Role of Echo in Atrial fibrillation:
Cardioversion, pulmonary vein isolation and atrial function

Hui Kyung Jeon M.D.,PH.D.
Cardiology,Uijongbu ST. Mary's Hospital,
The Catholic University of Korea

15th APCDE 2011 2011.4.15

Atrial Fibrillation

- The most common sustained arrhythmia and is responsible for almost 300,000 hospital admissions annually.

- Its prevalence increases from 1% among those < 60 years old to almost 9% among octogenarians (0.4% in general population).

  It affects 2.2 million people in the USA.

Clinical problem in AF

- AF is typically associated with a rapid ventricular response that results in alterations in the patient's clinical and hemodynamic state.
- The loss of atrial systolic contribution to total left ventricular filling leads to depressed cardiac output and symptoms of dyspnea and fatigue.
- In addition, the resulting stasis of blood, enhanced platelet aggregation, and coagulation predisposes to the formation of atrial thrombi and subsequent thromboembolism, the most feared complication of AF.

Echo role in AF

- Cardioversion
- [illegible]
- Atrial function

Role of Echocardiography in Patients Undergoing Cardioversion of AF

- Conventional Cardioversion
  - conventionally treated with therapeutic anticoagulation for 3 weeks **before** and 4 weeks **after** cardioversion
- TEE-Guided Cardioversion
  - alternative cardioversion in the early cardioversion of patients with AF

Advantages and Disadvantages of the Conventional Approach to Cardioversion of Patients With Atrial Fibrillation

Table 2. Advantages and Disadvantages of the Conventional Approach to Cardioversion of Patients With Atrial Fibrillation

Advantages	Disadvantages
• Use of warfarin for 3 to 4 weeks before cardioversion may lower the stroke rate from 5.6% to a very low stroke rate of < 2% (5,60,64,70).	• Delaying cardioversion to normal sinus rhythm for 3 to 4 weeks potentially decreases functional capacity (34,35).
• Relatively easy to administer with regular monitoring of INRs (7,13).	• Prolonging treatment for 7 to 8 weeks increases the risk of bleeding complications (16,26,30,70–72).
• Suitable for community hospitals (7,13).	• Not followed by routine clinical practice, especially in the elderly (65,73).
• The conventional approach has withstood the "test of time" since the 1960s.	• Patients who are at the highest risk for developing systemic embolization who should receive more prolonged or intensive anticoagulation are not routinely identified (1,74).

INR = international normalized ratio.

Klein AL et al.J. Am. Coll. Cardiol. 2001;37;691–704

TEE-Guided Cardioversion

Table 3. Summary of Studies of Transesophageal Echocardiography (TEE)-Guided Approach to Cardioversion of Atrial Fibrillation, Including the Incidence of Thrombus by TEE and Recorded Embolic Events

Study	Reference Number	n	Atrial Thrombi	Embolic Events
Orsinelli (1993)	103	39	9 (23%)	1 (2.56%)
Stoddard (1995)	113	206	37 (18%)	0
Klein (1997)	4	126	7 (13%)	0
Weigner (1998)	114	466	64 (13.9%)	1 (0.21%)
Grimm (1998)	115	417	28 (7%)	0
Corrado (1999)	116	123	11 (9%)	0
ACUTE (2000)	16	619	79 (13.6%)	5 (0.81%)
Total		1,996	235 (11.8%)	7 (0.35%)

ACUTE = Assessment of Cardioversion Using Transesophageal Echocardiography.

Klein AL et al.J. Am. Coll. Cardiol. 2001;37;691-704

TEE guided cardioversion

Assessment of Cardioversion Using Transesophageal Echocardiography (ACUTE) Multicenter Study

The New England
Journal of Medicine

VOLUME 344 MAY 10, 2001 NUMBER 19

USE OF TRANSESOPHAGEAL ECHOCARDIOGRAPHY TO GUIDE CARDIOVERSION IN PATIENTS WITH ATRIAL FIBRILLATION

ALLAN L. KLEIN, M.D., RICHARD A. GRIMM, D.O., R. DANIEL MURRAY, PH.D., CAROLYN APPERSON-HANSEN, M.STAT., RICHARD W. ASINGER, M.D., IAN W. BLACK, M.D., RAVIN DAVIDOFF, M.B., B.CH., RAIMUND ERBEL, M.D., JONATHAN L. HALPERIN, M.D., DAVID A. ORSINELLI, M.D., THOMAS R. PORTER, M.D., AND MARCUS F. STODDARD, M.D., FOR THE ASSESSMENT OF CARDIOVERSION USING TRANSESOPHAGEAL ECHOCARDIOGRAPHY INVESTIGATORS*

Study protocol

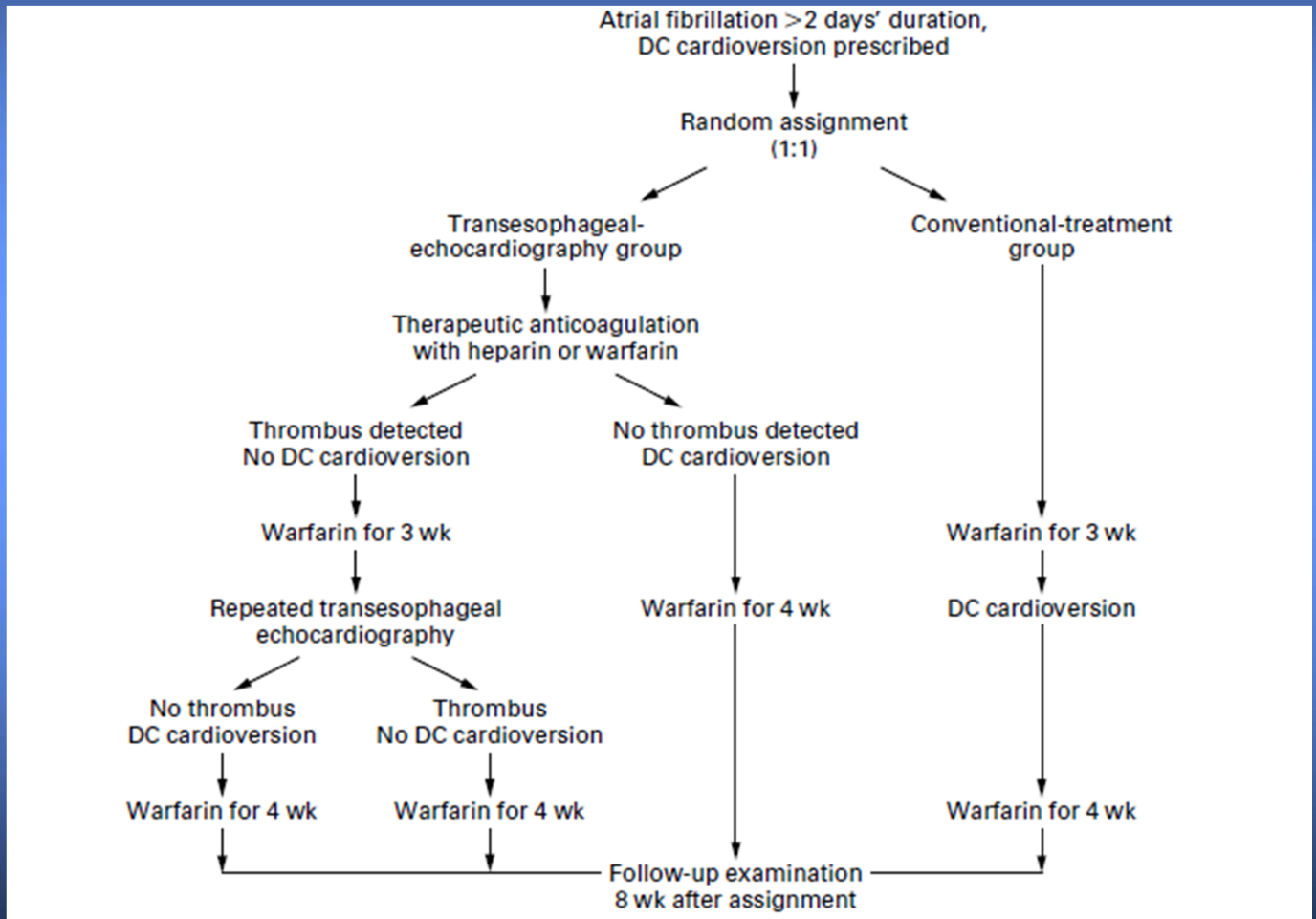


Figure 1. The Study Protocol.

Of a total of 1222 patients enrolled in the study, 619 were randomly assigned to a treatment strategy guided by transesophageal echocardiography with brief anticoagulation, and a total of 603 were assigned to the conventional treatment strategy with anticoagulation for three weeks before cardioversion. The extended period of anticoagulation before cardioversion in the conventional-treatment group resulted in a larger number of spontaneous conversions, greater difficulty in maintaining therapeutic anticoagulation levels, more refusals of electrical cardioversion by patients, and more scheduling difficulties. DC denotes direct current, and TEE transesophageal echocardiography. The numbers of patients are given in parentheses.

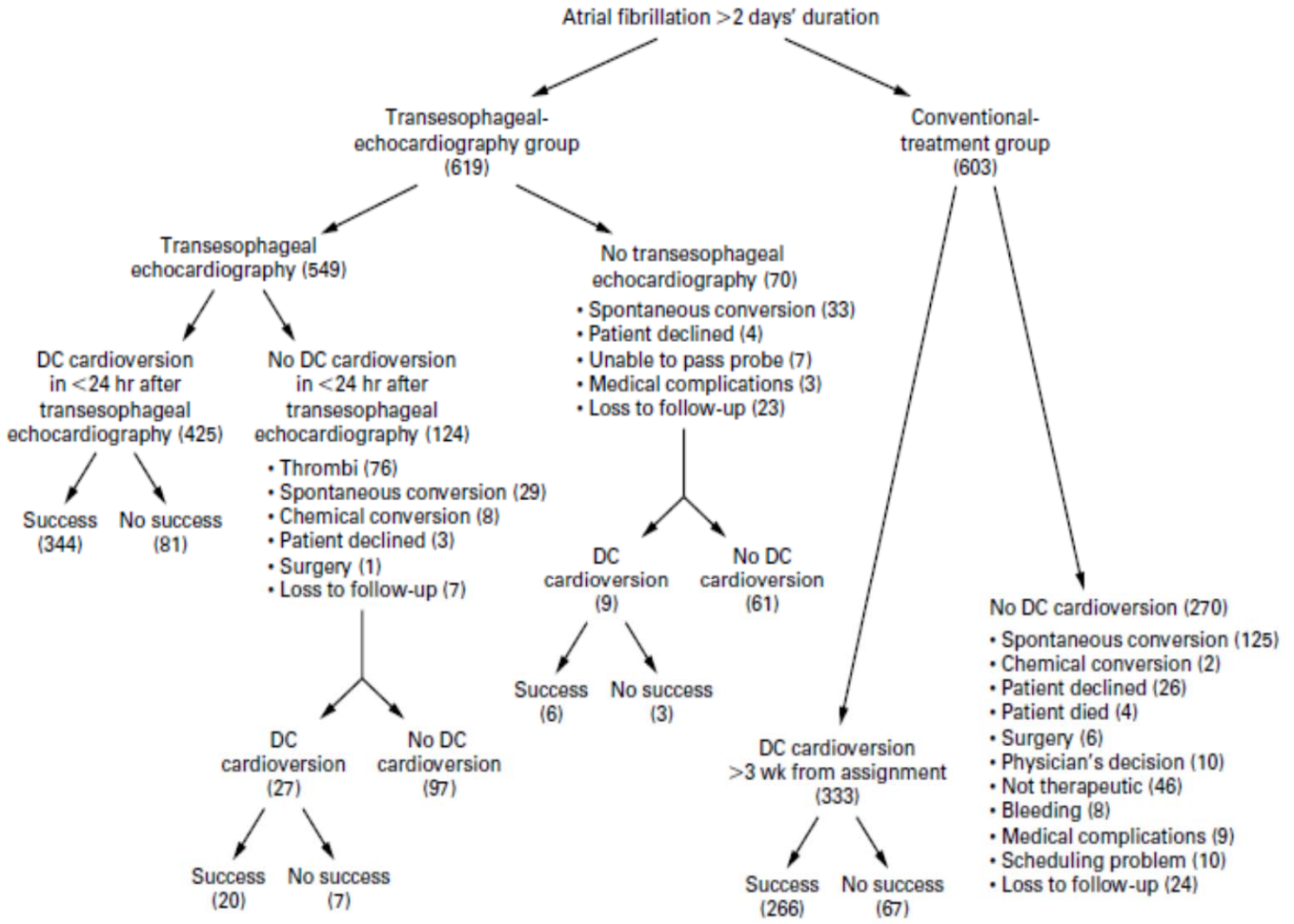


Figure 2. Treatment Outcomes.

