.B.S., PIERRE BORDACHAR, M.D., SYLVAIN REUTER, M.D., RAYMOND ROUDAUT, M.D., JACQUES CLÉMENTY, M.D., and PIERRE JAÏS, M.D.

- PV isolation
- Roofline
- Inferior LA / CS
- Organising activity at LAA, septum etc
- Mitral isthmus

JCE 2005; 16:1125-1137

# POTENTIAL COMPLICATIONS OF AF ABLATION



8745 patients

Cardiac Tamponade - 1.2%

Stroke/TIA - 1.0%

PV Stenosis - 1.3%

Death - 4 patients

Circulation 2005

## Worldwide Survey on the Methods, Efficacy, and Safety of Catheter Ablation for Human Atrial Fibrillation

Riccardo Cappato, MD; Hugh Calkins, MD; Shih-Ann Chen, MD; Wyn Davies, MD;  
Yoshito Iesaka, MD; Jonathan Kalman, MD; You-Ho Kim, MD; George Klein, MD;  
Douglas Packer, MD; Allan Skanes, MD

# POTENTIAL COMPLICATIONS OF AF ABLATION

**Early complications of pulmonary vein catheter ablation for atrial fibrillation: A multicenter prospective registry on procedural safety**

Emanuele Bertaglia, MD,\* Franco Zoppo, MD,\* Claudio Tondo, MD,† Andrea Colella, MD,‡  
Roberto Mantovan, MD,§ Gaetano Senatore, MD,|| Nicola Bottoni, MD,¶ Giovanni Carreras, MD,#  
Leonardo Corò, MD,\*\* Pietro Turco, MD,†† Massimo Mantica, MD,‡‡ Giuseppe Stabile, MD §§

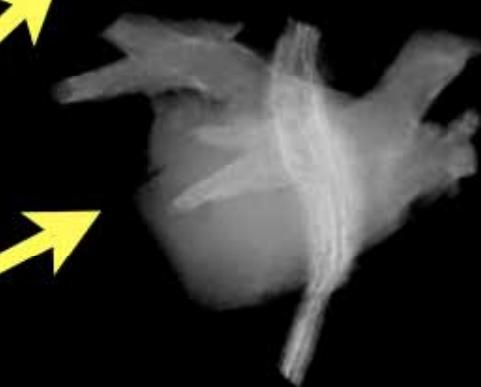
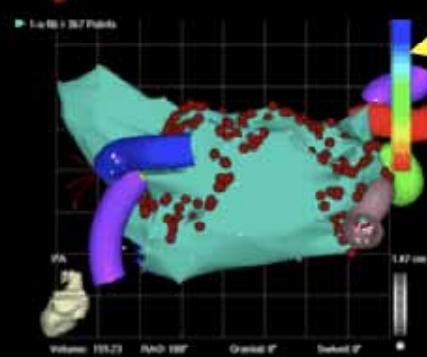
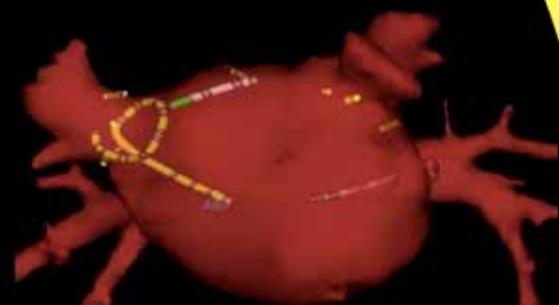
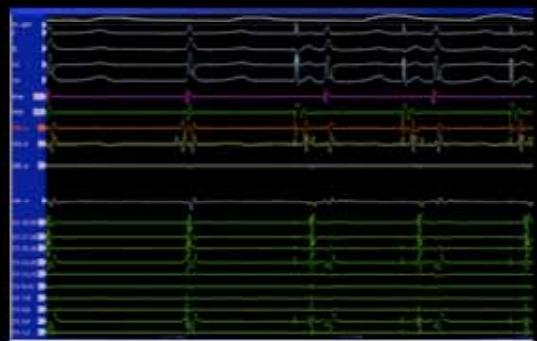
1011 patients

- Cardiac Tamponade - 0.6%
- Stroke/TIA - 0.5%
- PV Stenosis - 0.4%
- Death - 0 patients



Heart Rhythm 2007

# PATIENT MONITORING FOR AF ABLATION



# PATIENT MONITORING FOR AF ABLATION

## WHY MONITOR?

- Prevention of complications
- Early detection of complications

## WHEN TO MONITOR?

- During procedure
- After procedure



# CARDIAC PERFORATION

## POTENTIAL FOR CARDIAC PERFORATION

- INCIDENCE - Low
- CONSEQUENCES - Potentially serious
- STAGES OF PROCEDURE
  - Transeptal puncture
  - LA ablation
  - RA ablation

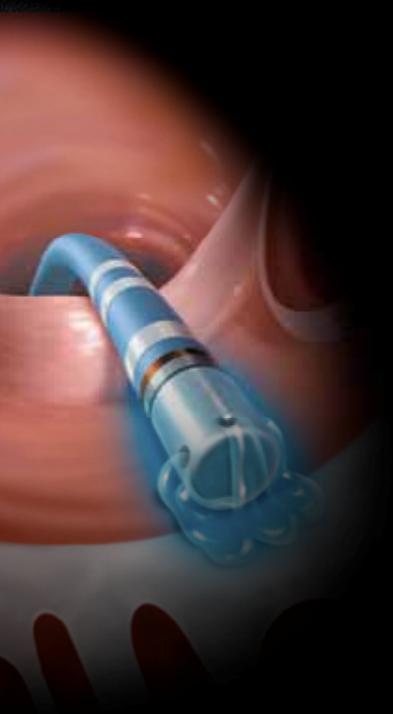


# CARDIAC PERFORATION

## MECHANISMS FOR CARDIAC PERFORATION

### Incidence and Prevention of Cardiac Tamponade Complicating Ablation for Atrial Fibrillation

LI-FERN HSU, PIERRE JAÏS, MÉLÈZE HOCINI, PRASHANTHAN SANDERS,  
CHRISTOPHE SCAVÉE, FREDERIC SACHER, YOSHIHIDE TAKAHASHI, MARTIN ROTTER,  
JEAN-LUC PASQUIE, JACQUES CLÉMENTY, and MICHEL HAÏSSAGUERRE  
From the Hôpital Cardiologique du Haut-Lévêque, Bordeaux-Pessac, France



