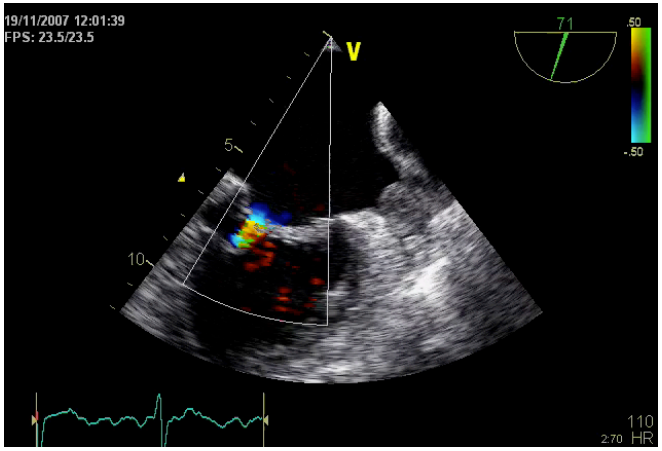
VII Congresso
Novas Fronteiras
em Cardiologia

Imagiologia na Fibrilhação Auricular

# Papel da imagem na estratificação de risco e na predição do risco tromboembólico

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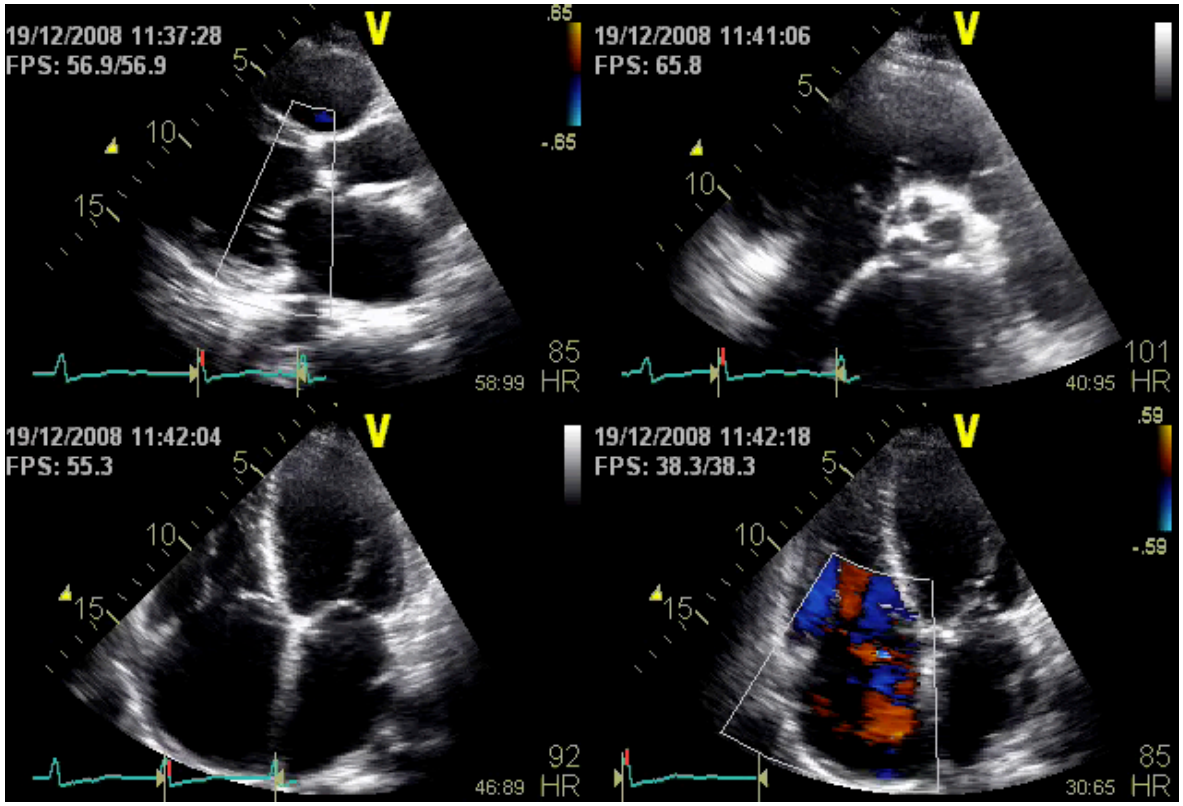
HOSPITAL DE SANTA CRUZ

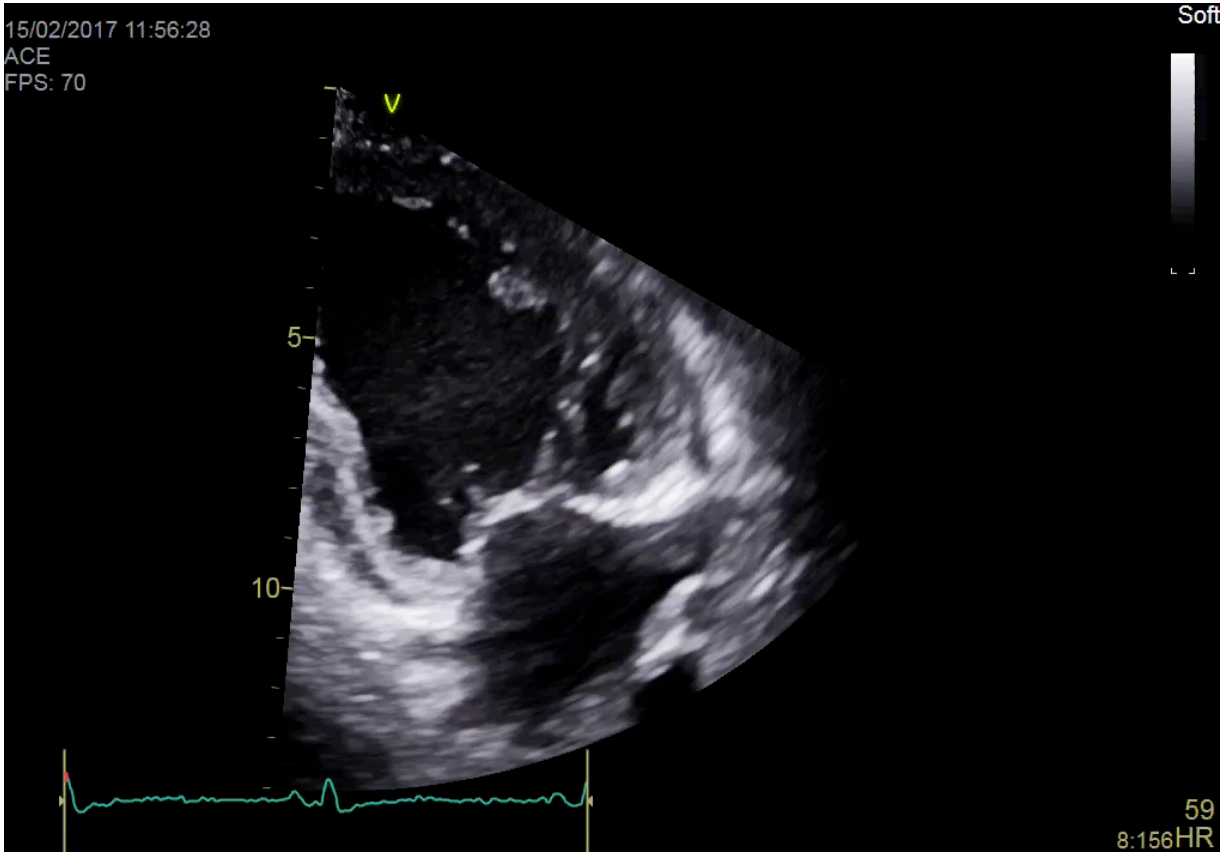
# Diagnosis and timely detection of atrial fibrillation