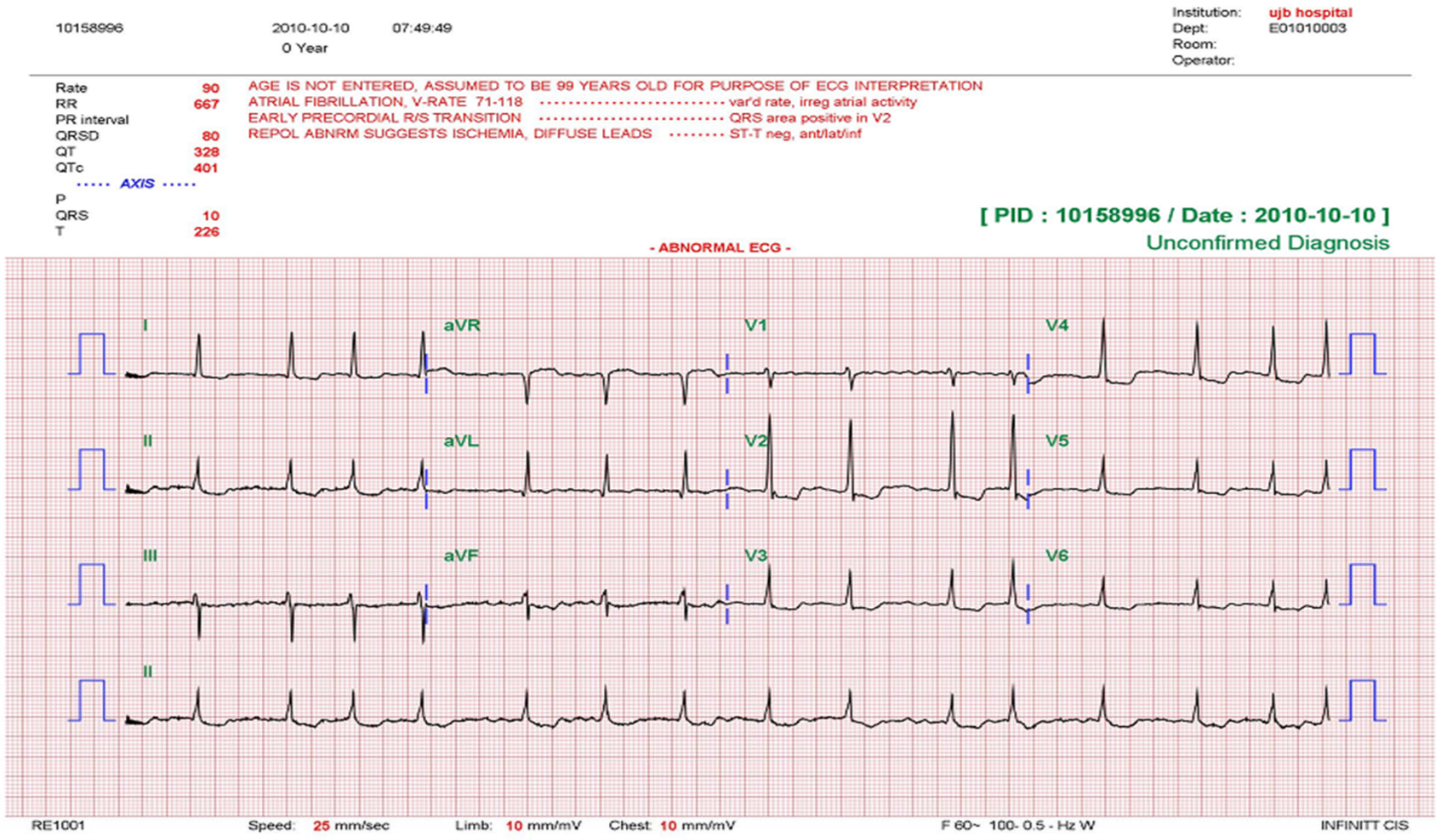
Results of ACUTE Multicenter Study

- there was no difference in the composite end point of stroke, transient ischemic attack and peripheral embolism between the TEE-guided arm and the conventional arms (0.81% vs.0.50%; p = 0.50).
- However, there was a significant difference in the composite end point of major and minor bleeding between the TEE-guided arm and the conventional arms (2.9% vs. 5.5%; p = 0.02)
- there was no significant difference in 8-week maintenance of normal sinus rhythm, cardiac deaths or cardioversion related deaths between the two arms.

ACUTE Multicenter trial

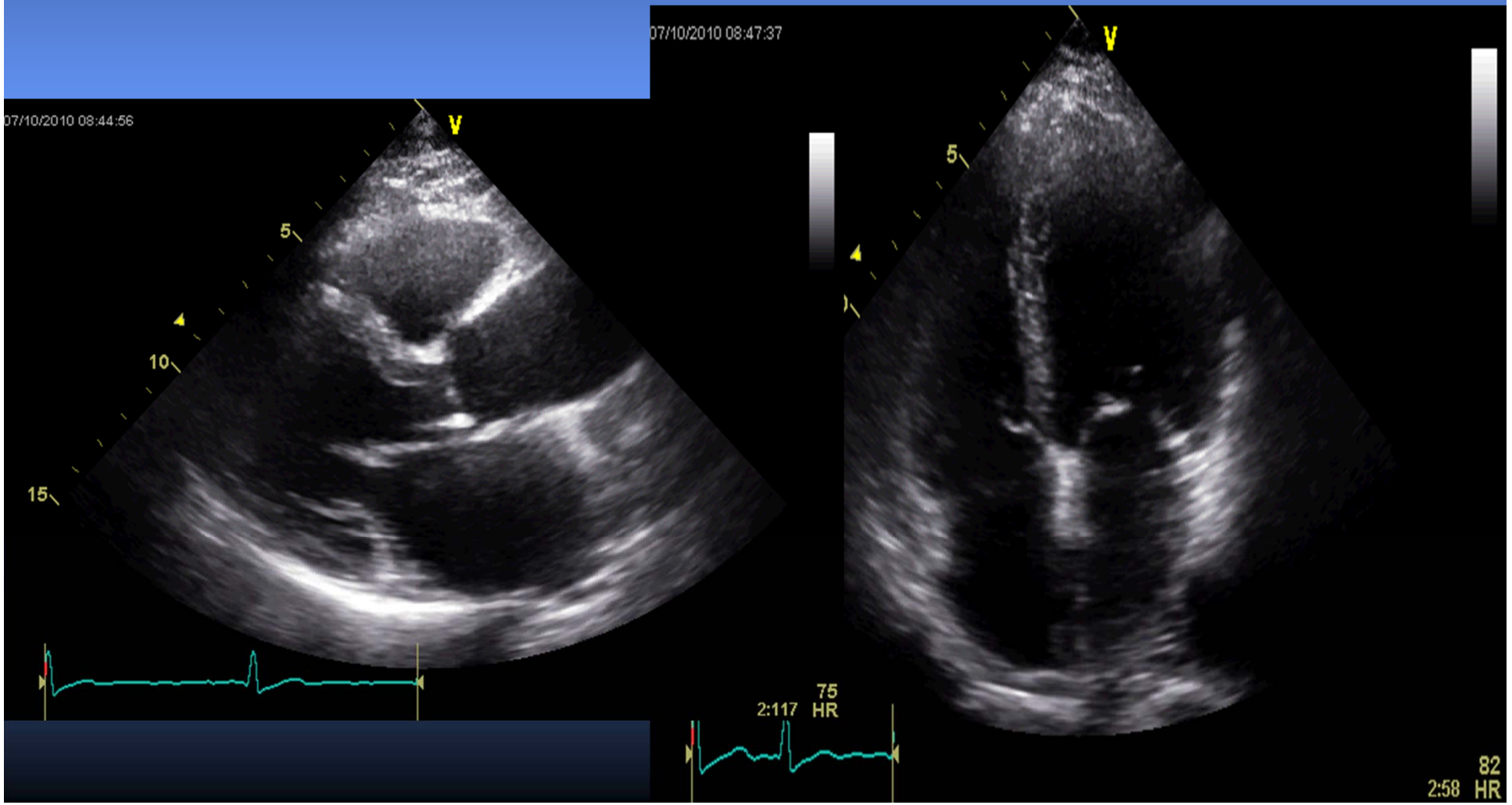
- The TEE-guided approach with short-term anticoagulation may be considered as a clinically effective alternative to the conventional anticoagulation strategy in the management of patients undergoing cardioversion