Risk higher during linear ablation compared to PV isolation

- Catheter manipulation
- “Popping” during RF Delivery
- mainly related to energy delivery

# CARDIAC PERFORATION

## PREVENTION

### TRANSEPTAL ACCESS

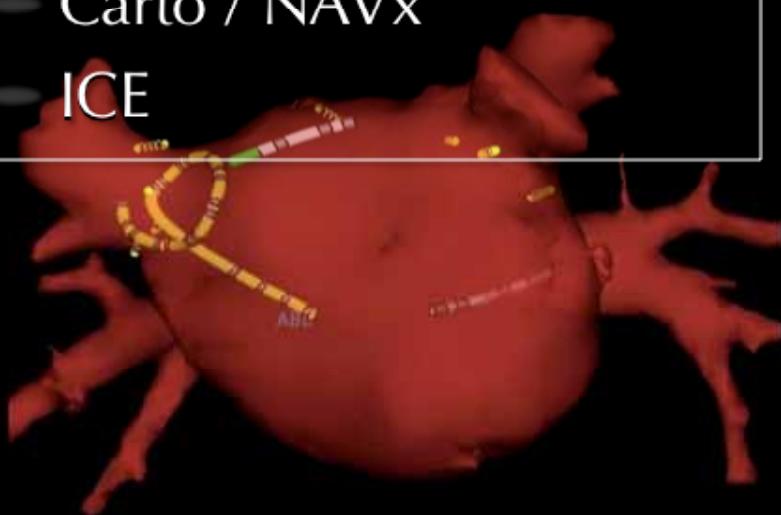
- Pre-procedure TEE
- PFO
- Single vs double puncture
- Needle Tracking
- ICE

### "POPPING"

- Energy delivery as low as necessary
- ICE
- "microbubbles"

### CATHETER MANIPULATION

- Pre-procedure Imaging
  - CT / MRI
- Catheter Tracking
  - fluoroscopy
  - Carto / NAVx
- ICE



# CARDIAC PERFORATION

## IF PREVENTION FAILS.....

### CLINICAL MONITORING

- BP Monitoring
- ? arterial line
- Fluoroscopy

### INTRACARDIAC ECHO

- Early detection
- effusion detected ~22min prior to hemodynamic instability
- Monitoring progression

### Outcomes After Cardiac Perforation During Radiofrequency Ablation of the Atrium

T. JARED BUNCH, M.D., SAMUEL J. ASIRVATHAM, M.D., PAUL A. FRIEDMAN, M.D., KRISTI H. MONAHAN, R.N., THOMAS M. MUNGER, M.D., ROBERT F. REA, M.D., LAWRENCE J. SINAK, M.D., and DOUGLAS L. PACKER, M.D.



JCE 2005

# THROMBOEMBOLIC EVENTS

## RISK OF THROMBUS FORMATION

Activation of coagulation cascade by

- Intravascular catheter placement
- Duration of procedure

Left Atrial Thrombus Associated  
With Ablation for Atrial Fibrillation:  
Identification With Intracardiac Echocardiography

Jian-Fang Ren, MD, FACC, Francis E. Marchlinski, MD, FACC, David J. Callans, MD, FACC  
*Philadelphia, Pennsylvania*

Thrombus formation even with  
intraprocedural anticoagulation with  
ACT >250 s



JACC 2004

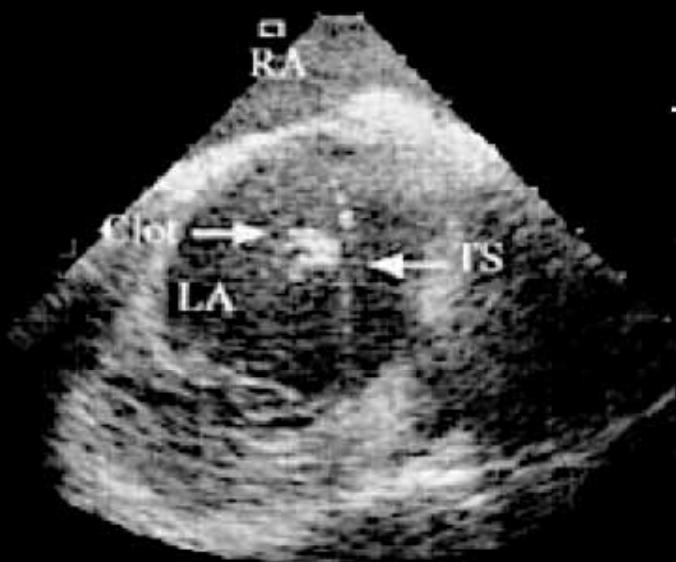
# THROMBOEMBOLIC EVENTS

## RISK OF THROMBUS FORMATION

### Intracardiac Ultrasound Detection of Thrombus on Transseptal Sheath: Incidence, Treatment, and Prevention

KATANEH MALEKI, M.D., REZA MOHAMMADI, M.D., DAVID HART, M.D.,  
DELIA COTIGA, M.D., NADA FARHAT, M.S., and JONATHAN S. STEINBERG, M.D., F.A.C.C.