Echo-machines uses a **single-lead ECG**

## Tool for screening



# LAA thrombus TTE & Sinus Rhythm



# Imaging-based prognostic parameters in patients with AF

**Table 1** Imaging-based prognostic parameters in patients with atrial fibrillation

| Imaging technique | Study | No. | Age, years | Gender (% male) | Parameter | Outcome | Risk ratio |
|---|---|---|---|---|---|---|---|
| Conventional 2D TTE | AFFIRM trial[w12] | 2433 | 69±9 | 57 | LV hypertrophy | All-cause mortality<br>Stroke | HR 1.46 (95% CI 1.14 to 1.86), p=0.003<br>HR 1.89 (95% CI 1.17 to 3.08), p=0.001 |
| | Belgrade Atrial Fibrillation Study[w11] | 842 | 51±12 | 63 | LA dilatation (M-mode)<br>LV systolic dysfunction | Incident heart failure | HR 2.6 (95% CI 1.7 to 4.0), p<0.001<br>HR 2.8 (95% CI 2.1 to 3.7), p<0.001 |
| | SPAF I trial[w14] | 568 | 67±12 | 70 | LA dilatation (M-mode)<br>LV systolic dysfunction | Arterial thromboembolism | RR 1.6 (95% CI 1.0 to 2.5), p=0.04<br>RR 2.0 (95% CI 1.0 to 4.0), p=0.05 |
| | Pooled data from the SPAF I, SPINAF and BAATAF trials[w10] | 1066 | 67±10 | 78 | LA dilatation (M-mode)<br>LV systolic dysfunction | Stroke | RR 1.2 per 1 mm increment, p=0.1<br>RR 2.5 (95% CI 1.5 to 4.4), p<0.001 |
| | Osranek *et al*[w13] | 46 | 46±12 | 83 | LA dilatation (bi-plane area-length method) | All-cause mortality | HR 1.24 per 10 mL/m$^2$ increment (95% CI 1.04 to 1.49), p=0.017 |
| Speckle tracking TTE | Su *et al*[w4] | 196 | 70±10 | 67 | LV global longitudinal strain | Cardiovascular death, non-fatal stroke and heart failure hospitalisation | HR 1.121 (95% CI 1.023 to 1.128), p=0.014 |
| Conventional 2D TEE | SPAF III study[w9] | 786 | 69±9 | 76 | Spontaneous echo contrast<br>LAA thrombus<br>LAA peak velocity <20 cm/s<br>Complex aortic plaque | Stroke | RR 3.7, p<0.001<br>RR 2.5, p=0.04<br>RR 1.7, p=0.008<br>RR 2.1, p<0.001 |
| MDCT/MRI | Di Biase *et al*[w8] | 932 | 59±10 | 79 | LAA chicken wing shape | Stroke | OR 0.21 (95% CI 0.05 to 0.91), p=0.036 |

Bax JJ, et al. Heart 2014;0:1–7

# Echocardiography in newly diagnosed atrial fibrillation patients: A systematic review and economic evaluation

Conclusions When $CHADS_2$ was used, the addition of TTE in identifying patients with left atrial abnormality was cost-effective for informing some OAC decisions. The number of QALYs required for TTE to be cost-effective is small, and that if benefits beyond those associated with a reduction in stroke are believed probable then TTE is likely to be cost-effective in all scenarios.

Our findings suggest that further research would be useful, following up newly diagnosed patients with AF who have undergone TTE, to study treatments given as a result of TTE diagnoses and subsequent cardiovascular events.

This could identify additional benefits of routine testing, beyond stroke prevention. Studies assessing the proportion of people with a $CHADS_2$ score of 0 or 1 that have left atrial abnormality would provide better estimates of the cost-effectiveness of TTE, and allow more accurate estimates of the sensitivity and specificity of TTE for identifying left atrial abnormality in AF to be obtained

Health Technology Assessment
School of Health and Related Research (ScHARR),
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Volume 17, Issue 36,
2013, Pages 1-263

**Table 3.** Independent Transesophageal Echocardiographic Correlates of Thromboembolic Risk: Multivariate Analysis*

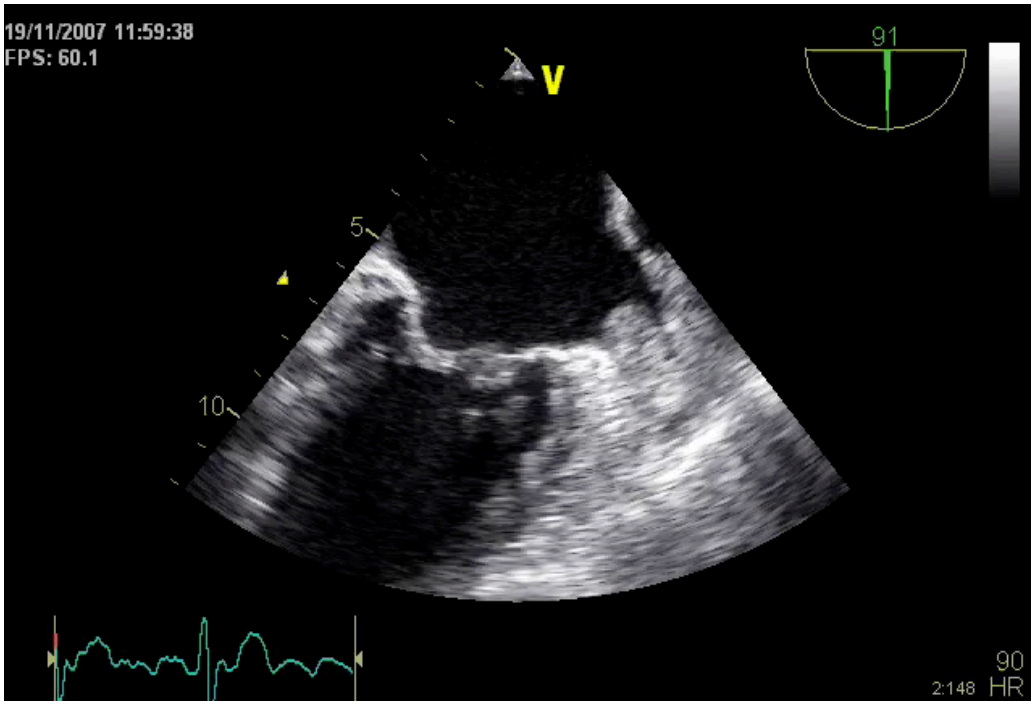
| Risk Group | Relative Risk† | p Value |
|---|---|---|
| Moderate vs. low risk | | |
| LAA thrombus | 2.7 | < 0.001 |
| LAA peak flow velocity ≤20 cm/s | 1.8 | 0.003 |
| High vs. moderate risk | | |
| Complex aortic plaque | 2.9 | < 0.001 |
| Dense SEC | 2.7 | < 0.001 |
| Moderate+high vs. low risk | | |
| LAA thrombus | 2.5 | 0.04 |
| Dense SEC | 3.7 | <0.001 |
| LAA peak flow velocity <20 cm/s | 1.7 | 0.008 |
| Complex aortic plaque | 2.1 | < 0.001 |