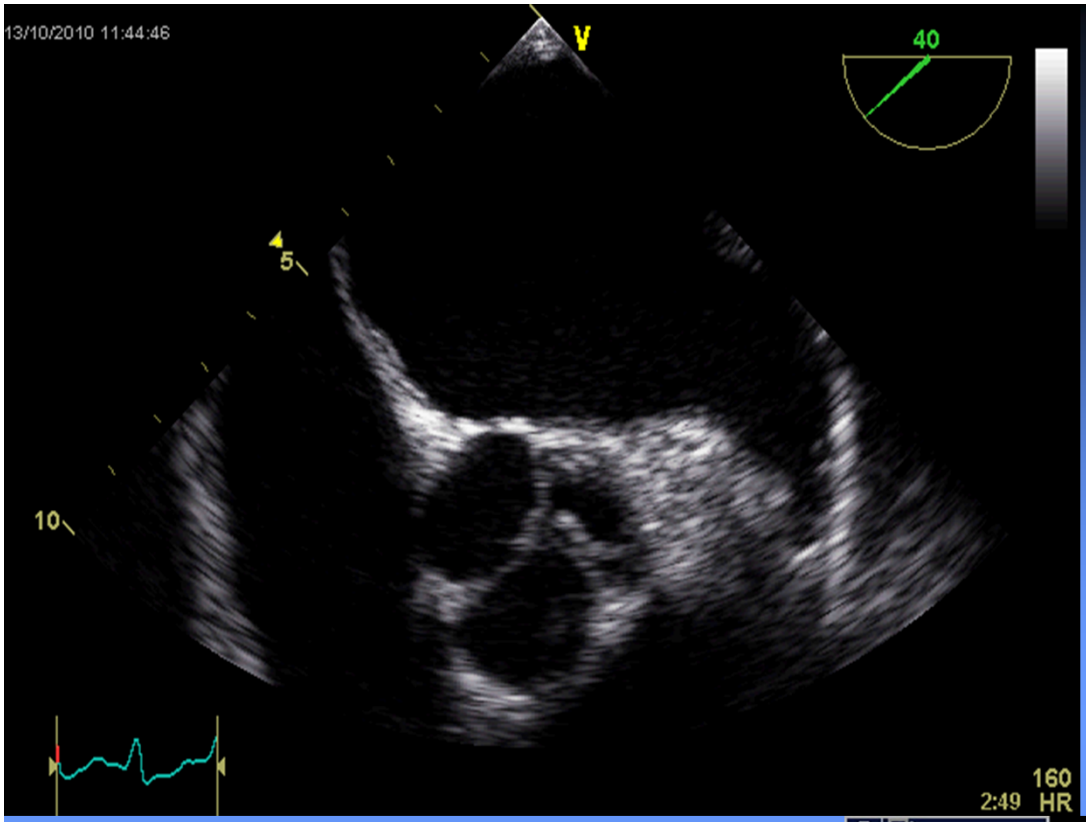
CASE
64/male,palpitation,dyspnea



TTE

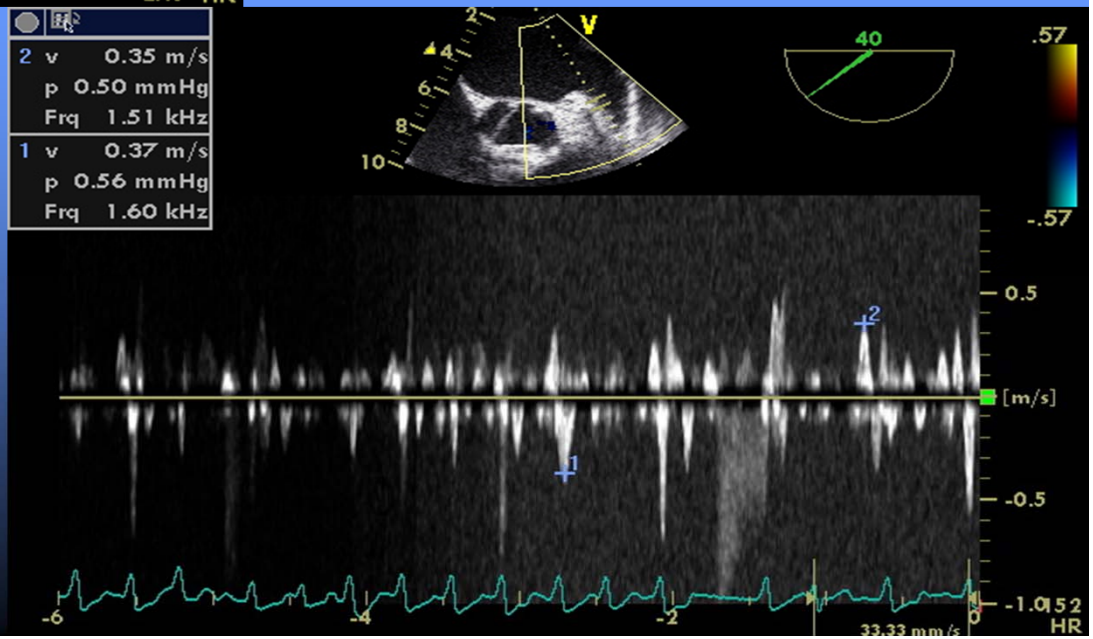
An LA volume index 40 mL/m2



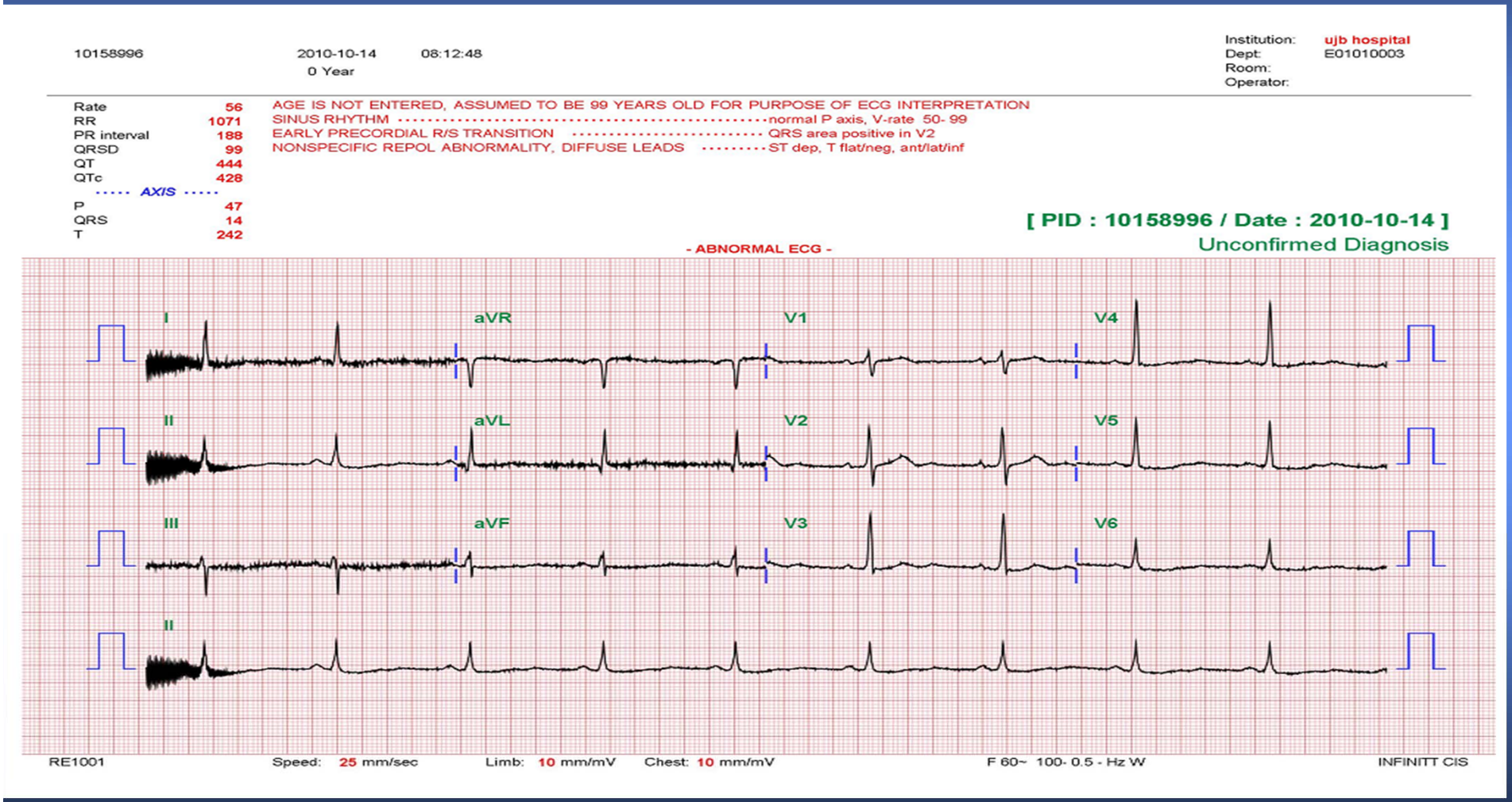


TEE

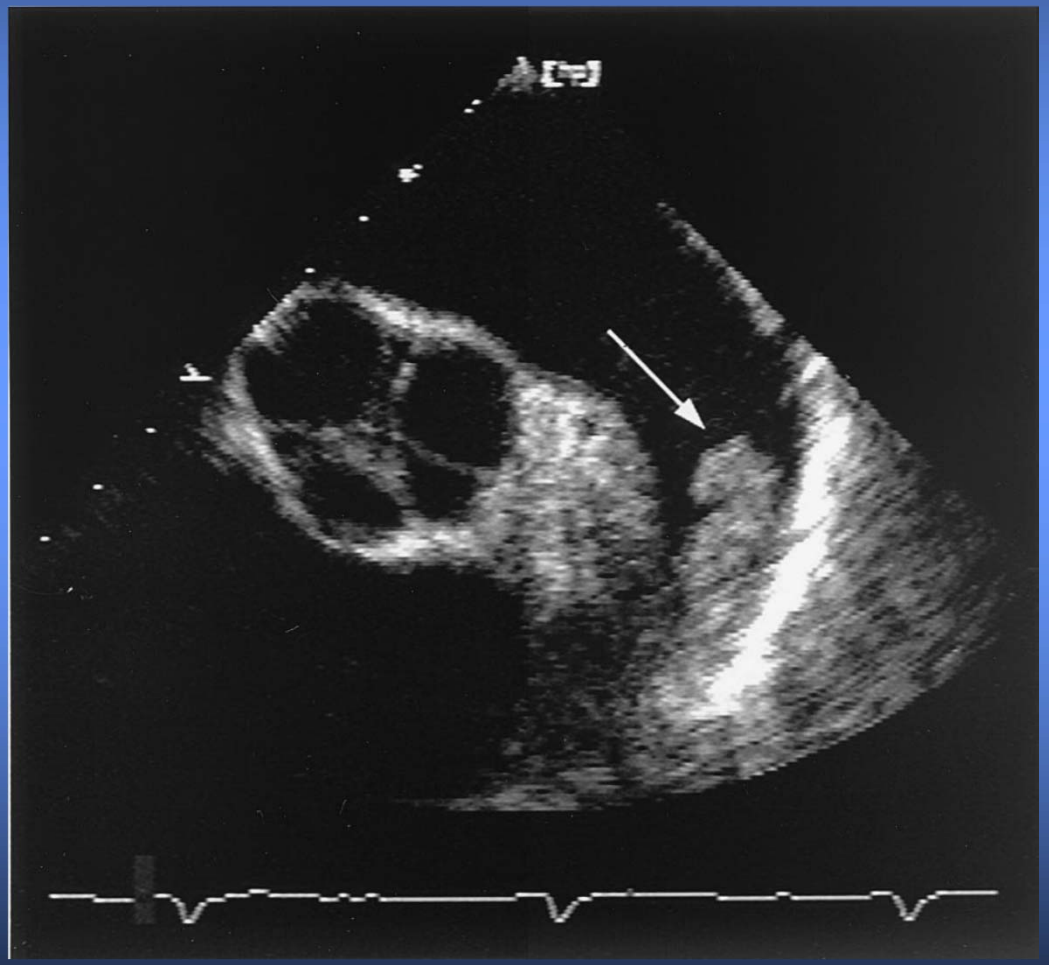
LAA Empting velocity



TEE Guided cardioversion



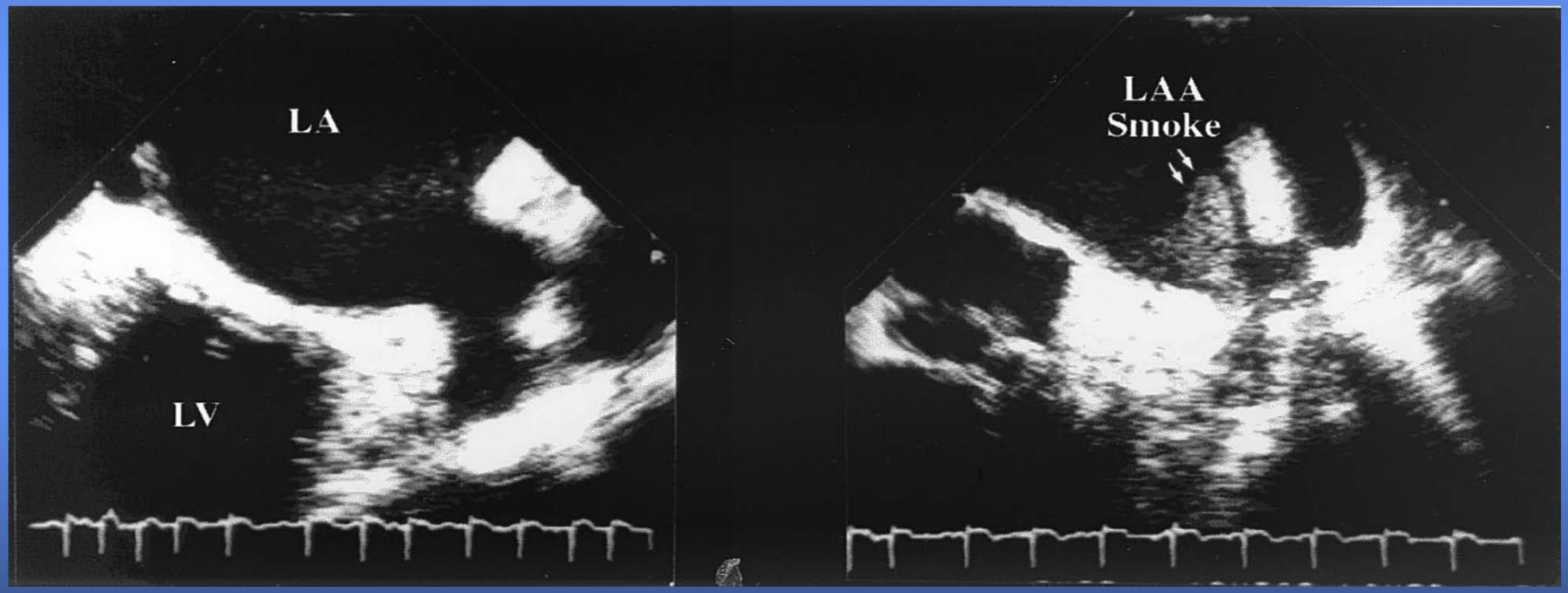
Role of TEE in detection of thrombus



Cardioversion was postponed in this patient.

Klein AL et al.J. Am. Coll. Cardiol. 2001;37;691-704

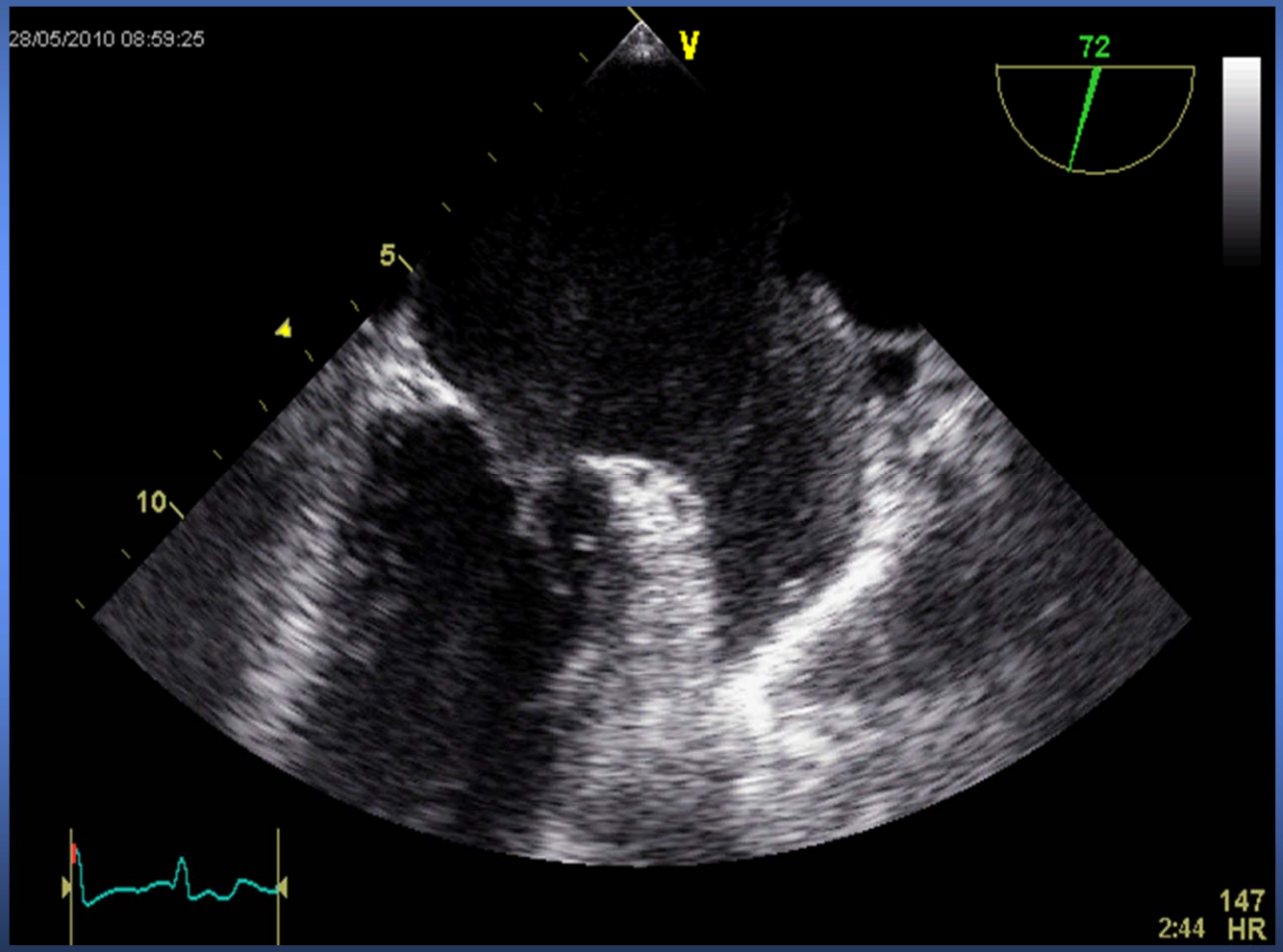
TEE both immediately before and after cardioversion