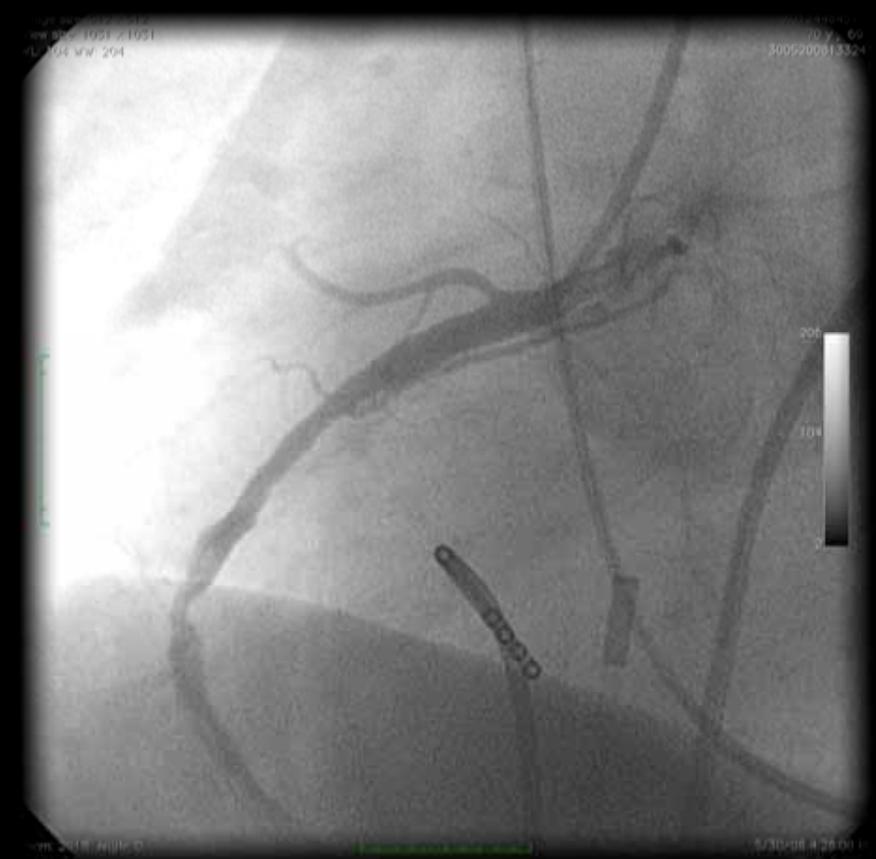
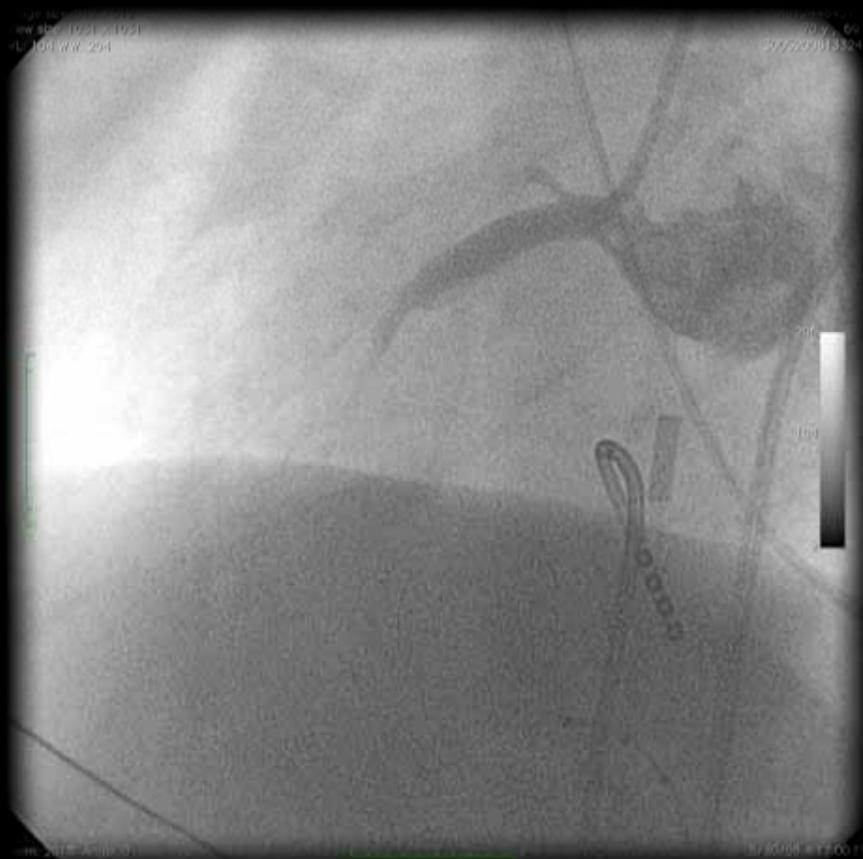
From the Arrhythmia Service and Division of Cardiology, St. Luke's-Roosevelt Hospital Center and Columbia University College of Physicians and Surgeons, New York, New York; and the Valley Hospital, Ridgewood, New Jersey, USA



- Thrombus formation associated with
- LA spontaneous echo contrast
  - Increased LA diameter
  - Persistent AF

# THROMBOEMBOLIC EVENTS

## AIR EMBOLISM



# THROMBOEMBOLIC EVENTS

## PREVENTION

### BEFORE PROCEDURE

- Adequate anticoagulation
- TEE to screen for thrombi

### DURING PROCEDURE

- Adequate heparinization
- ACT 250-300 (>300 for LASEC)
- Transeptal sheath management



**Increased Intensity of Anticoagulation May Reduce Risk of Thrombus During Atrial Fibrillation Ablation Procedures in Patients with Spontaneous Echo Contrast**

JIAN-FANG REN, M.D., FRANCIS E. MARCHLINSKI, M.D., DAVID J. CALLANS, M.D.,  
EDWARD P. GERSTENFELD, M.D., SANJAY DIXIT, M.D., DAVID LIN, M.D.,  
HEMAL M. NAYAK, M.D., and HENRY H. HSIA, M.D.

From the Division of Cardiovascular Medicine, Department of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, Pennsylvania, USA

# THROMBOEMBOLIC EVENTS

## PREVENTION

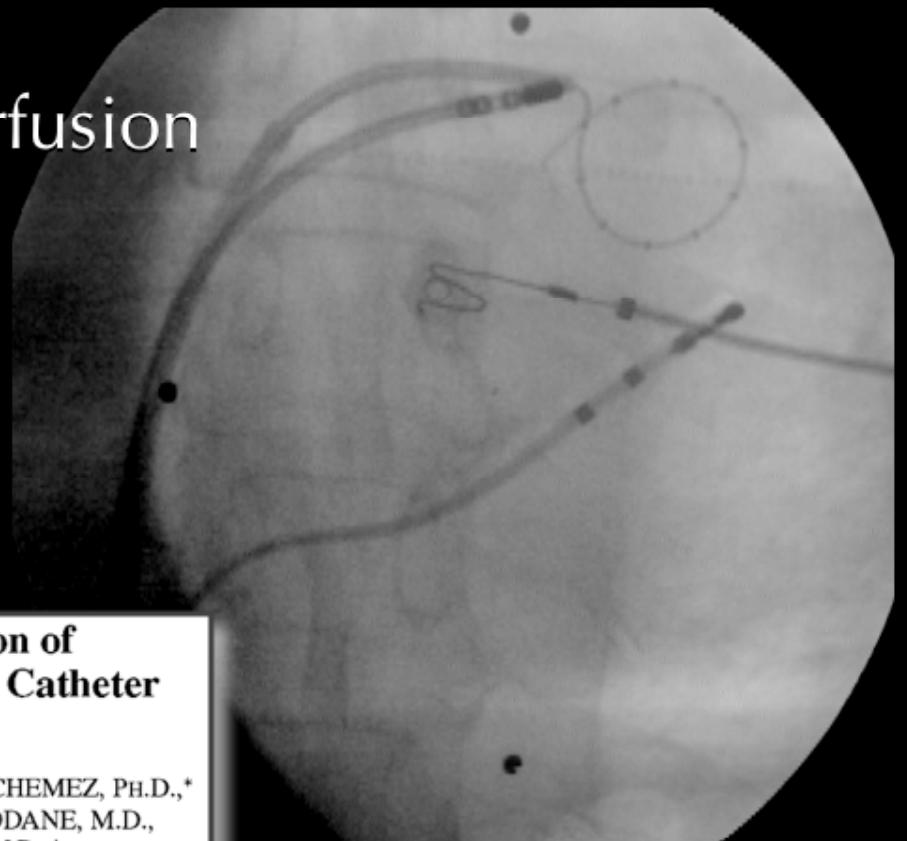
### TRANSEPTAL SHEATH

- High-flow continuous perfusion with heparinized saline
- Withdraw sheath into RA whenever possible
- Single transeptal sheath