Bax JJ, et al. Heart 2014;0:1–7

# AF, ATRIAL THROMBI AND STROKE

Atrial fibrillation increases stroke rate by five times

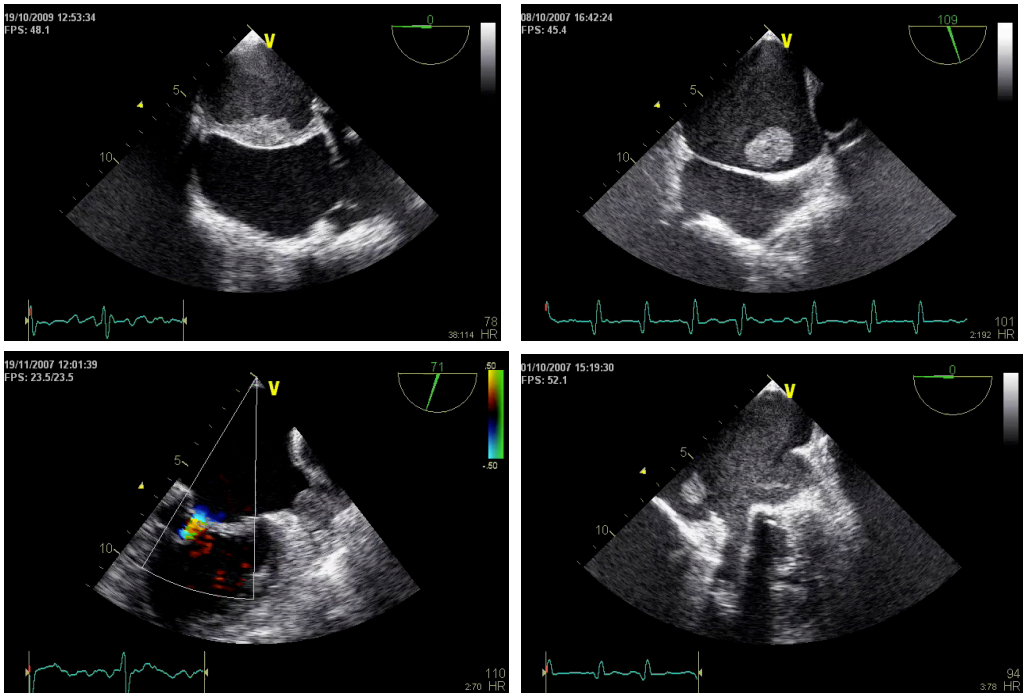
Over **80% of these embolic strokes** are from **clots** originating in the **left atrial appendage**




"The Left Atrial Appendage: our Most Lethal Human Attachment!"

Johnson WD et al. Eur J Cardiothorac Surg. 2000

# Spontaneous Echo-Contrast and Thrombi




The 2 strongest predictors of cardioembolic stroke

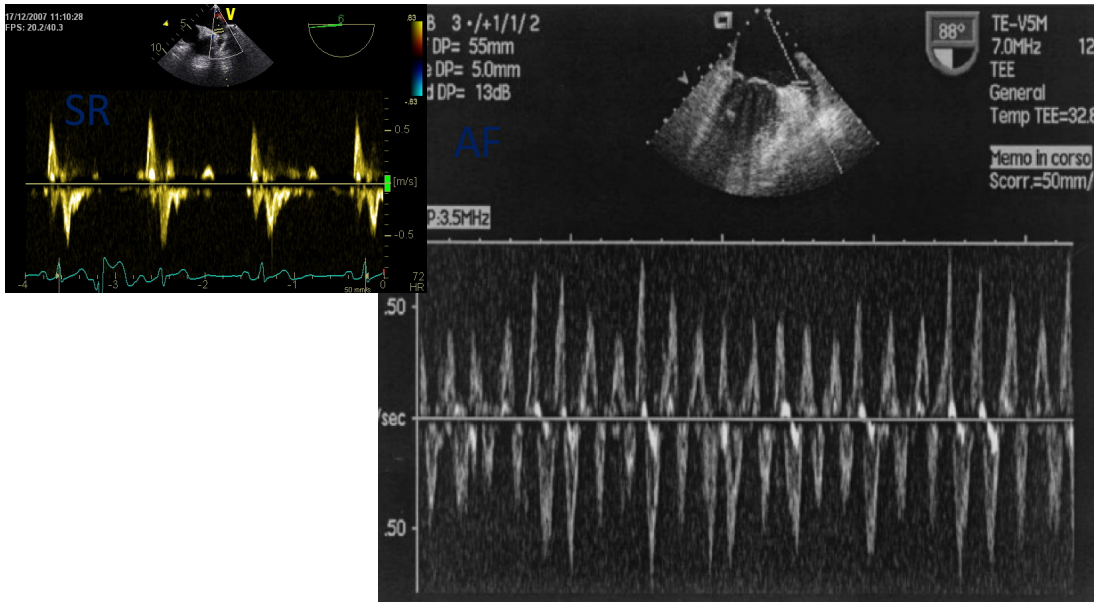
Represent an advanced grade of prothrombotic state

Recorded by TEE
and only rarely by TTE

# Function of LAA

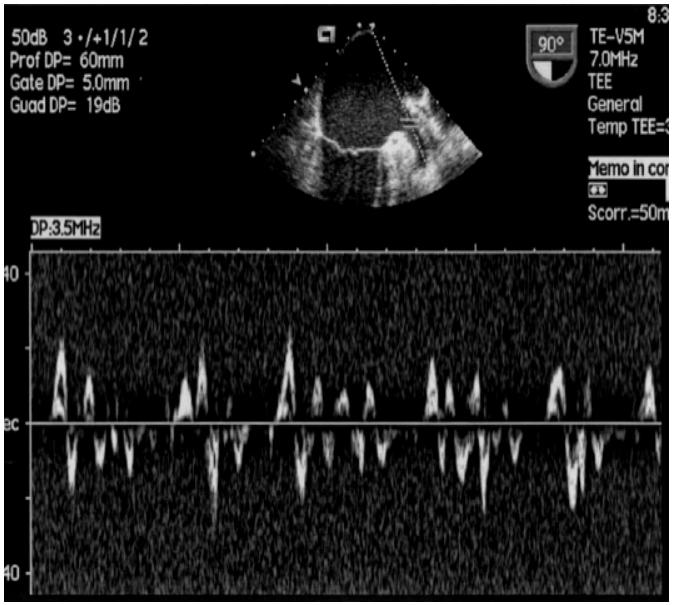
## LAA EMPTYING PEAK VELOCITIES

### High flow profile




LAA peak velocity = 52 cm/s

### Low flow profile

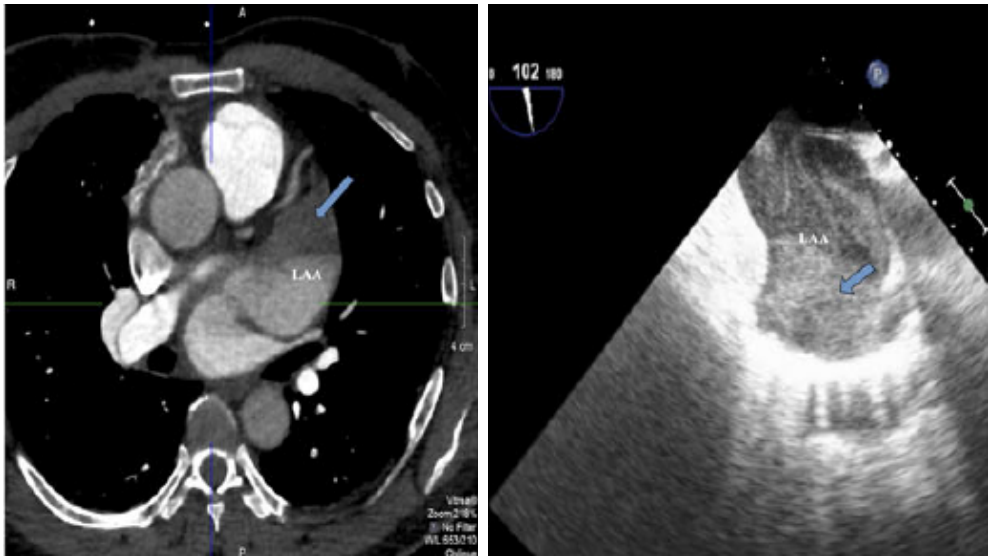



LAA peak velocity = 18 cm/s

Risk stratification Independent of the basic rhythm

Handke et al, JASE 2005, 18; 1366

861 consecutive patients before AF ablation
CTA and TEE same day
single hospital (2006–2013)