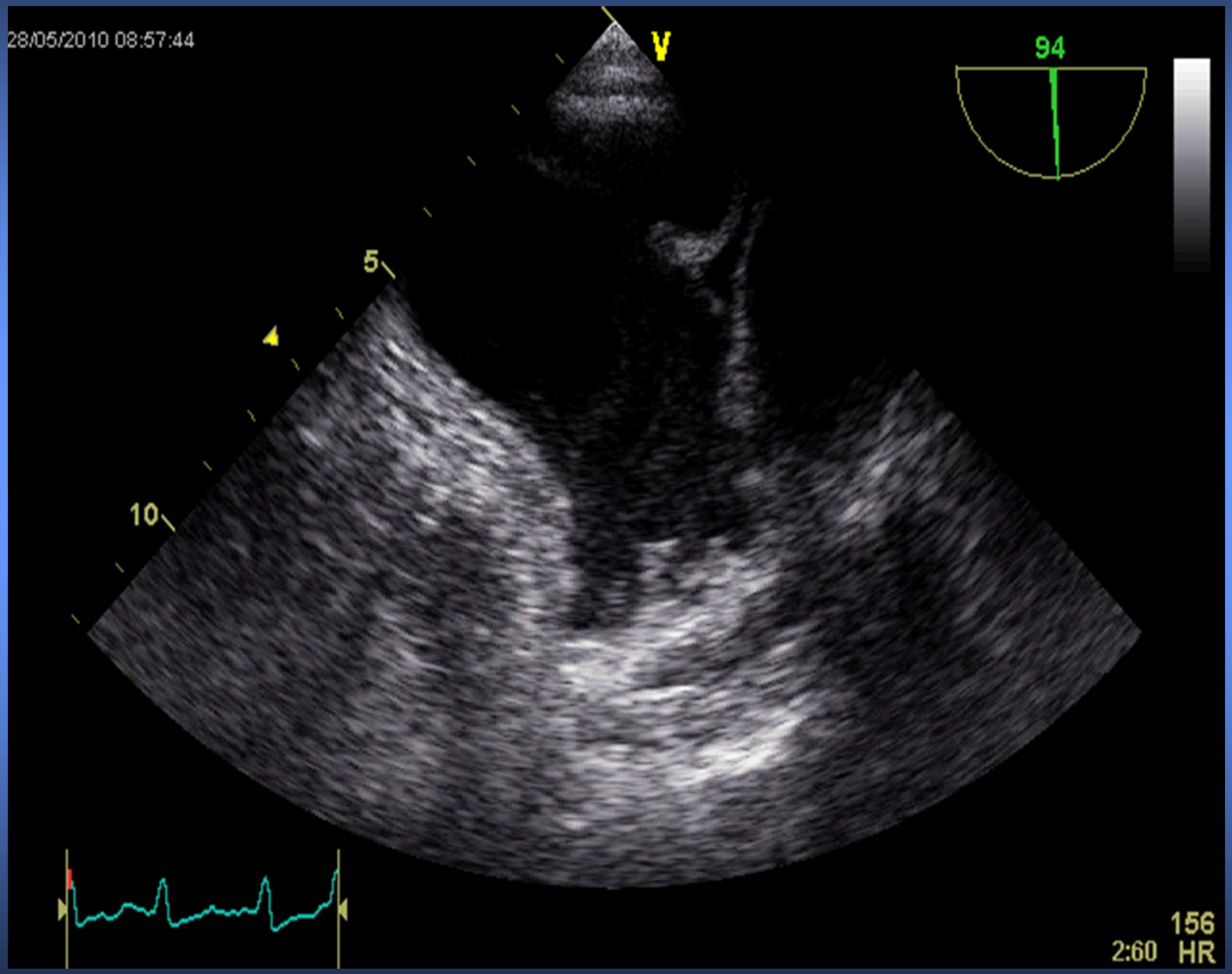


Precardioversion (left) and postcardioversion (right) images of the left atrial appendage (LAA) using TEE. After DC cardioversion, left atrial appendage function diminishes and spontaneous echocardiographic contrast intensifies.

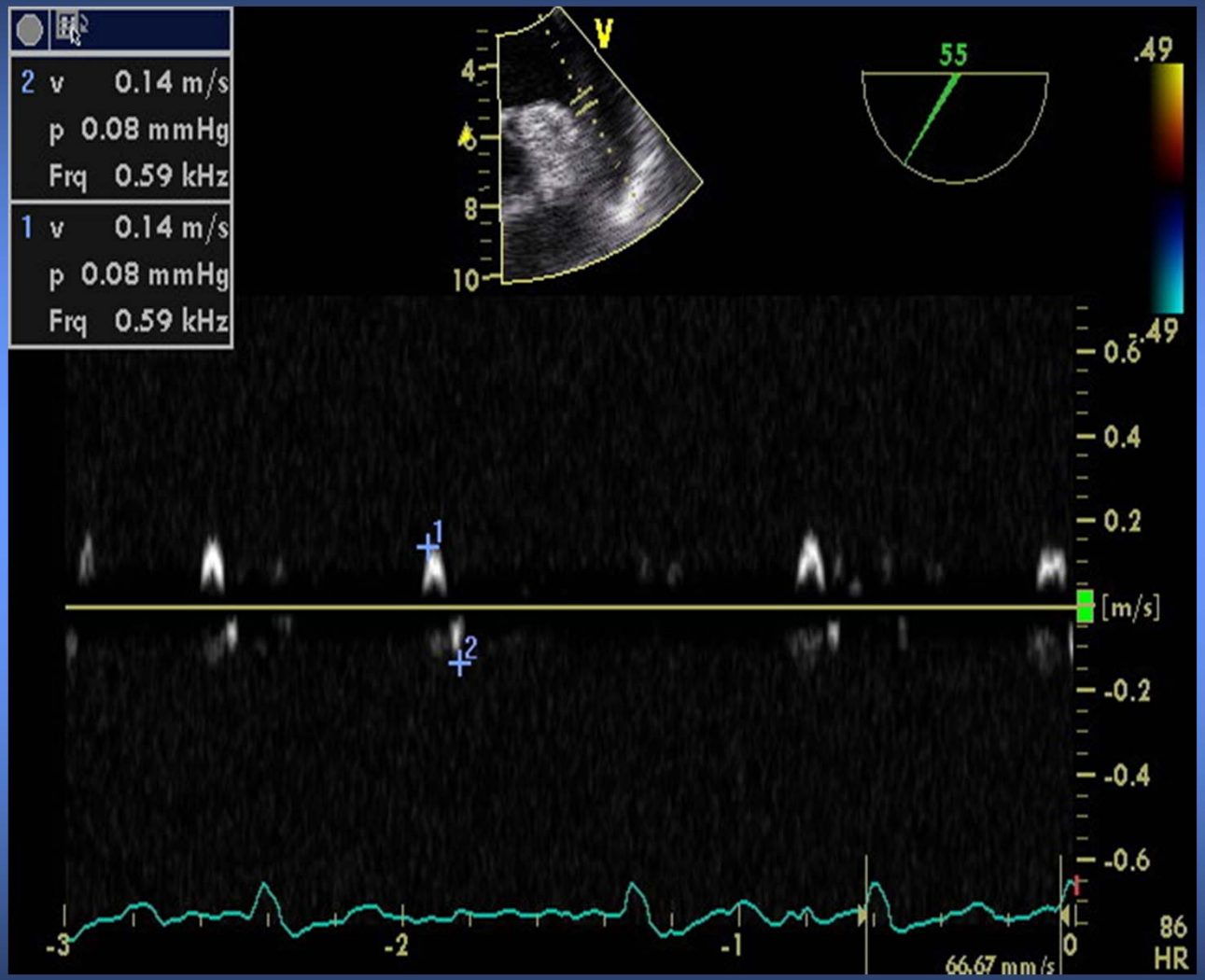
Klein AL et al.J. Am. Coll. Cardiol. 2001;37;691-704

LAA SEC(spontaneous echo contrast)



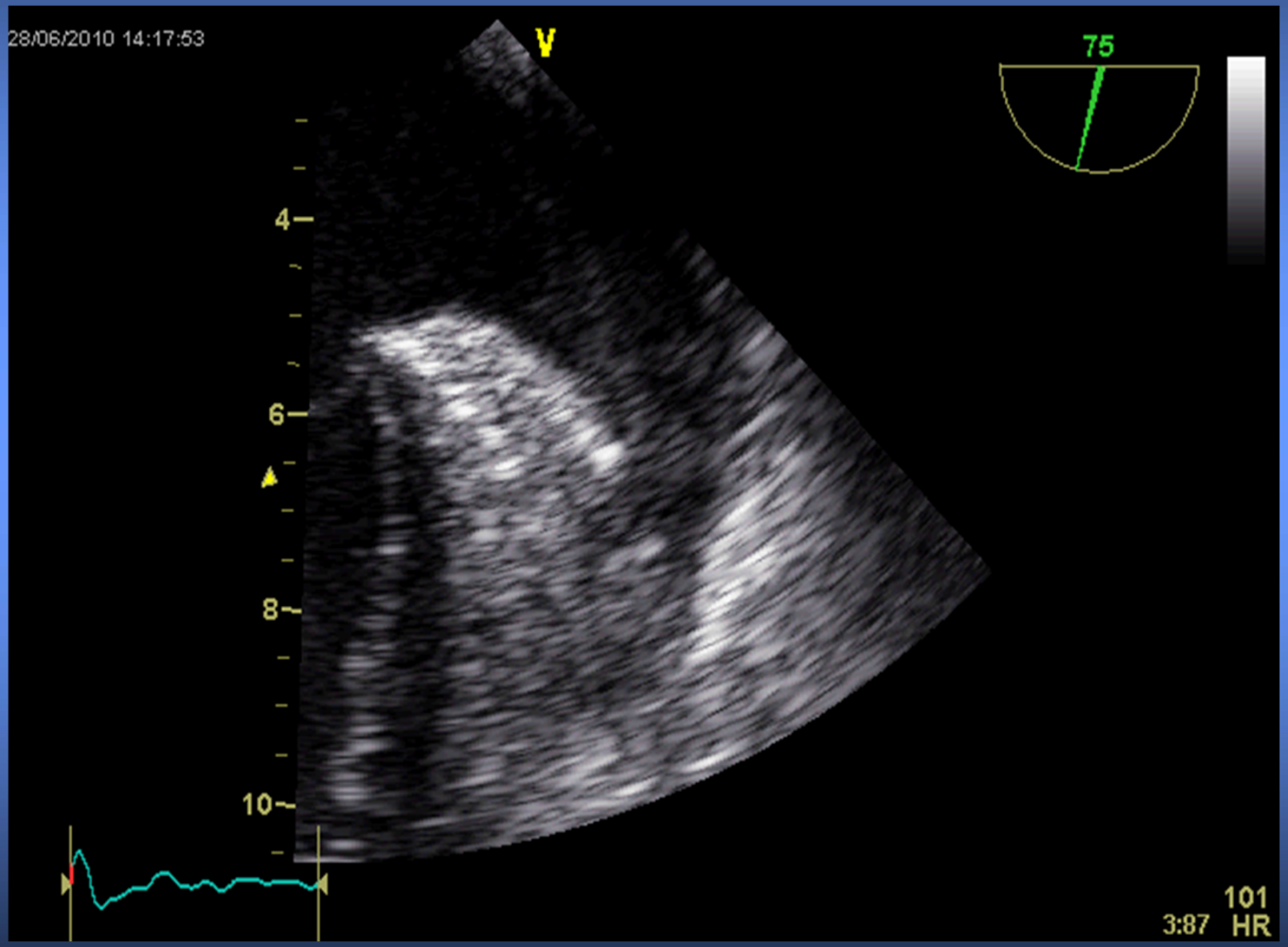

28/05/2010 08:57:44
V
94
5
4
10
156
2:60 HR

Pulsed wave Doppler of the left atrium appendage emptying velocity



Velocities <20 cm/s are associated with spontaneous echo contrast and thrombus formation.