**High-Flow Perfusion of Sheaths for Prevention of Thromboembolic Complications During Complex Catheter Ablation in the Left Atrium**

BRUNO CAUCHEMEZ, M.D., FABRICE EXTRAMIANA, M.D., SIMON CAUCHEMEZ, PH.D.,\*  
STÉPHANE COSSON, M.D., HANANE ZOUZOU, M.D., MOHAMED MEDDANE, M.D.,  
LAURE REVault D'ALLONNES, M.D., THOMAS LAVERGNE, M.D.,†  
ANTOINE LEENHARDT, M.D., PHILIPPE COUMEL, M.D., and EMMANUEL HOUDART, M.D.‡

From the Department of Cardiology, Lariboisière Hospital, Paris, France; \*INSERM U444, Paris, France; †Department of Cardiology, Georges Pompidou Hospital, Paris, France; and ‡Department of Neuroradiology, Lariboisière Hospital, Paris, France



# PULMONARY VEIN STENOSIS

Decreasing incidence but still important....

Significant pulmonary vein stenosis occurs in ~1% patients after AF ablation



Symptoms highly variable,  
often mimic pulmonary  
disease

# PULMONARY VEIN STENOSIS

## **Pulmonary Vein Stenosis After Radiofrequency Ablation of Atrial Fibrillation**

### **Functional Characterization, Evolution, and Influence of the Ablation Strategy**

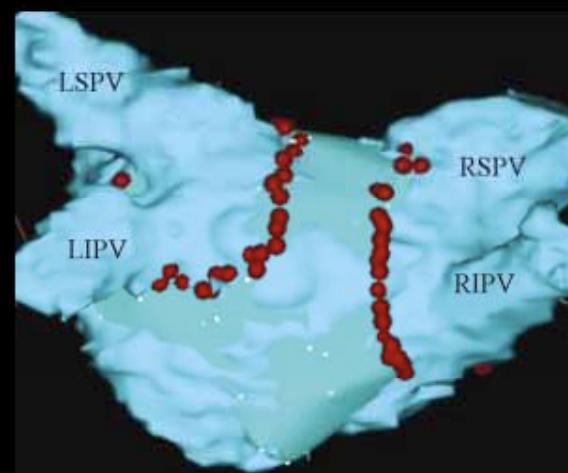
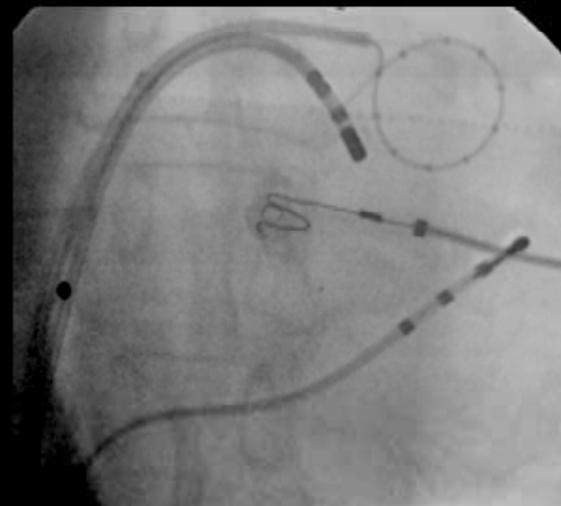
Eduardo B. Saad, MD; Antonio Rossillo, MD; Cynthia P. Saad, MD; David O. Martin, MD;  
Mandeep Bhargava, MD; Demet Erciyes, MD; Dianna Bash, RN; Michelle Williams-Andrews, RN;  
Salwa Beheiry, RN; Nassir F. Marrouche, MD; James Adams, MD; Ennio Pisanò, MD;  
Raffaele Fanelli, MD; Domenico Potenza, MD; Antonio Raviele, MD; Aldo Bonso, MD;  
Sakis Themistoclakis, MD; Joannes Brachmann, MD; Walid I. Saliba, MD;  
Robert A. Schweikert, MD; Andrea Natale, MD

- Incidence decreases with more ostial/antral ablation
- Severe stenosis (>70%) - symptomatic
- Mild to moderate stenosis - no symptoms
- However, mild narrowing initially does not preclude future development of severe stenosis

# PULMONARY VEIN STENOSIS

## PREVENTION

- Change ablation site to as proximal as possible
  - a) fluoroscopy
  - b) Carto / NAVx
  - c) ICE
- Reduce energy delivery
- Catheter impedance monitoring