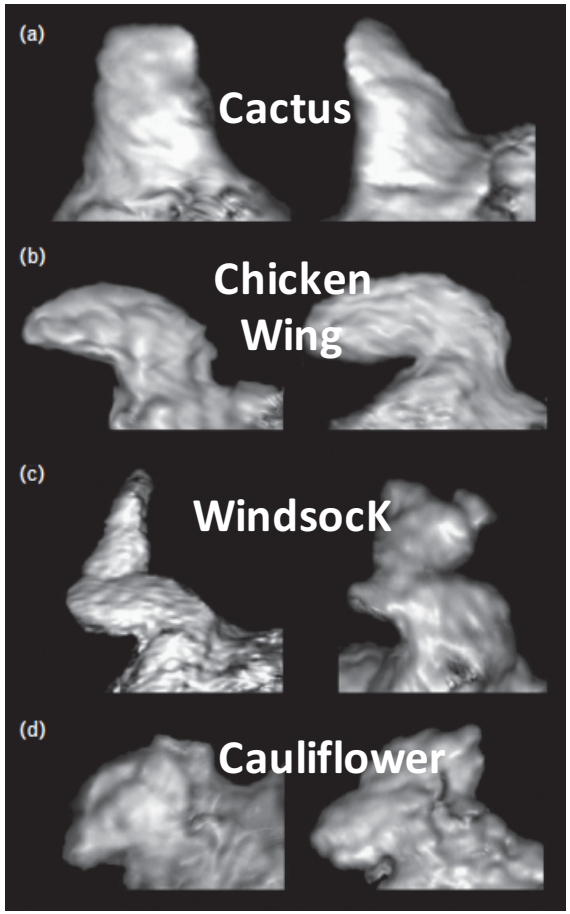

Excellent NPV of CTA in assessment of LAA stasis and thrombus

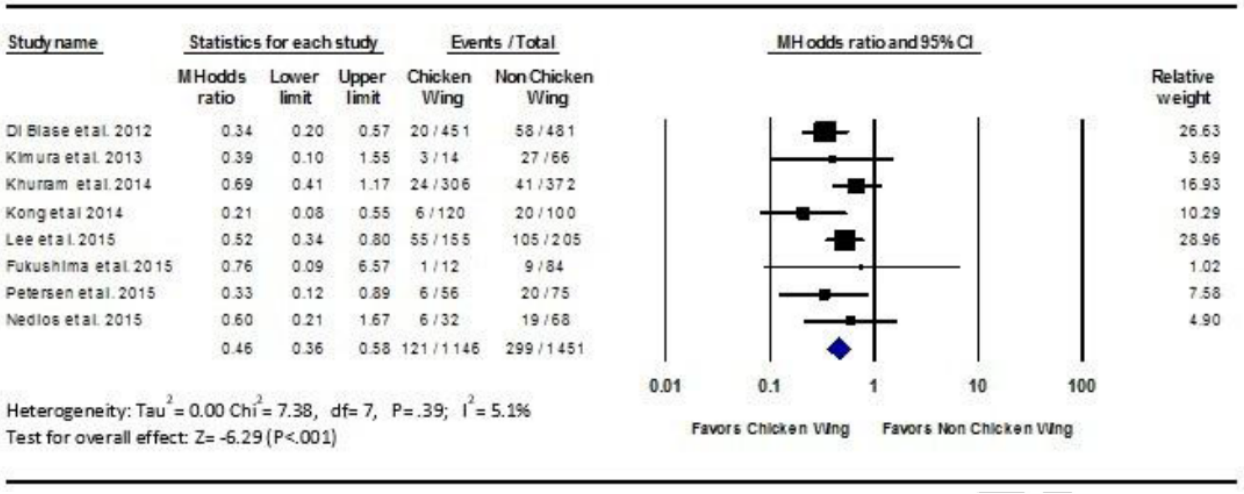
Positive predictive value of only 13%

Possible to eliminate TEE in up to 80% of AF ablation patients based on negative CTA findings

Wan, L et al. PACE 2016; 39:1388–93

# Morphology of LAA



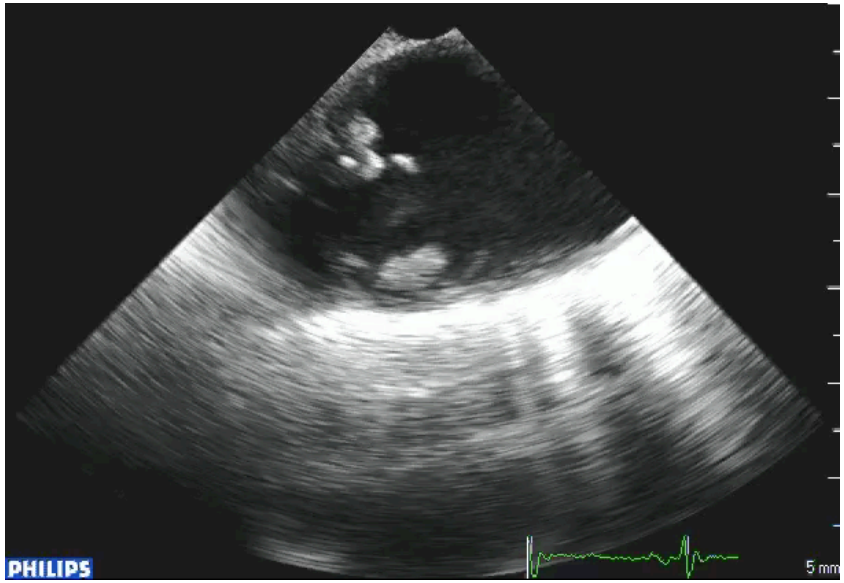

Lupercio F et al. Heart Rhythm 2016

Anselmino M et al. Cardiovasc Med 2016, 17:169–176l.