LAA Thrombus



Echo role in AF

- Cardioversion
- Pulmonary vein isolation
- Atrial function

Managing catheter ablation for AF: the role of echocardiography

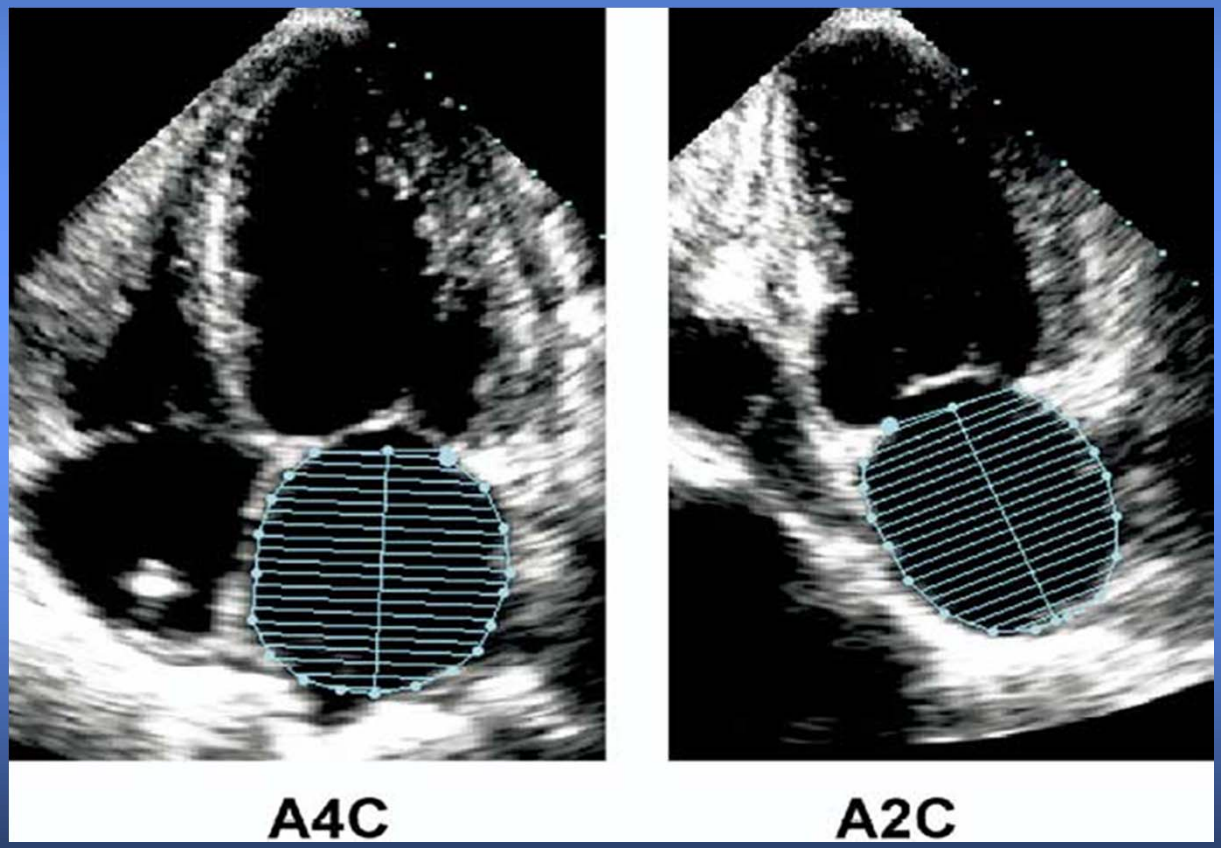
- Initial evaluation and selection of patients for catheter ablation of atrial fibrillation: role of TTE
- Echocardiography in pre-procedural imaging: role of TEE
  - Exclusion of left atrium and left atrium appendage thrombus
  - Assessment of the left atrium and pulmonary vein anatomy and stenosis
- Echocardiography in assessment of complications of catheter ablation
  - Pulmonary vein stenosis

Role of TTE

- Assess baseline LA and left ventricular (LV) size and function and to identify clinically silent valve,myocardial, pericardial, and congenital heart disease which may predispose to AF.
- TTE can readily determine LA size and function. LA diameter measurements from M-mode echocardiography have a tendency to underestimate true LA size; hence ideally LA volume assessment should use the area–length or Simpson's formula.
- An LA volume index of > 41 mL/m2 can predict recurrence of AF after catheter ablation.
- Recently, the use of three dimensional echocardiography to assess LA volume has been validated against MRI and has less test/retest as well as inter- and intra-observer variability compared with 2D echocardiography methods

- Reliable and reproducible qualitative and quantitative volumetric measures of LV size and EF are easily obtained from TTE
- Catheter ablation of selected symptomatic patients with AF and heart failure and/or reduced ejection fraction(EF) may be appropriate.
- LA volume index 34 mL/m2 is an independent predictor of death, heart failure, atrial fibrillation, and ischemic stroke.

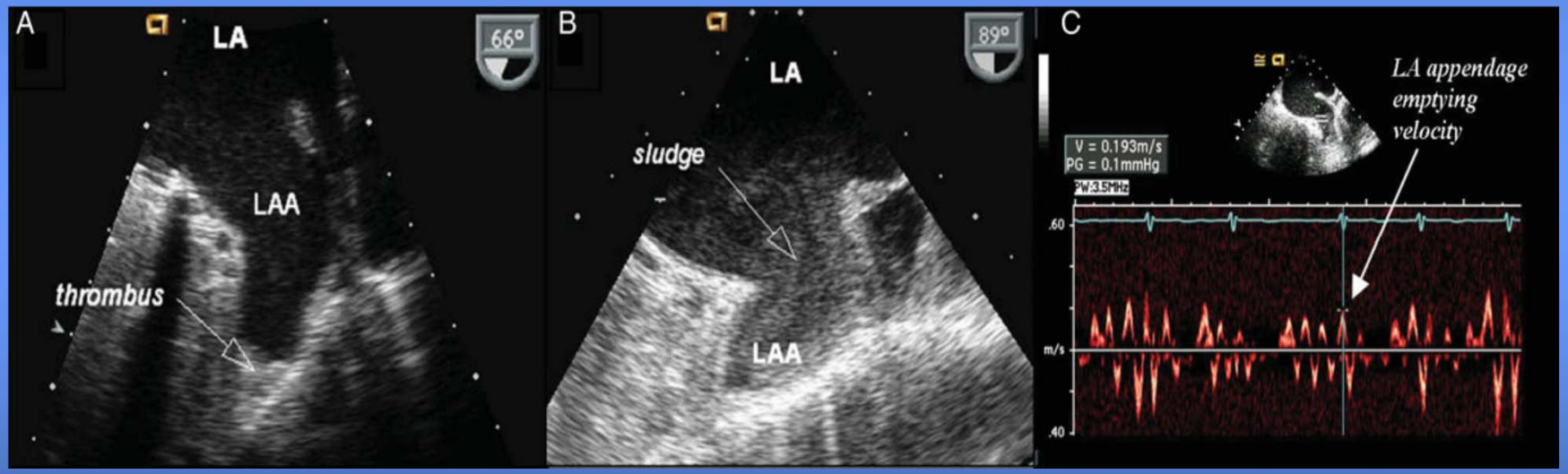
Measurement of left atrial (LA) volume from biplane method of disks (modified Simpson's rule) using apical 4-chamber (*A4C*) and apical 2-chamber (*A2C*) views at ventricular end systole (maximum LA size).



ASE COMMITTEE RECOMMENDATIONS for Chamber Quantification.
JASE, December 2005

Echocardiography in pre-procedural imaging: role of TEE

Exclusion of left atrium and left atrium appendage thrombus
The presence of thrombus in the LA or LA appendage is an absolute contraindication to catheter ablation of AF



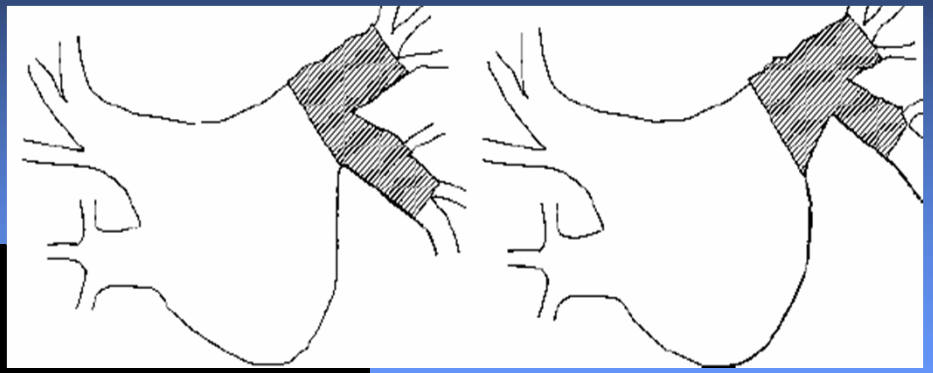
(A) Thrombus in the left atrial appendage;
(B) 'Sludge' is an intermediate stage of thrombosis characterized by precipitous, dense spontaneous echo contrast seen throughout the cardiac cycle;
(C) Pulsed wave Doppler of the left atrium appendage emptying velocity measured at end diastole. Velocities <20 cm/s are associated with spontaneous echo contrast and thrombus formation.

Ruvin S. Gabriel and Allan L. Klein Europace (2008) 10, iii8–iii13

Assessment of the left atrium and pulmonary vein anatomy and stenosis

- Accurate definition of PV and LA anatomy is essential for planning catheter ablation procedures for AF.
- Variation in PV anatomy is common with 18–44% of patients
- Unusual PV configurations can substantially influence the success rate of catheter ablation, particularly if variant veins are not adequately treated.
- The presence of a single ostium for the left PV predicted a lower maintenance of sinus rhythm at 12 months
- While CT and MRI remain the imaging modalities of choice, TEE can also identify differences in PV anatomy. Concordance with MRA was high at 95%

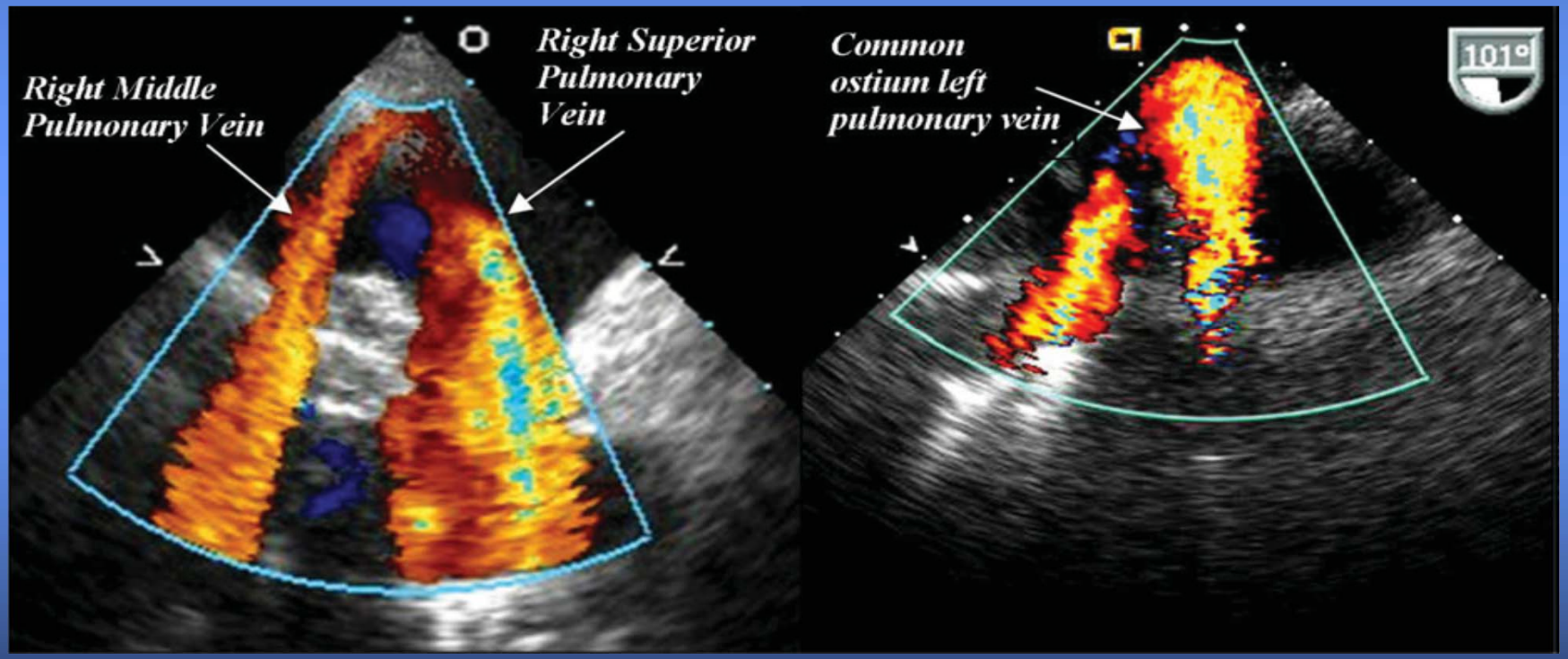
Variation in PV anatomy



Anatomic variation

- Common trunk
  conjoined vessel with saddle outside the border of left atrium
  - long common trunk :
  - short common trunk :
- Accessory Vessel: additional vessel more than typical 4 vessel, drain to LA directly (rt.middle vein)

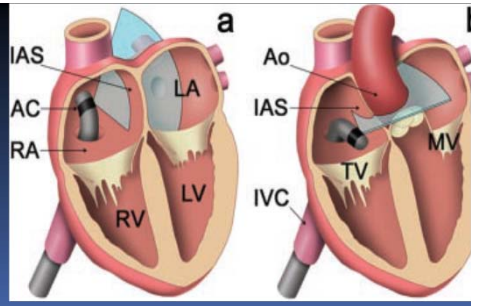
Assessment of variation in pulmonary venous anatomy