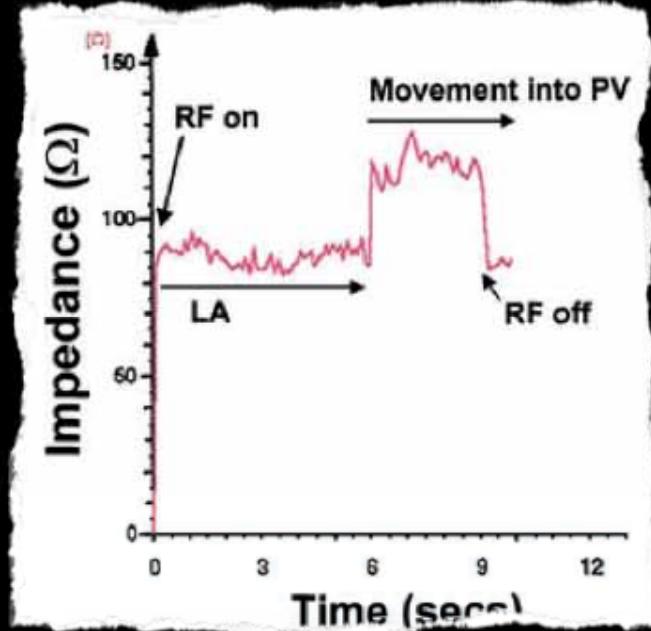
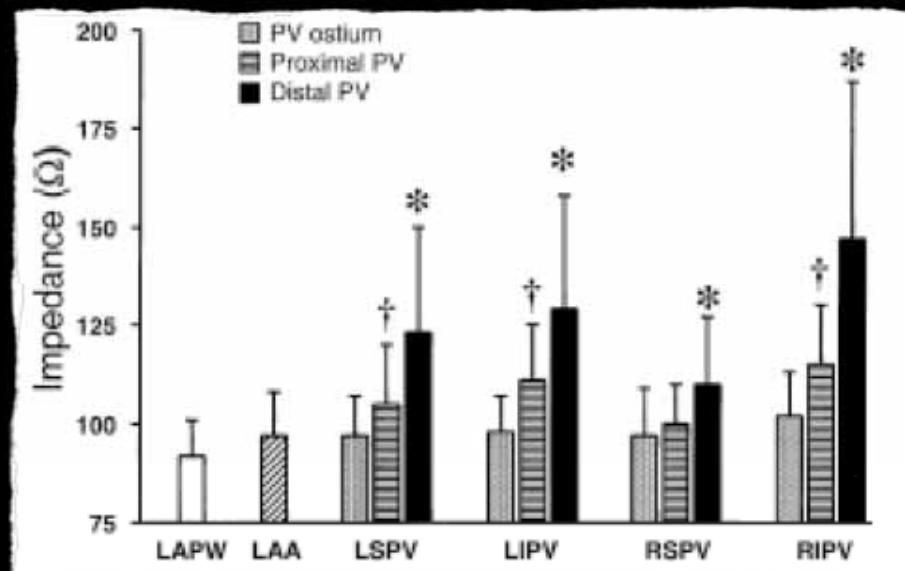


# PULMONARY VEIN STENOSIS PREVENTION

JCE 2004

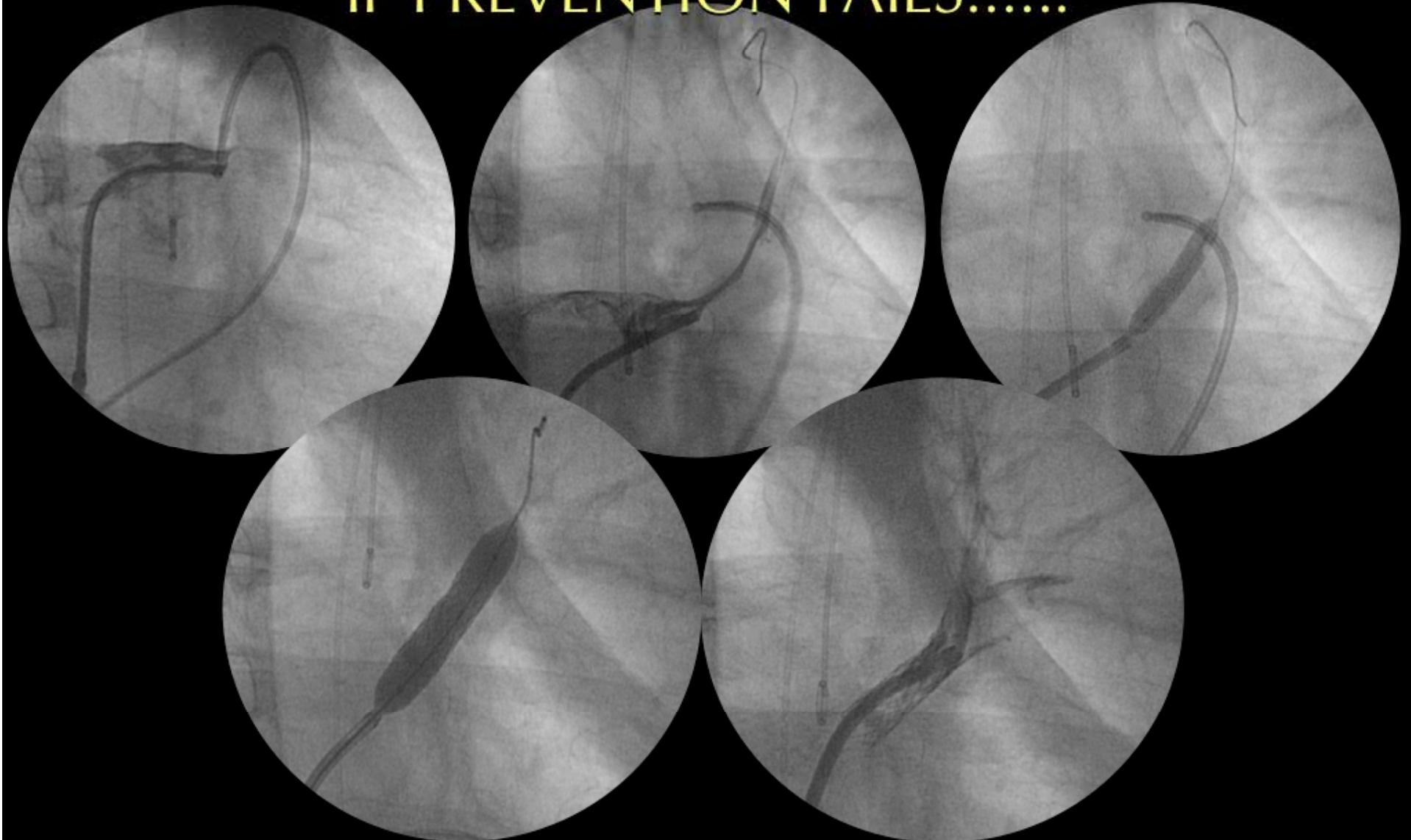
## Detection of Inadvertent Catheter Movement into a Pulmonary Vein During Radiofrequency Catheter Ablation by Real-Time Impedance Monitoring

PETER CHEUNG, M.D., BURR HALL, M.D., AMAN CHUGH, M.D., ERIC GOOD, D.O.,  
KRISTINA LEMOLA, M.D., JIHN HAN, M.D., KAMALA TAMIRISA, M.D.,  
FRANK PELOSI, Jr., M.D., FRED MORADY, M.D., and HAKAN ORAL, M.D.



# PULMONARY VEIN STENOSIS

IF PREVENTION FAILS.....