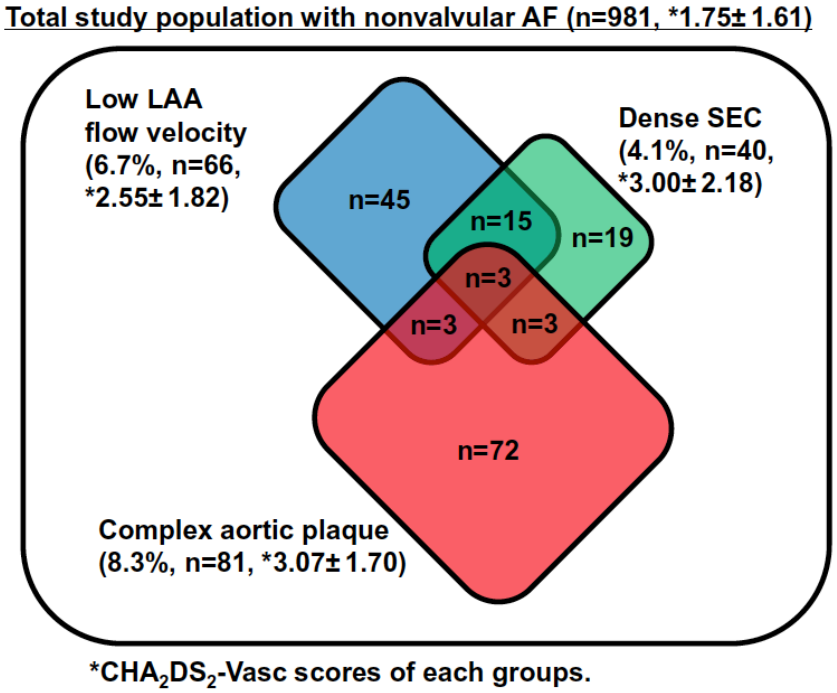
# **CxAoP**: an important risk factor for non-CE stroke and thromboembolism in NVAF

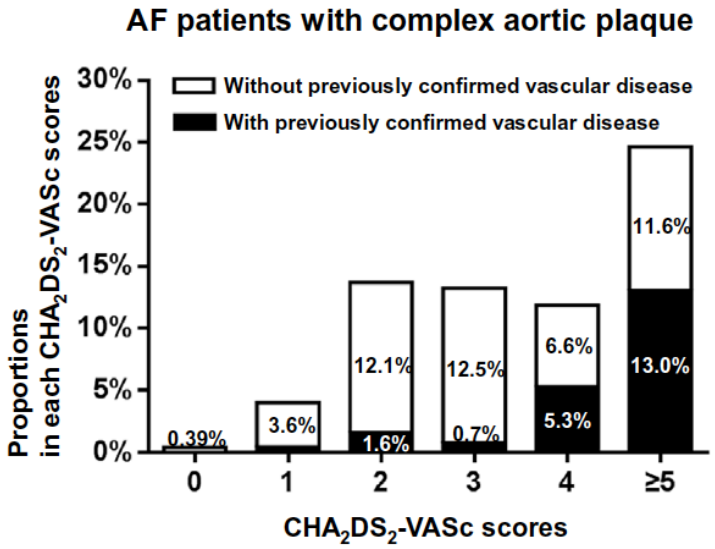
Patients with CxAoP have different characteristics

- Older age
- Higher prevalence of hypertension
- Smoking history
- Paroxysmal AF with a smaller LA size




# 981 pts TEE for pre-AF ablation




the CHA2DS2VASc score was underestimated in 3.6% of intermediate-risk patients and 11.3% of high-risk patients before evaluating for CxAoP by TEE

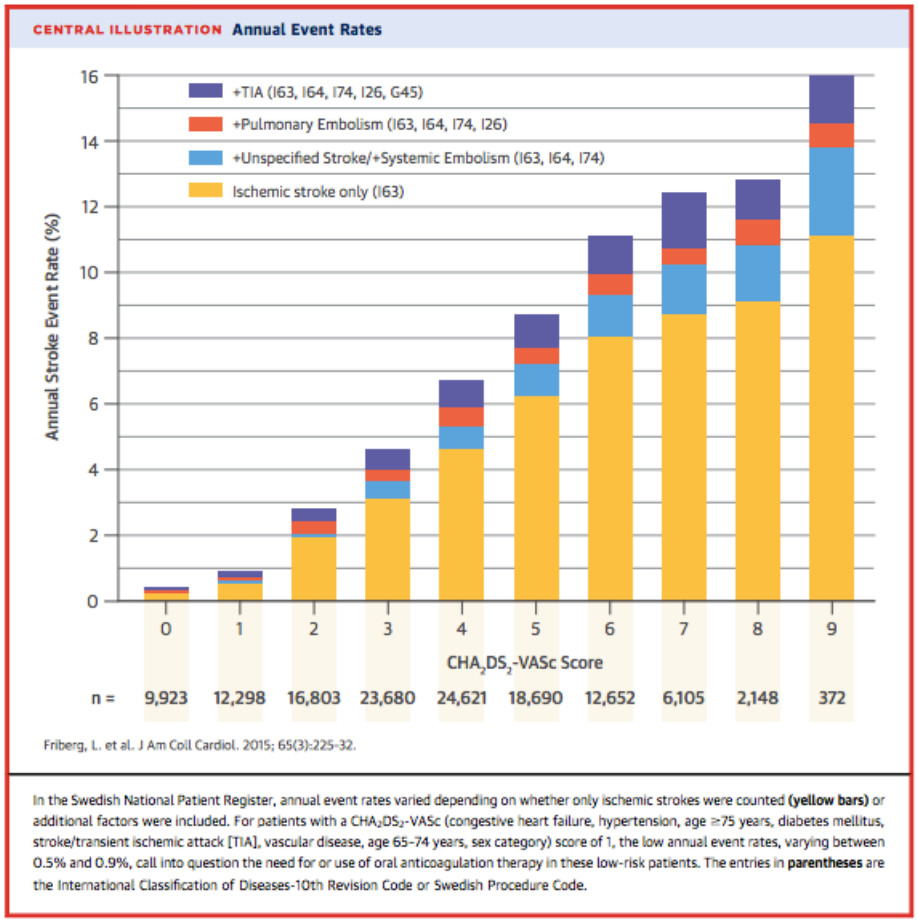
P.-S. Yang, et al. Int J Cardiol 2016

# Risk Stratification in AF

| CHA2DS2-VASc Risk | Score | CHA2DS2-VASc Score | Adjusted stroke rate (% / year) |
|---|---|---|---|
| | | 0 | 0 |
| CHF or LVEF <40% | 1 | 1 | 1.3 |
| Hypertension | 1 | 2 | 2.2 |
| Age > 75 | 2 | 3 | 3.2 |
| Diabetes | 1 | 4 | 4 |
| Stroke / TIA / Thromboembolism | 2 | 5 | 6.7 |
| Vascular Disease | 1 | 6 | 9.8 |
| Age 65-74 | 1 | 7 | 9.6 |
| Female | 1 | 8 | 6.7 |
| | | 9 | 15.2 |

# 140,420 patients with AF

## in Swedish nationwide health registries




J Am Coll Cardiol 2015;65:225–32

# Impact of Diastolic Function Parameters on the Risk for Left Atrial Appendage Thrombus in Patients with Nonvalvular Atrial Fibrillation: A Prospective Study

266 pts TTE immediately before clinically indicated TOE

## Prevalence of LAA thrombus based on e' and E/e' ratio

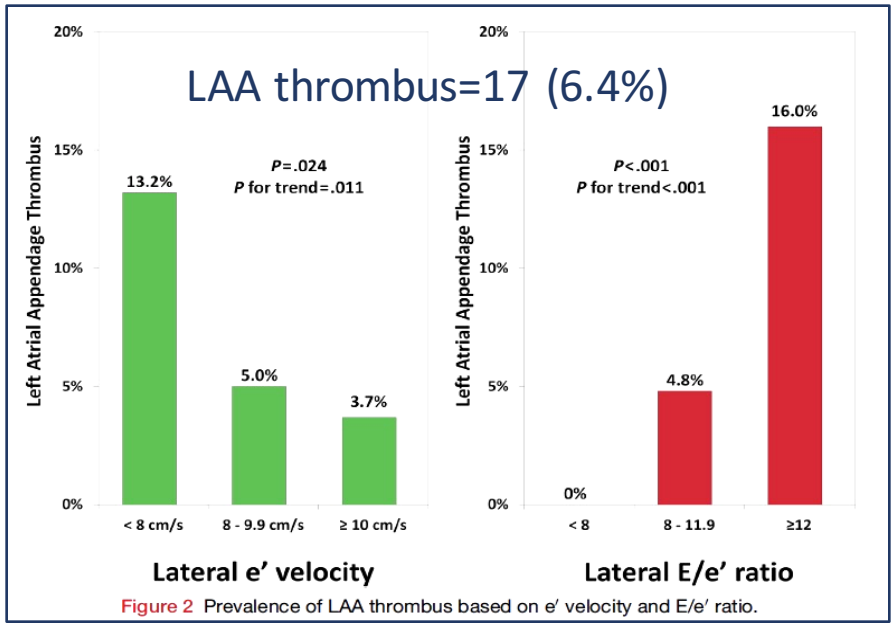



Figure 2 Prevalence of LAA thrombus based on e′ velocity and E/e′ ratio.