Examples of variation in pulmonary venous anatomy

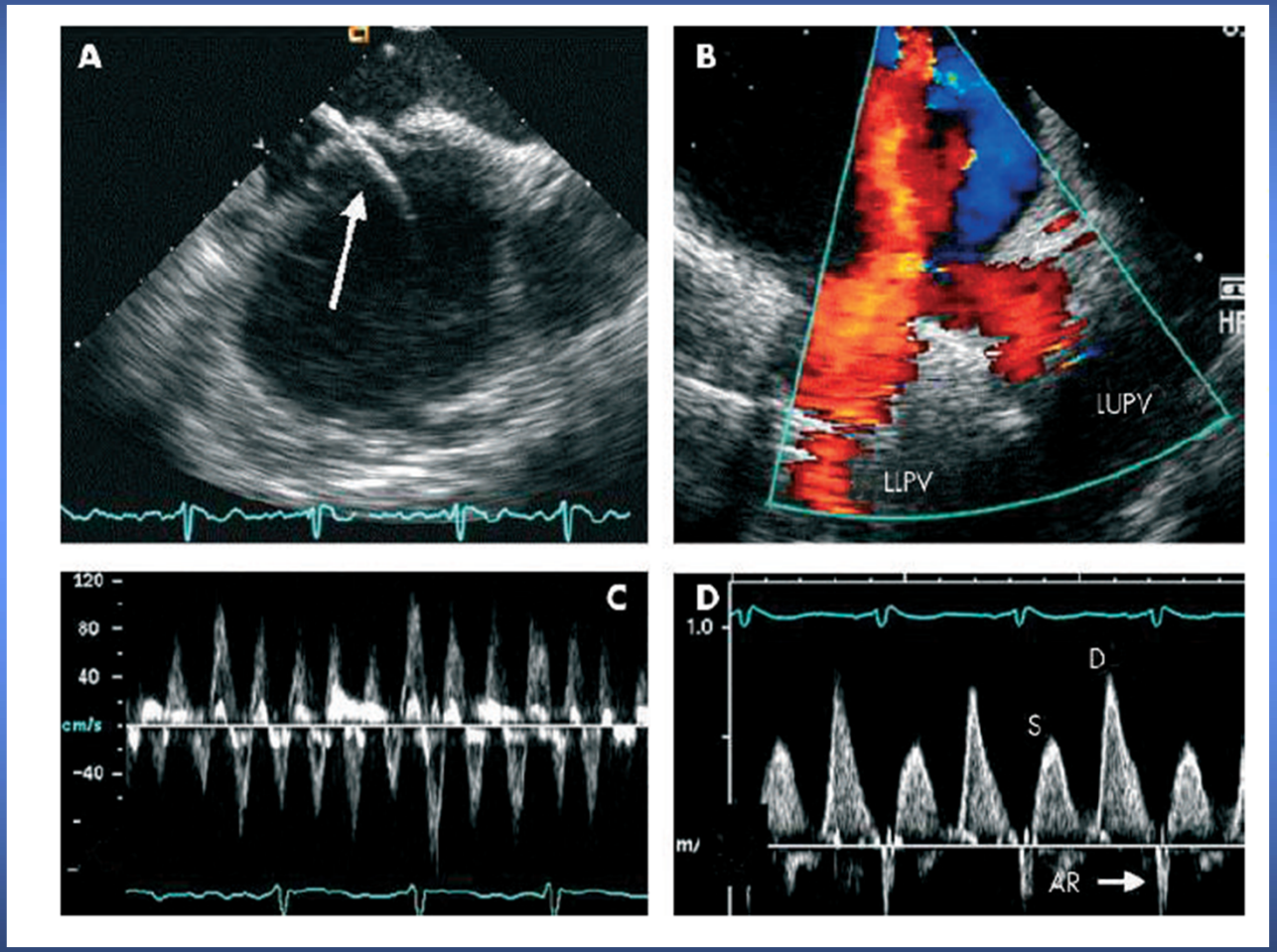
Separate ostium for the right middle and superior pulmonary veins (left).
Common ostium of the left superior and inferior pulmonary veins (right).

Intracardiac Echocardiography(ICE)



- Intracardiac echocardiography (ICE) is performed with a 6–12 MHz transducer placed in the right atrium via a 6–10 French sheath in the right femoral vein.
- Modified from intravascular ultrasound probes, these steerable monoplane transducers produce ultrasound waves mechanically or, like TEE, via a phased array.
- The latter offer the same modalities as TEE including color, pulsed wave, and continuous wave Doppler, to allow assessment of intracardiac flow in addition to 2D visualisation of structures.
- ICE can play a key role in the guidance of cardiac interventions and in some centres is used routinely for radiofrequency ablation procedures as well as recently for percutaneous closure of patent foramen ovale or atrial septal defects.
- The routine use of intracardiac echocardiography (ICE) to identify PV ostia and avoiding ablation within the PV itself has significantly reduced the incidence of this complication, with published rates ranging from 0 to 38%.

Images acquired from intracardiac echocardiography (ICE)



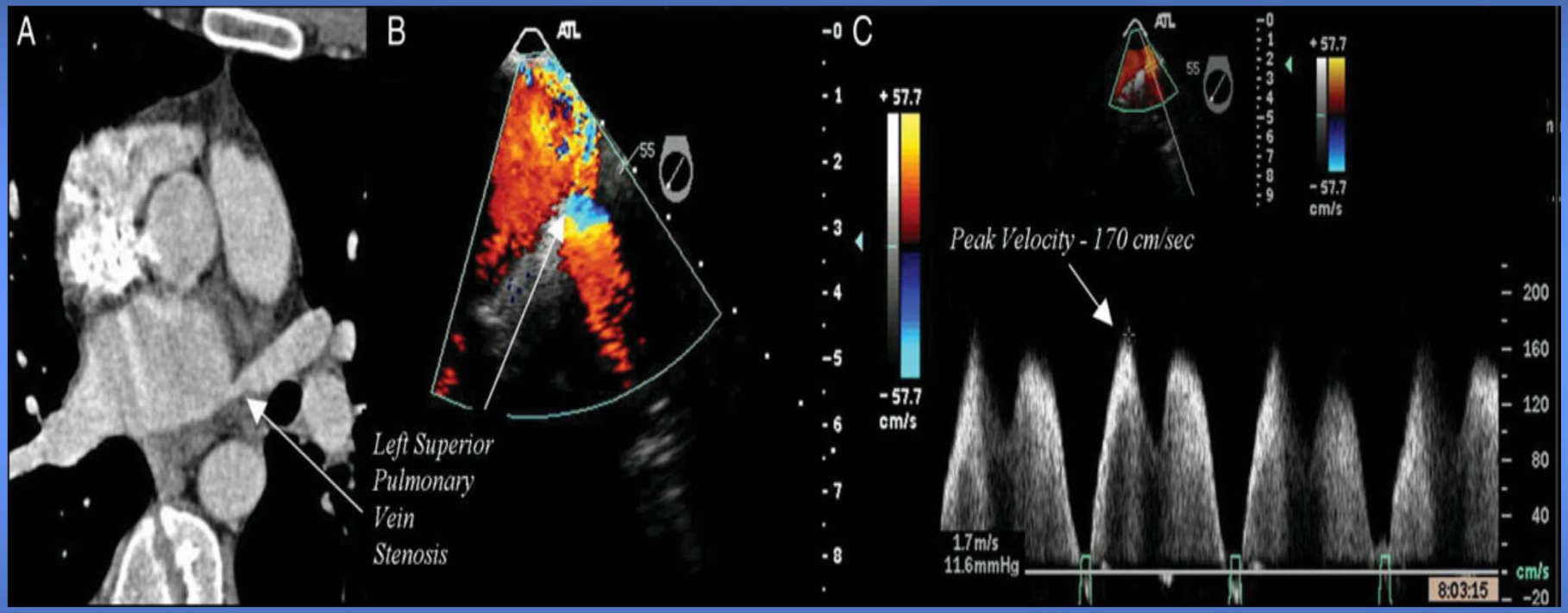
(A) Transeptal puncture with catheter(arrow) passing from right atrium to left atrium.
(B) Colour flow mapping showing the confluence of the left upper and lower pulmonary veins (LUPV and LLPV).
(C) Pulsed wave Doppler of the LAA showing preservation of velocities in a patient with AF.
(D) Pulsed Doppler of the LUPV showing blunting of systolic (S) flow compared to diastolic (D) flow and a narrow atrial systolic reversal (AR) following cardioversion in the same patient.

Major complications of AF ablation

- PV stenosis
- Tamponade
- Stroke
- Atrio-esophageal fistula
- Phrenic nerve injury

Pulmaonary vein (PV) stenosis is a potential complication and may lead to symptoms that are often go unrecognized.

TEE can identify significant pulmonary vein stenosis



A diameter of < 7 mm may be sufficient to call significant anatomic stenosis

(A) CT scan with ostial narrowing in the left superior pulmonary vein

(B) Significant ostial narrowing with turbulence and aliasing of the color Doppler identifies significant pulmonary vein stenosis on transoesophageal echocardiography

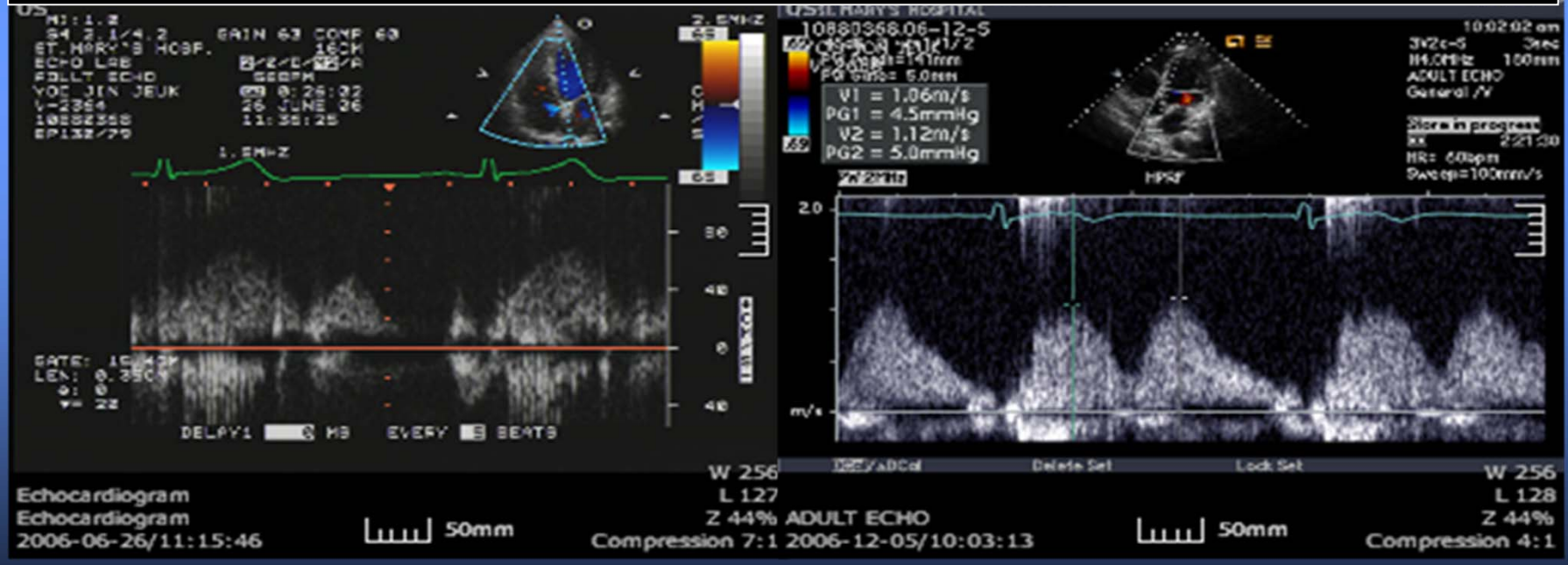
(C) Pulsed-wave Doppler of pulmonary venous inflow.
>100 cm/s confirms haemodynamically significant stenosis.

Ruvin S. Gabriel and Allan L. Klein Europace (2008) 10, iii8–iii13

TTE can identify significant pulmonary vein stenosis

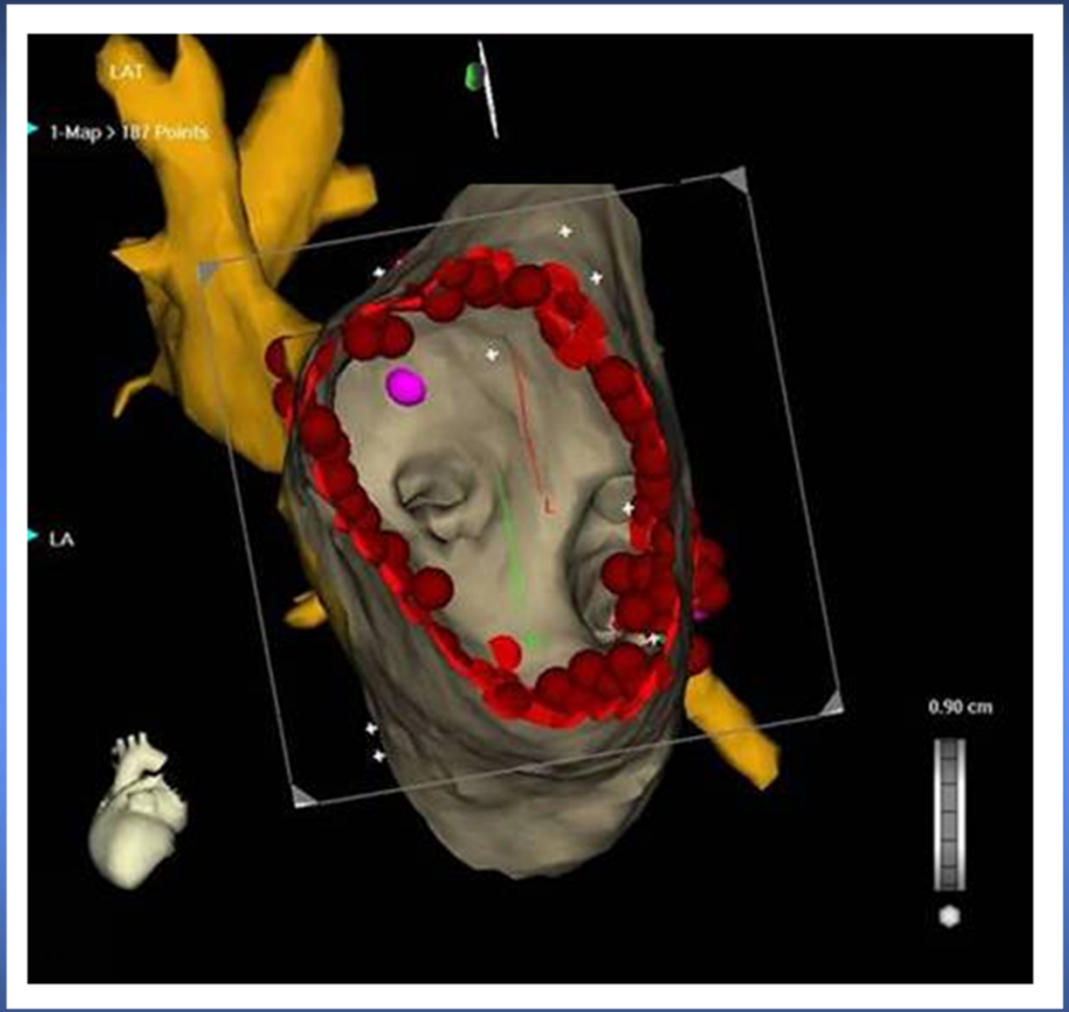
- AF, M/49

1 week After Catheter Ablation	6 month After Catheter Ablation



Using Transthoracic Doppler echocardiography,
PV stenosis was defined as a postprocedural maximum PVF >110 cm/sec, corresponding to data published by Yu et al.
J Cardiovasc Electrophysiol 2001;12:887-92.