# PULMONARY VEIN STENOSIS

Monitoring Post-Angioplasty or Stent

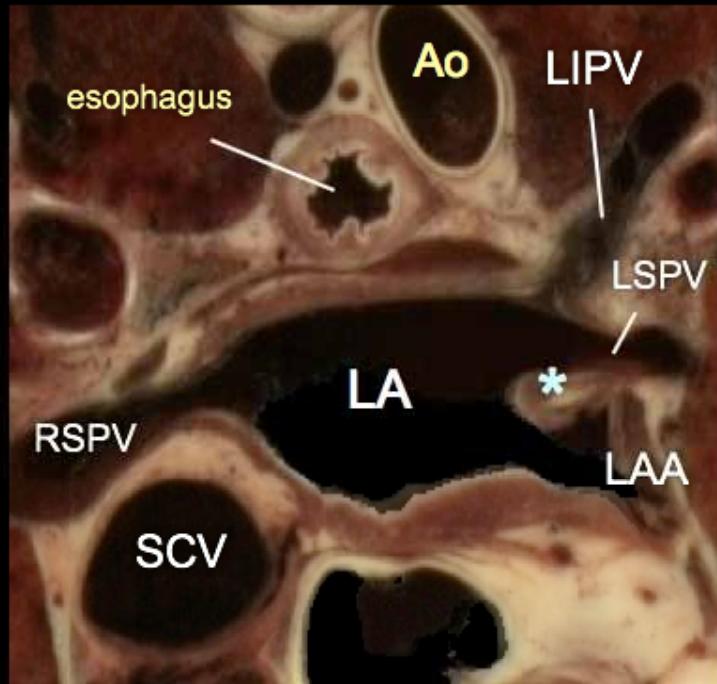


- Restenosis rate is high after PV angioplasty, especially without concomitant stenting

# ATRIO-ESOPHAGEAL FISTULA

## Atrio-Esophageal Fistula as a Complication of Percutaneous Transcatheter Ablation of Atrial Fibrillation

Carlo Pappone, MD, PhD; Hakan Oral, MD; Vincenzo Santinelli, MD; Gabriele Vicedomini, MD;  
Christopher C. Lang, MB, ChB; Francesco Manguso, MD, PhD; Lucia Torracca, MD;  
Stefano Benussi, MD; Ottavio Alfieri, MD; Robert Hong, MD; William Lau, MD; Kirk Hirata, MD;  
Neil Shikuma, MD; Burr Hall, MD; Fred Morady, MD



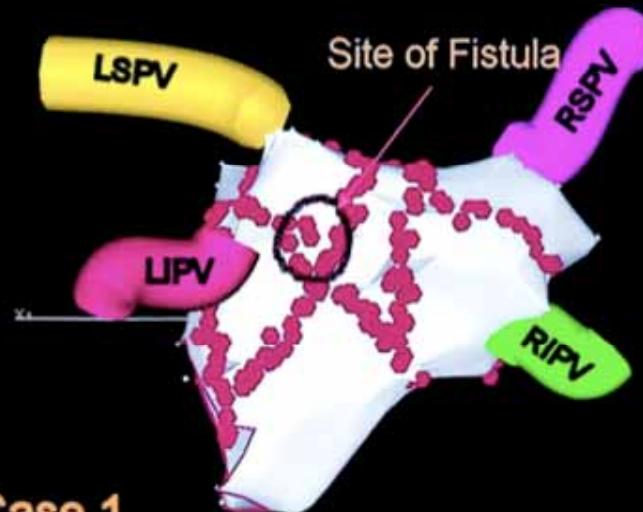
### Position of LA & Esophagus

Close proximity of LA posterior wall to esophagus

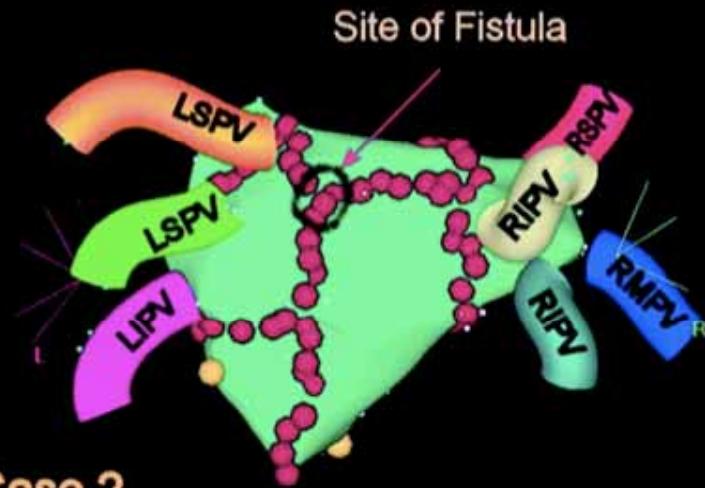
Fat pad of variable thickness separates posterior LA wall from esophagus