Table 3 Discriminative capacity of $CHA_2DS_2$-VASc score and echocardiographic parameters in predicting LAA thrombus

| Variable | AUC | 95% CI | *P* |
|---|---|---|---|
| $CHA_2DS_2$-VASc score | 0.75 | 0.63–0.86 | .001 |
| Lateral E/e′ ratio | 0.83 | 0.75–0.91 | <.001 |
| Septal E/e′ ratio | 0.80 | 0.72–0.88 | <.001 |
| Averaged E/e′ ratio | 0.83 | 0.76–0.91 | <.001 |
| Lateral e′ velocity | 0.76 | 0.63–0.88 | <.001 |
| Septal e′ velocity | 0.71 | 0.57–0.85 | .004 |
| LA volume index | 0.66 | 0.48–0.84 | .054 |
| LVEF | 0.69 | 0.57–0.83 | .011 |
| LVEF/LA volume index | 0.69 | 0.53–0.85 | .026 |

Discriminative capacity is represented by the AUC calculated by the ROC method.

Doukky R et al. JASE 2016

# Impact of Diastolic Function Parameters on the Risk for Left Atrial Appendage Thrombus in Patients with Nonvalvular Atrial Fibrillation: A Prospective Study

Table 2 Association between echocardiographic parameters and LAA thrombus

| Variable | All subjects (*n* = 266) | LAA thrombus: Present (*n* = 17) | LAA thrombus: Absent (*n* = 249) | *P** |
|---|---|---|---|---|
| E velocity (cm/sec) | 93 ± 28 | 112 ± 26 | 91 ± 28 | .004 |
| Lateral e′ velocity (cm/sec) | 10.2 ± 3.8 | 7.0 ± 3.2 | 10.4 ± 3.7 | <.001 |
| Septal e′ velocity (cm/sec) | 7.9 ± 6.6 | 5.7 ± 2.7 | 8.1 ± 6.7 | .004 |
| Lateral E/e′ ratio | 10.8 ± 6.4 | 19.4 ± 10.1 | 10.2 ± 5.6 | .002 |
| Septal E/e′ ratio | 14.6 ± 8.1 | 23.0 ± 9.5 | 14.0 ± 7.7 | .001 |
| Averaged E/e′ ratio | 12.0 ± 6.4 | 20.3 ± 8.6 | 11.4 ± 5.8 | .001 |
| LA volume index (mL/m$^2$) | 34 ± 15.8 | 43 ± 18 | 33 ± 15 | .031 |
| LVEDV index (mL/m$^2$) | 53 ± 29 | 70 ± 33 | 52 ± 28 | .029 |
| LVEF (%) | 48 ± 17 | 37 ± 15 | 49 ± 17 | .010 |
| LV mass index (g/m$^2$) | 103 ± 40 | 113 ± 29 | 102 ± 40 | .302 |
| Degree of SEC (scale, 0-4) | 0.6 ± 1.1 | 3.0 ± 1.1 | 0.4 ± 0.9 | <.001 |
| LAA emptying velocity (cm/sec) | 42 ± 22 | 22 ± 6 | 44 ± 22 | <.001 |

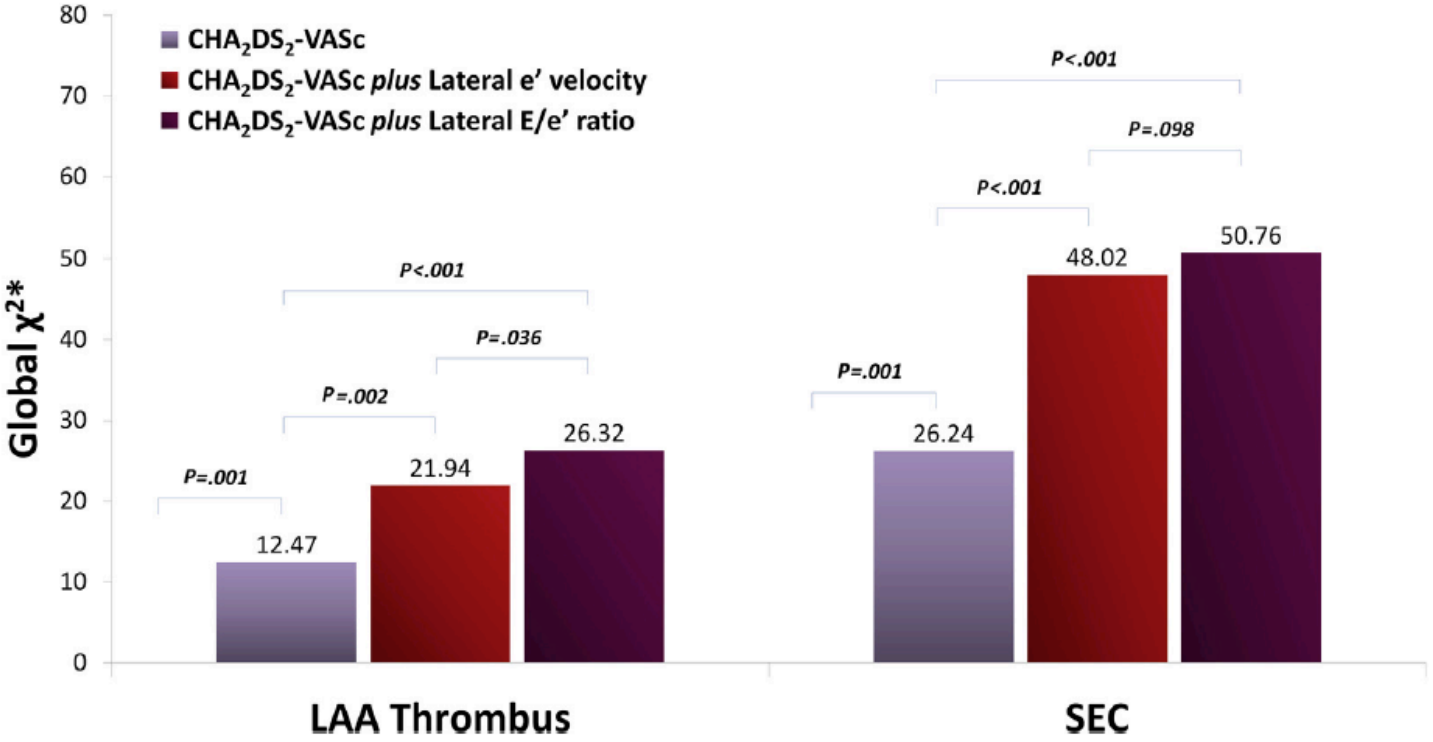
TTE

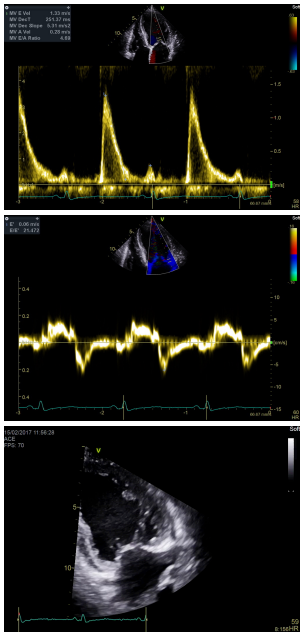
TOE

Doukky R et al. JASE 2016

# Impact of Diastolic Function Parameters on the Risk for Left Atrial Appendage Thrombus in Patients with Nonvalvular Atrial Fibrillation: A Prospective Study