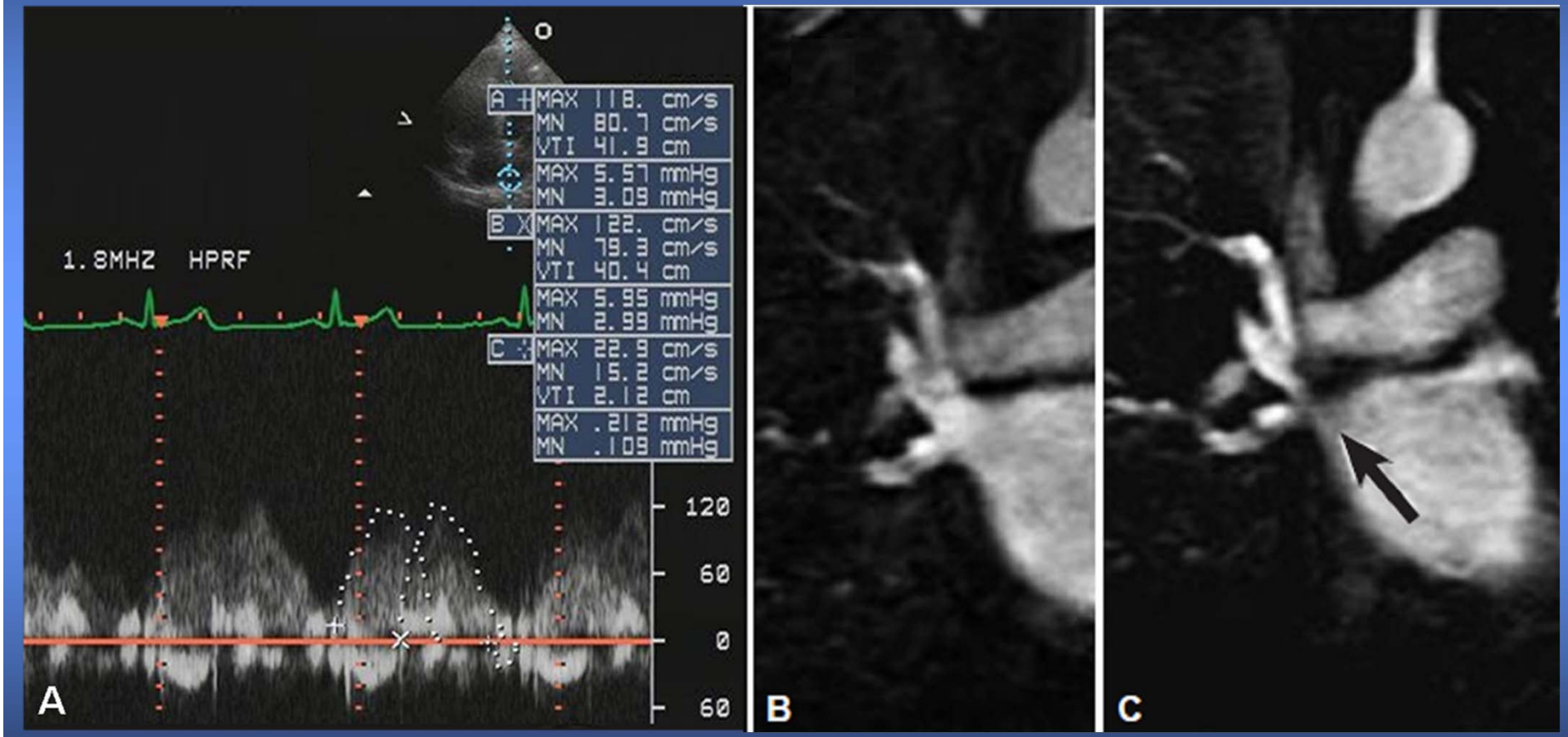
CARTOMERGE images of LA and PV that have registered a 3-D CT image with the GPS-like CARTO system (endoscopic view).



LA: left atrium, PV: pulmonary vein, 3-D CT: 3-dimensional computed tomography, GPS: global positioning system.

Lee DH, Oh YS, et al. Korean Circ J 2010;40:442-447

Fig. 3. Doppler (A) and MR imaging (B: pre ablation, C: post ablation) of PV in patients with pulmonary vein stenosis that developed after PVI. The black arrow showed significant right superim vein stenosis.



MR: magnetic resonance, PV: pulmonary vein, PVI: pulmonary vein isolation.

Lee DH, Oh YS, et al. Korean Circ J 2010;40:442-447

Echocardiography in anticoagulation and thromboembolism prevention post-catheter ablation

Table 1 Echocardiographic predictors of thrombo-embolism

Echocardiographic predictors of thrombo-embolism
• Left ventricular dysfunction
• Increased left atrial size
• Left atrial appendage thrombus/sludge
• Severe spontaneous echo contrast
• Left atrial mechanical dysfunction (appendage emptying velocity <20 cm/s)
• Complex aortic atheroma

Ruvin S. Gabriel and Allan L. Klein Europace (2008) 10, iii8–iii13

Echo role in AF

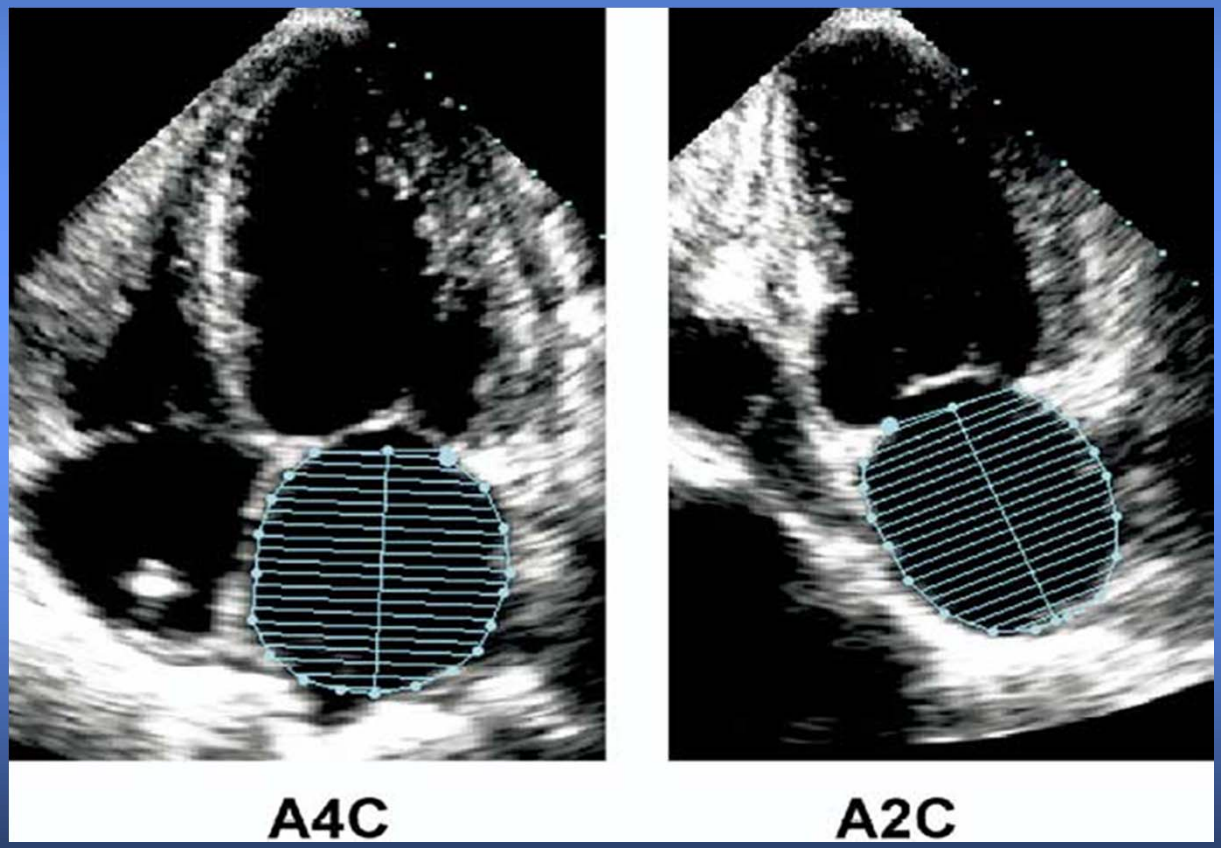
- Cardioversion
- [illegible]
- Atrial function

Echo role in AF : Atrial function

Atrial mechanical function prior to and after ablation, cardioversion

- Phasic LA volumes
- Transmitral peak early (E) and atrial (A) wave velocities,
- Pulsed tissue Doppler imaging of the atrial (A') wave
- Atrial strain, and strain rate

Measurement of left atrial (LA) volume from
biplane method of disks (modified Simpson's rule) using
apical 4-chamber (*A4C*) and apical 2-chamber (*A2C*) views
at ventricular end systole (maximum LA size).



ASE COMMITTEE RECOMMENDATIONS for Chamber Quantification.
JASE, December 2005

Phasic LA volumes

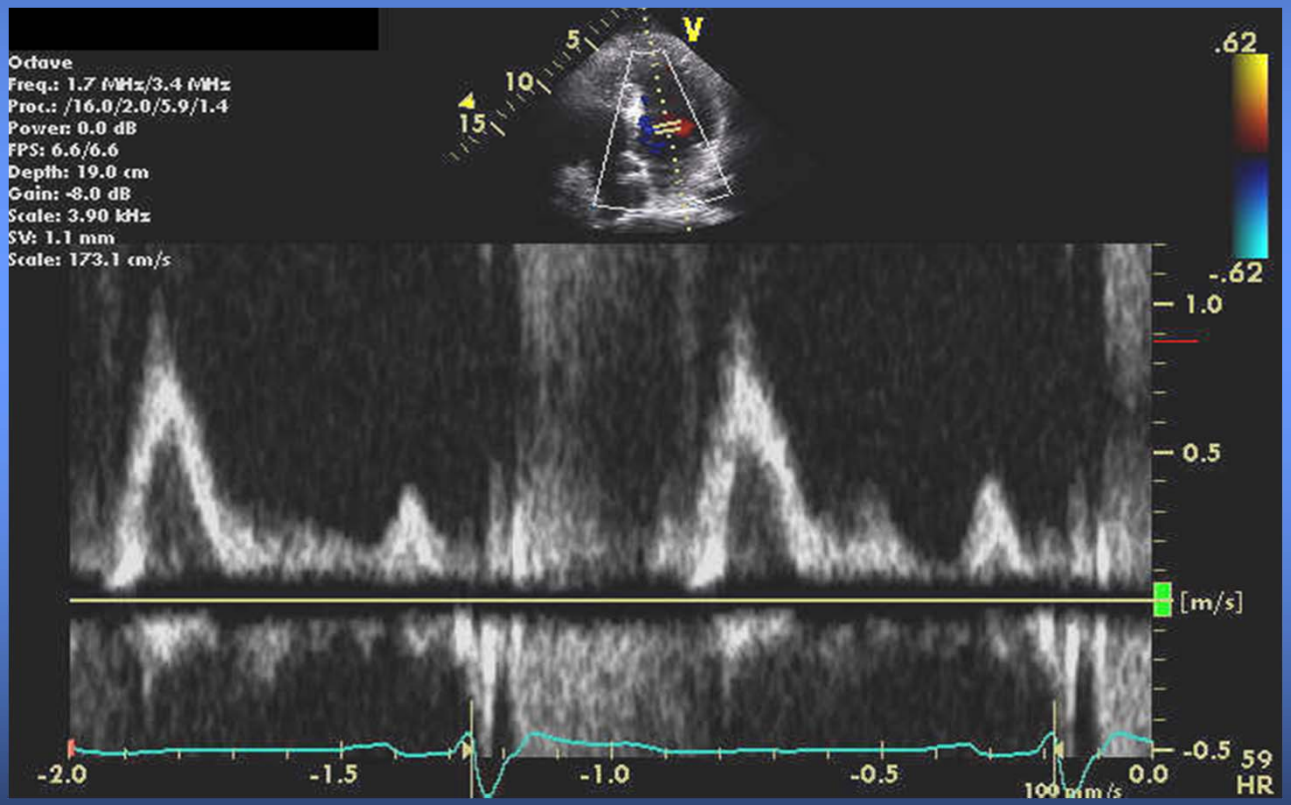
- The following LA volumes were measured:
  - maximum LA volume (before mitral valve opening),
  - pre-A volume (before atrial contraction), and
  - minimum volume (after atrial contraction).