Circulation 2004

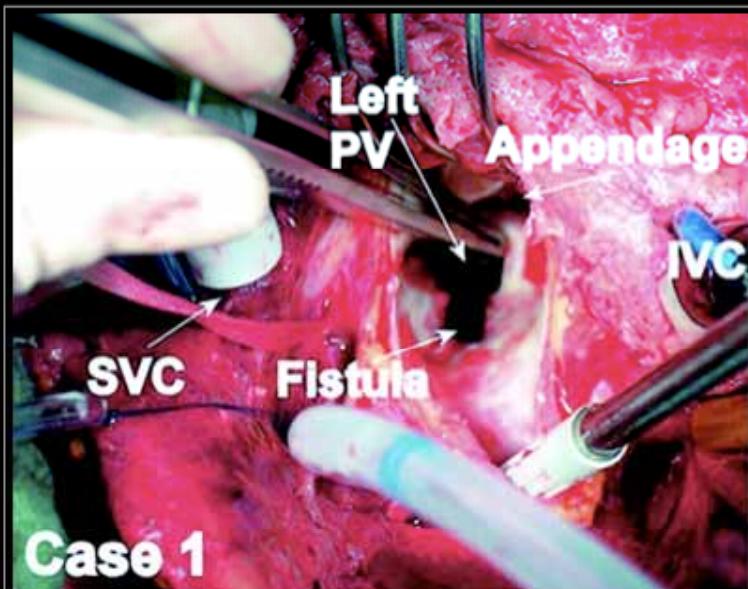
# ATRIO-ESOPHAGEAL FISTULA



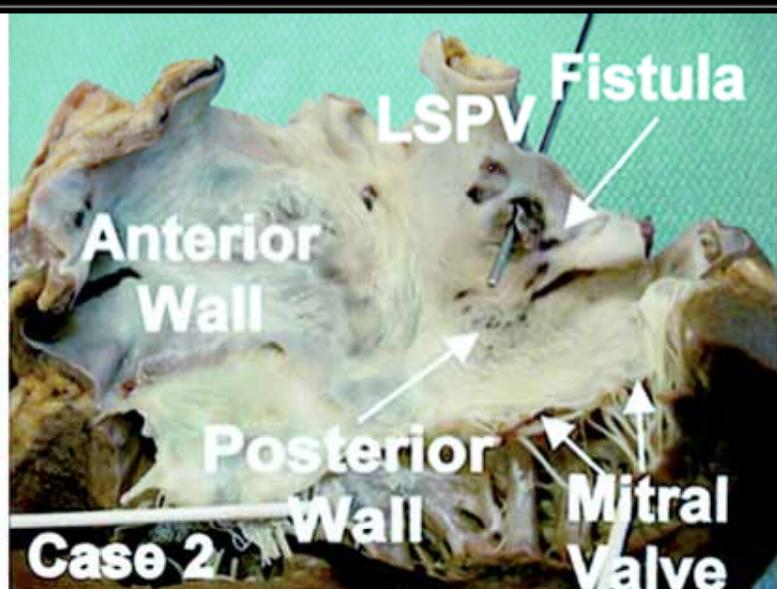
Case 1



Case 2



Case 1



Case 2

Pappone C, et al. Circulation 2004; 109:2724-2726

# ATRIO-ESOPHAGEAL FISTULA

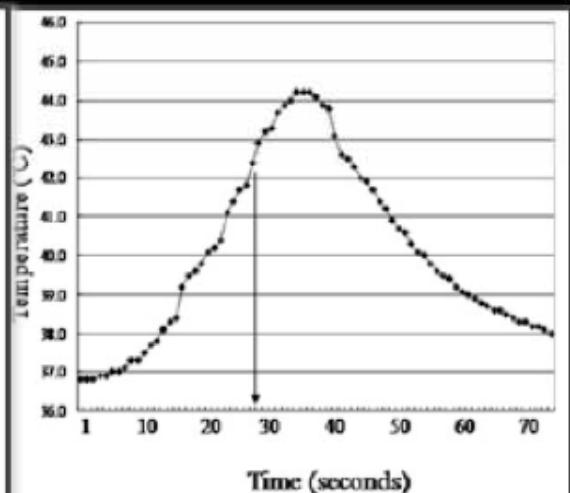
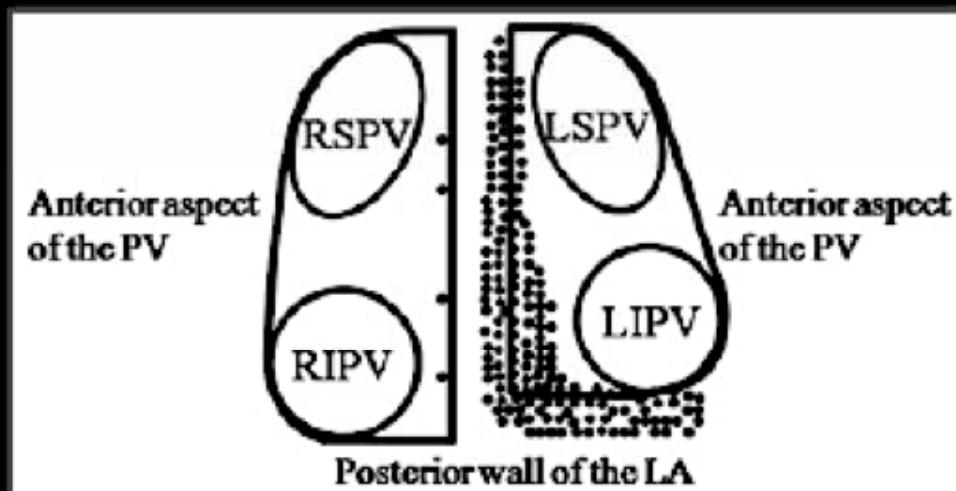
## Assessment of Temperature, Proximity, and Course of the Esophagus During Radiofrequency Ablation Within the Left Atrium

Jennifer E. Cummings, MD; Robert A. Schweikert, MD; Walid I. Saliba, MD; J. David Burkhardt, MD; Johannes Brachmann, MD; Jens Gunther, MD; Volker Schibgilla, MD; Atul Verma, MD; MarkAlain Dery, DO, MPH; John L. Drago; Fethi Kilicaslan, MD; Andrea Natale, MD

Circulation 2005

- RF application in LA near course of esophagus results in increased luminal temperature
- Esophageal course variable

Kuwahara et al.  
JCE 2009



# ATRIO-ESOPHAGEAL FISTULA

## PREVENTION

Esophageal imaging and strategies for avoiding injury during left atrial ablation for atrial fibrillation

Jian-Fang Ren, MD, David Lin, MD, Francis E. Marchlinski, MD, David J. Callans, MD,  
Vickas Patel, MD, PhD