## Incremental predictive value of diastolic function parameters beyond $CHA_2DS_2$-VASc score



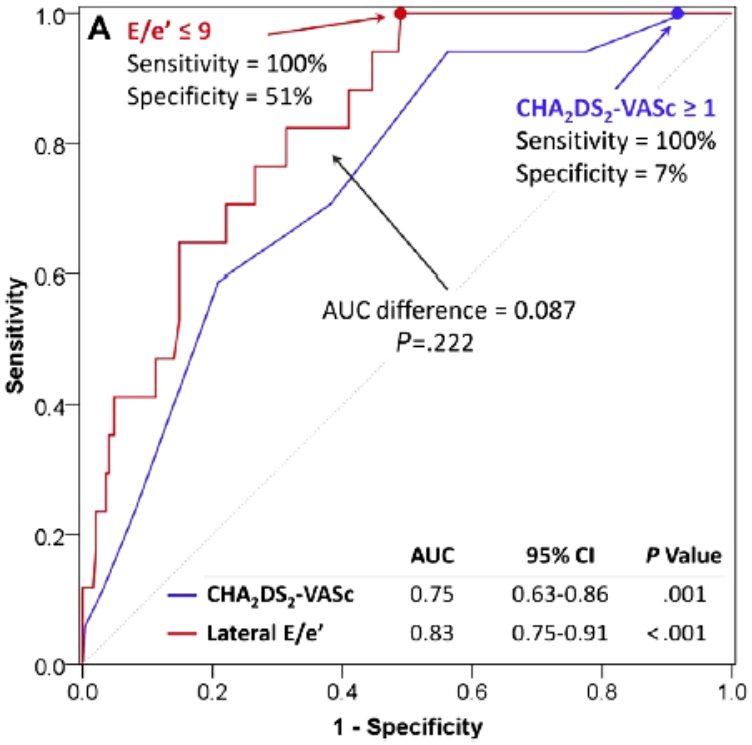



Doukky R et al. JASE 2016

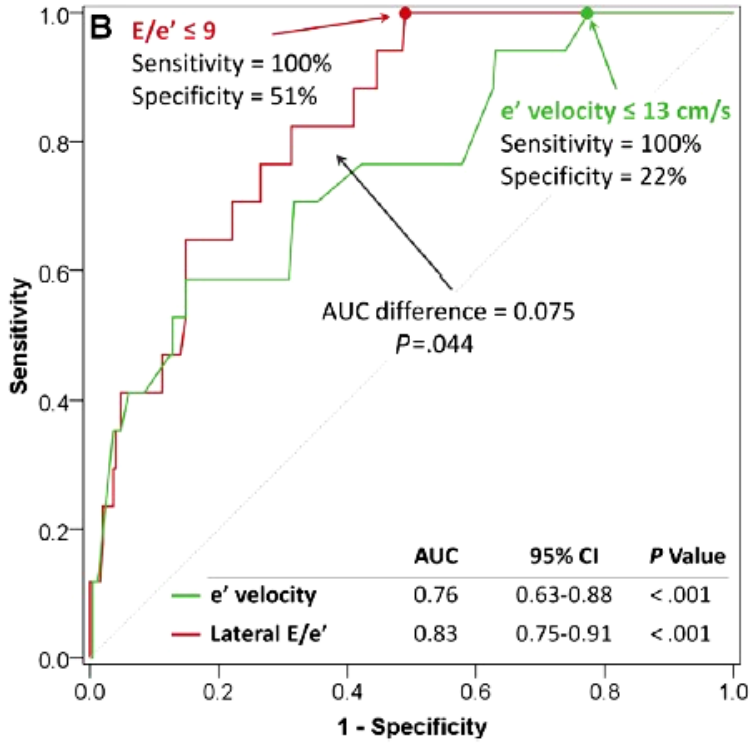
# Impact of Diastolic Function Parameters on the Risk for Left Atrial Appendage Thrombus in Patients with Nonvalvular Atrial Fibrillation: A Prospective Study

## Diagnosis of LAA thrombus

### E/e' vs $CHA_2DS_2$-VASc score

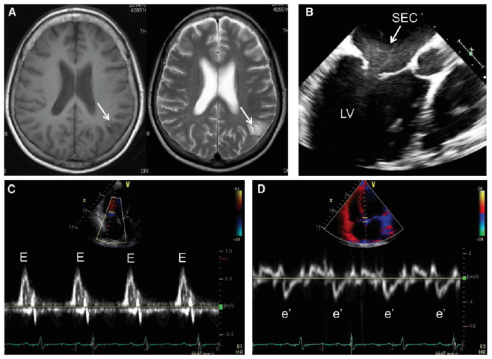



### E/e' vs lateral e' velocity




Doukky R et al. JASE 2016

# Relationship between tissue Doppler measurements of left ventricular diastolic function and silent brain infarction in patients with non-valvular atrial fibrillation