- LA emptying fraction was computed as the difference between LA maximum and minimum volumes/maximum volume,

- LA EF was computed as the difference between LA pre-A and minimum volumes/pre-A volume.

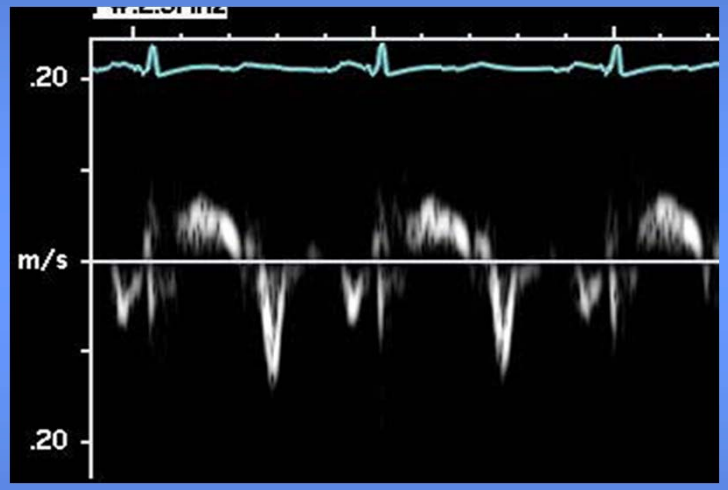
Mustafa Kurt,et al.Circ Cardiovasc Imaging 2009;2;10-15

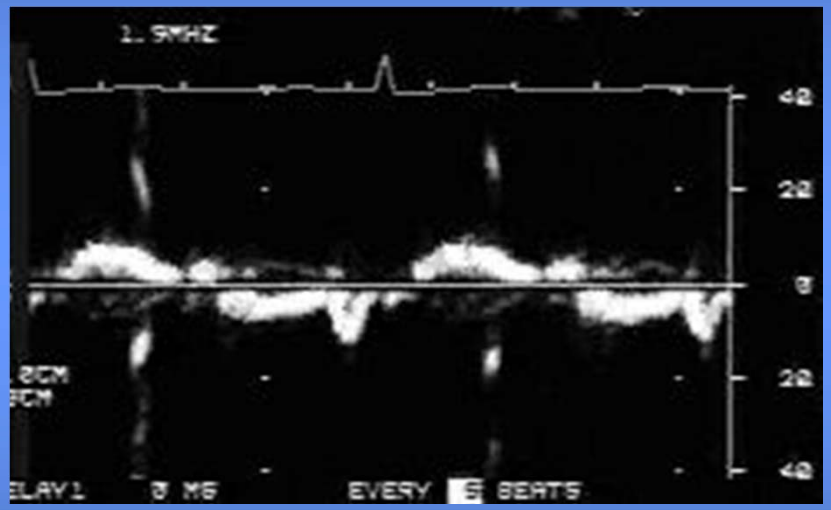
Transmitral peak early (E) and atrial (A) wave velocities



Nagueh et al. JASE 2009:22(2):107-34

Pulsed tissue Doppler imaging of the atrial (A') wave





Nagueh et al. JASE 2009:22(2):107-34

LA Strain, Strain rate

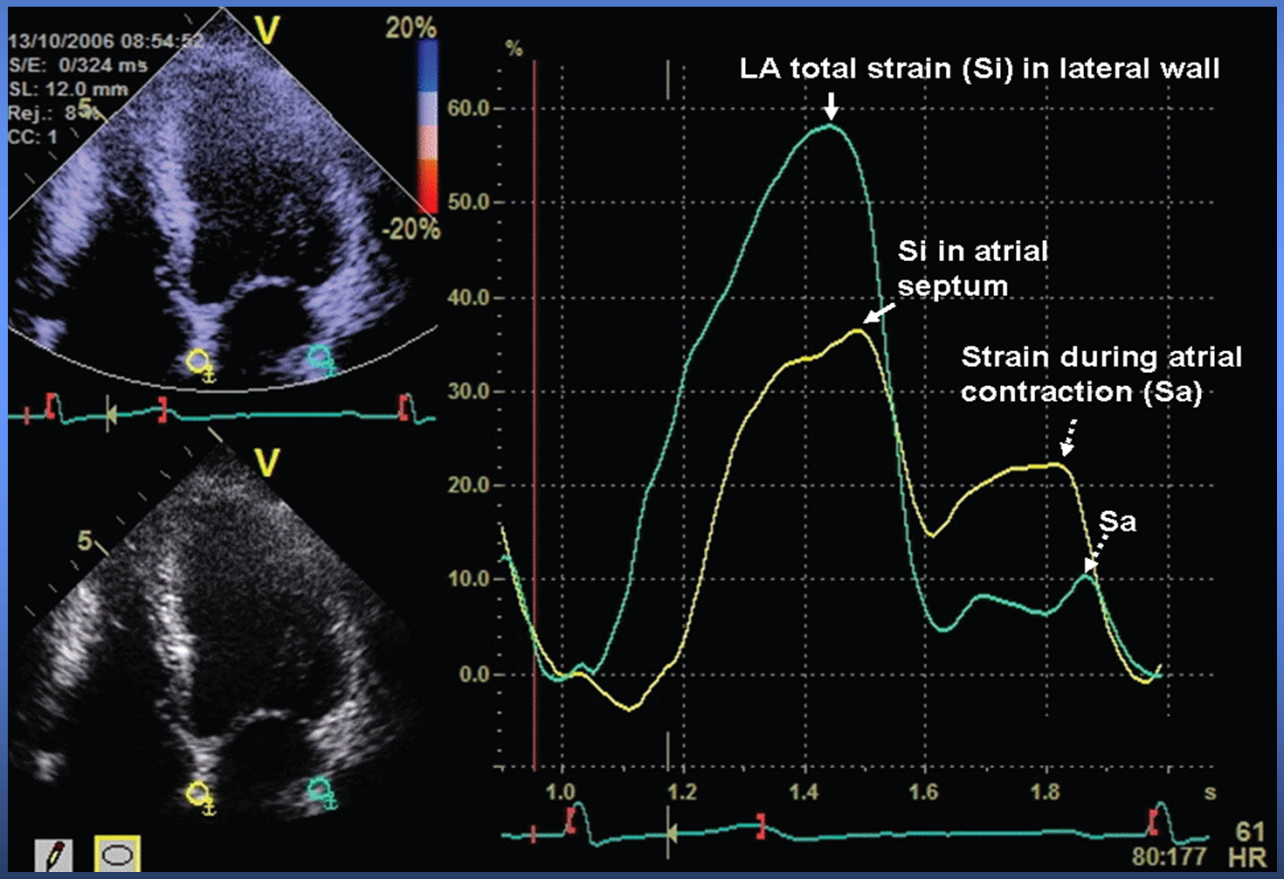
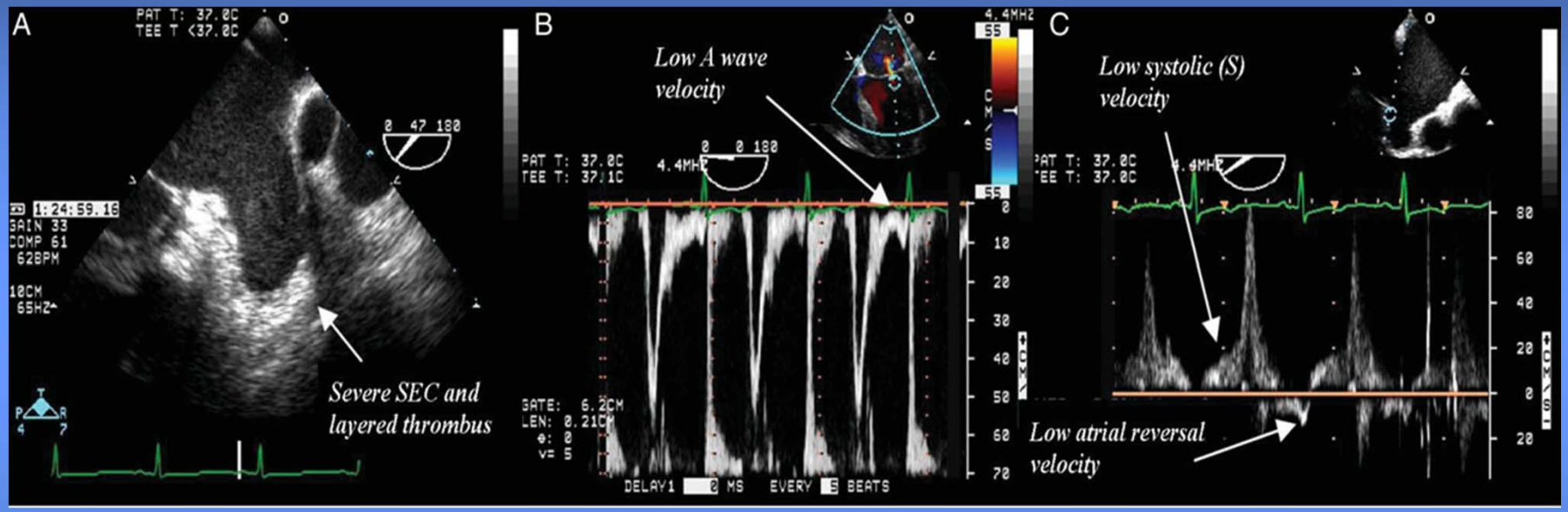


Figure 1. Example of LA strain curves. Septal LA strain is shown in yellow, and lateral strain is shown in blue. LAS strain refers to LA strain during the systolic phase of the cardiac cycle, and LAA strain refers to LA strain during atrial contraction.

Mustafa Kurt,et al.Circ Cardiovasc Imaging 2009;2;10-15

Atrial mechanical function



In a patient in normal sinus rhythm 3 months post-atrial fibrillation ablation:

(A) Severe spontaneous echo contrast and layered thrombus in left atrium appendage;
(B) Low transmitral pulsed Doppler atrial (A) wave velocity (10 cm/s);
(C) Markedly blunted systolic (S) flow and low atrial reversal wave velocity
on pulsed Doppler of the right superior pulmonary vein (,10 cm/s).

Ruvin S. Gabriel and Allan L. Klein Europace (2008) 10, iii8–iii13

Echo role in AF

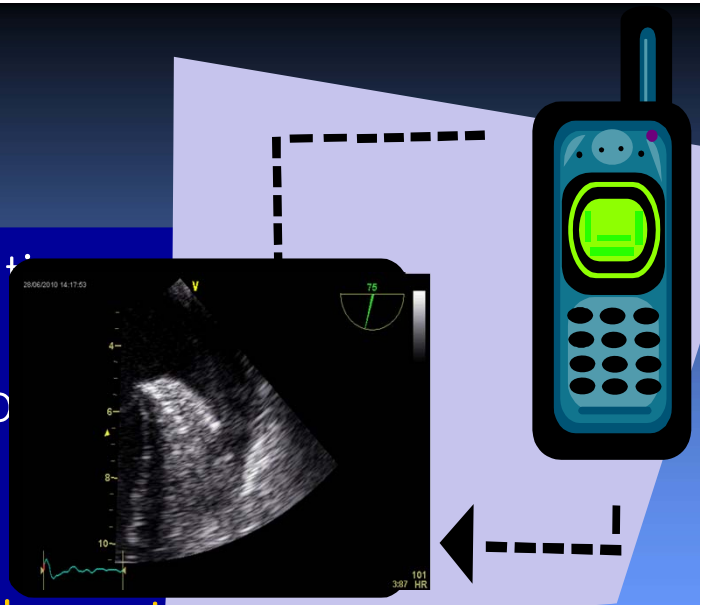
Table 1 Summary of the indices measured by different echocardiographic modalities

Transthoracic echo	LA dimensions and volumes LV dimensions and volumes LVEF LV diastolic function Valvar function
Transoesophageal echo	LA/LAA: structure, function, SEC, and thrombus RA/RAA structure, function and thrombus Pulmonary vein anatomy/flows Inter-atrial septum (PFO, etc) Ascending aorta and arch atheroma Valvar function Guide therapy*
Intracardiac echo	LA/LAA structure and function LA/LAA thrombus Inter-atrial septum Pulmonary vein anatomy/flows Guide therapy*

*Radiofrequency ablation, valvoplasty, PFO/ASD closure devices, LAA occlusion device insertion.
ASD, atrial septal defect; LA, left atrium; LAA, left atrial appendage; LV, left ventricle; LVEF, left ventricular ejection fraction; PFO, patent foramen ovale; RA, right atrium; RAA, right atrial appendage; SEC, spontaneous echo contrast.

Richard W Troughton et al. Heart 2003;89:1447–1454

SUMMARY



- The TEE-guided approach with short-term ant
  considered as a clinically effective alternative
  anticoagulation strategy in the management o
  undergoing cardioversion
- Echocardiography plays an integral and complementary role to CT, MRI, and ICE in the management of patients undergoing catheter ablation procedures for AF.
- The portability, non-invasiveness, absence of radiation exposure, and the few contraindications to both TTE and TEE ensure greater accessibility.
- The ability to provide both anatomical and functional information assists in the diagnosis of complications of AF conversion and ablation and management of long-term anticoagulation.

Thank You