### ESOPHAGEAL IMAGING

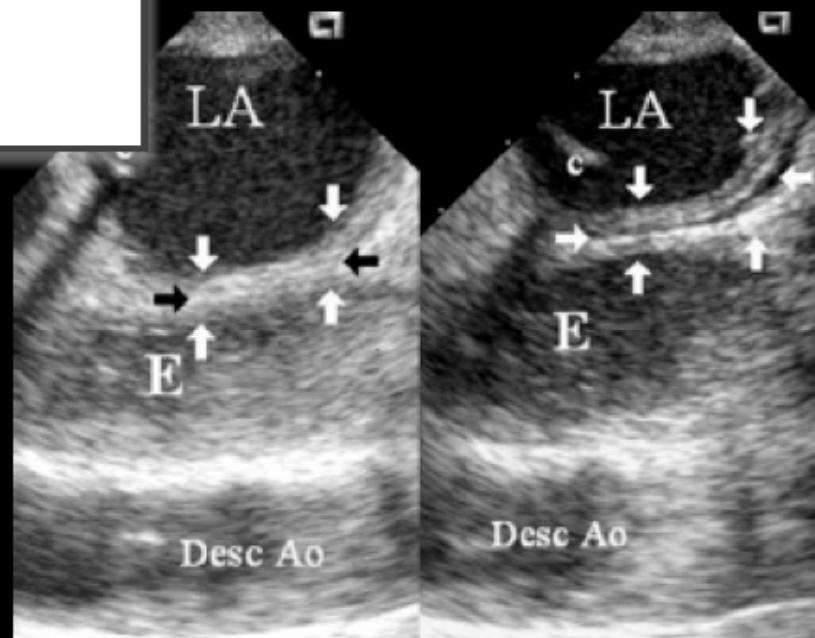
- Barium swallow
- ICE

### ESOPHAGEAL MONITORING

- Temperature probe

### RF DELIVERY

- Reduce power

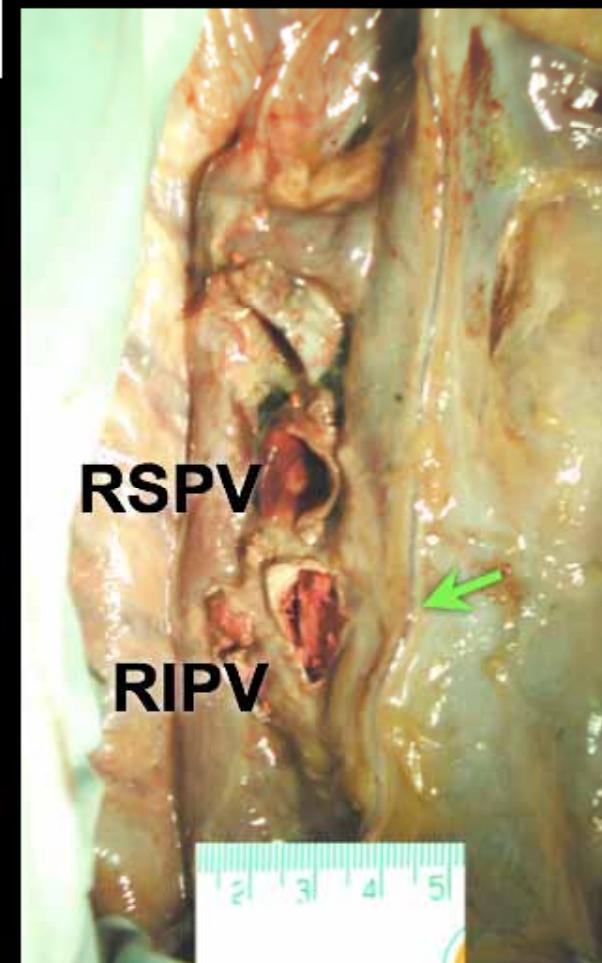
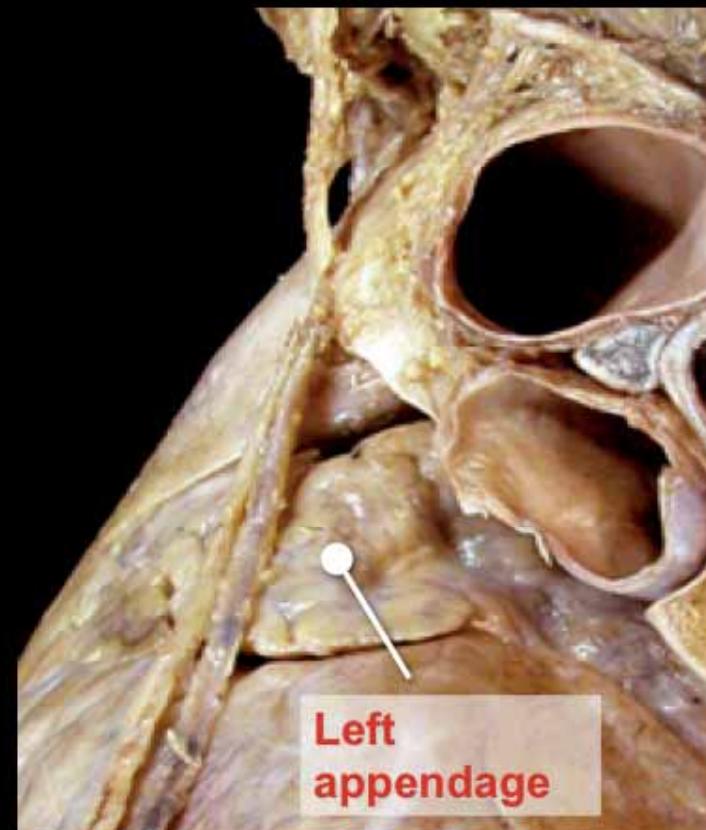


# PHRENIC NERVE INJURY

## How Close Are the Phrenic Nerves to Cardiac Structures? Implications for Cardiac Interventionalists

DAMIAN SÁNCHEZ-QUINTANA, M.D., PH.D.,\* JOSÉ ANGEL CABRERA, M.D., PH.D.,†  
VICENTE CLIMENT, M.D., PH.D.,\* JERÓNIMO FARRÉ, M.D., PH.D., F.E.S.C.,† ANDREAS  
WEIGLEIN, M.D., PH.D.,‡ and SIEW YEN HO, PH.D., F.R.C.PATH., F.E.S.C.¶

JCE 2005; 16:309-313



# PHRENIC NERVE INJURY

Phrenic Nerve Injury After  
Atrial Fibrillation Catheter Ablation  
Characterization and Outcome in a Multicenter Study

Frédéric Sacher, MD,\* Kristi H. Monahan, RN,†  
Stuart P. Thomas, MD,‡ Neil Davidson, MD,§ Pedro Adragao, MD,||  
Prashanthan Sanders, MBBS, PhD,\* Mélèze Hocini, MD,\* Yoshihide Takahashi, MD,\*  
Martin Rotter, MD,\* Thomas Rostock, MD,\* Li-Fern Hsu, MBBS,\* Jacques Clémenty, MD,\*  
Michel Haïssaguerre, MD,\* David L. Ross, MD,‡ Douglas L. Packer, MD,† Pierre Jaïs, MD,\*  
*Bordeaux-Pessac, France; Rochester, Minnesota; Sydney, Australia; Manchester, United Kingdom;  
and Carnaxide, Portugal*

- Occurs after ablation in following locations
- RSPV, SVC, LAA
- High output pacing prior to ablation in susceptible areas to identify location of phrenic nerve may avoid this complication

JACC 2006; 47:2498-2503

# CONCLUSION

- Despite advances in technology and refinements in technique, AF ablation is still associated with a small but significant risk of complications
- Minimization/prevention of these complications starts with pre-procedure planning, followed by intra-procedural monitoring, and post-procedural surveillance
- Early detection and recognition of these complications is important