171 neurologically asymptomatic pts with non-valvular AF

**TTE**: diastolic TDI parameters

**TOE**: LA thrombus, SEC, LAA emptying veloc, complex arch plaques

**Brain MRI**: SBI

Ishikawa S et al. Eur Heart J Card Imaging 2016

**Table 2** Echocardiographic characteristics and comparison between patients with and without SBI

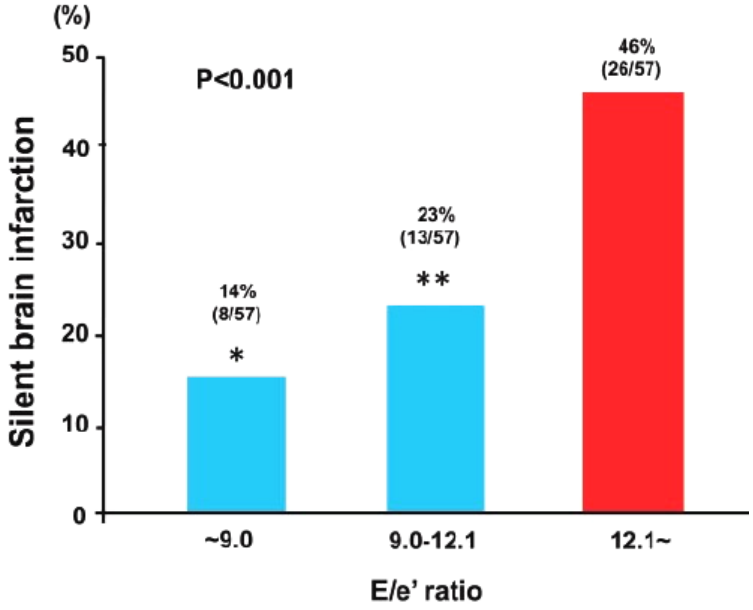
| | All patients (*n*=171) | With SBI (*n*=47) | Without SBI (*n*=124) | *P*-value |
|---|---|---|---|---|
| Transthoracic echocardiography | | | | |
| LVDd (mm) | 48 ± 6 | 48 ± 7 | 48 ± 5 | 0.815 |
| LVDs (mm) | 31 ± 7 | 31 ± 7 | 31 ± 7 | 0.873 |
| LVEF (%) | 55 ± 9 | 53 ± 10 | 56 ± 8 | 0.095 |
| IVS (mm) | 9.0 ± 1.3 | 9.2 ± 1.2 | 8.9 ± 1.4 | 0.183 |
| PW (mm) | 9.0 ± 1.2 | 9.1 ± 1.1 | 8.9 ± 1.2 | 0.226 |
| LV mass index (g/m$^2$) | 88 ± 23 | 93 ± 29 | 86 ± 21 | 0.293 |
| LA diameter (mm) | 41 ± 7 | 43 ± 6 | 41 ± 7 | 0.136 |
| LA volume index (mL/m$^2$) | 42 ± 16 | 45 ± 17 | 41 ± 15 | 0.143 |
| E-wave (cm/s) | 73 ± 21 | 81 ± 26 | 70 ± 18 | 0.003 |
| Deceleration time (ms) | 198 ± 57 | 200 ± 68 | 198 ± 53 | 0.794 |
| *e′* (cm/s) | 7.1 ± 2.1 | 6.3 ± 1.7 | 7.3 ± 2.1 | 0.003 |
| *E*/*e′* | 11.1 ± 4.3 | 13.6 ± 5.6 | 10.1 ± 3.2 | <0.001 |
| Transoesophageal echocardiography | | | | |
| LA thrombus | 2 (1) | 2 (4) | 0 (0) | 0.021 |
| SEC | 26 (15) | 15 (32) | 11 (9) | <0.001 |
| LAA emptying velocity (cm/s) | 47 ± 20 | 40 ± 20 | 49 ± 19 | 0.005 |
| Complex arch plaques | 27 (16) | 14 (30) | 13 (11) | 0.003 |

Categorical data are expressed as *n* (%) and continuous data as mean ± SD.

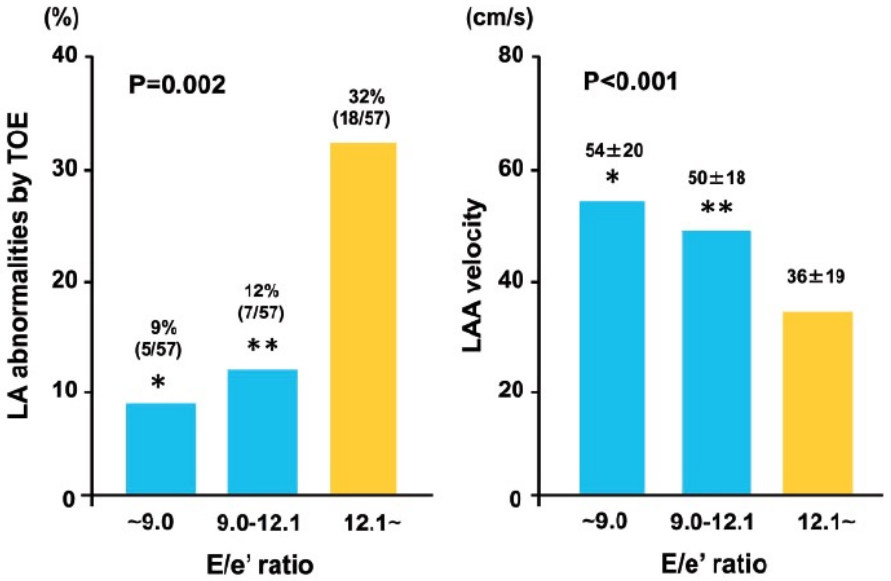
*E*, diastolic early transmitral flow velocity; *e′*, diastolic early mitral annular velocity; *E*/*e′*, diastolic early transmitral flow velocity/mitral annular velocity; LA, left atrial; LAA, left atrial appendage; LV, left ventricular; LVDd, LV end-diastolic dimensions; LVDs, LV end-systolic dimensions; LVEF, LV ejection fraction; IVS, interventricular septal wall thickness; PW, posterior wall thickness; SEC, spontaneous echo contrast.

Ishikawa S et al. Eur Heart J Card Imaging 2016

# Prevalences of SBI according the E/e' ratio




# LA abnormalities and LAA emptying velocity (TOE) according to E/e' ratio (TTE)




Ishikawa S et al. Eur Heart J Card Imaging 2016

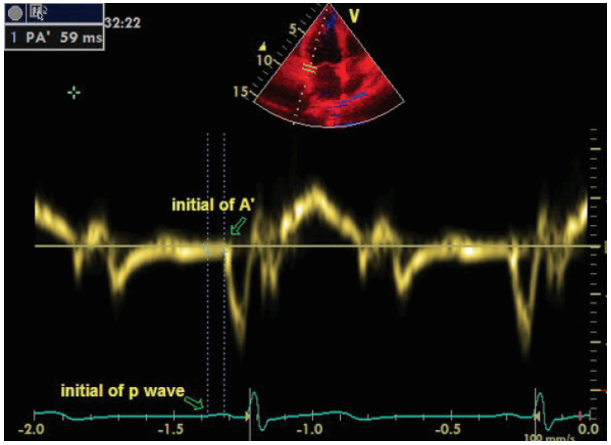
# Evaluation of the association between stroke/transient ischemic attack and atrial electromechanical delay in patients with paroxysmal atrial fibrillation

160 pts non-rheumatic PAF, 52 with a history stroke/TIA

**Table 3. Inter- and intra-atrial EMDs measured by tissue Doppler imaging**

| Variables | Stroke/TIA (+) (n=52) | Stroke/TIA (-) (n=108) | *P* |
|---|---|---|---|
| P-A'$_{septal}$, ms | 62.3±8.4 | 65.6±9.2 | 0.127 |
| P-A'$_{lateral}$, ms | 131±9 | 116±10 | <0.001 |
| P-A'$_{tricuspid}$, ms | 39.2±7.8 | 44.9±9.1 | 0.007 |
| Interatrial EMD, ms | 91.3±5.0 | 71.5±7.0 | <0.001 |
| Intra-left atrial EMD, ms | 68.2±6.1 | 50.8±6.5 | <0.001 |
| Intra-right atrial EMD, ms | 23.1±5.1 | 20.7±5.9 | 0.076 |

EMD - electromechanical delay; TIA - transient ischemic attack (variables with normal distribution were expressed as mean±SD)




Bayar, N et al. Anatol J Cardiol 2016; 16: 572-8

# Evaluation of the association between stroke/transient ischemic attack and atrial electromechanical delay in patients with paroxysmal atrial fibrillation

**Table 4. Predictors of stroke/TIA in univariate and multivariate logistic regression analyses**

| | | | Model A (LA-EMD) | | Model B (IA-EMD) | |
|---|---|---|---|---|---|---|
| | Univariate | | Multiple | | Multiple | |
| Variable | OR (95% CI) | *P* | Adjusted OR (95% CI) | *P* | Adjusted OR (95% CI) | *P* |
| LA-EMD | 1.280 (1.156–1.418) | <0.001 | 1.417 (1.193–1.684) | <0.001 | | |
| IA-EMD | 1.271 (1.157–1.396) | <0.001 | | | 1.398 (1.177–1.661) | <0.001 |
| Age | 1.045 (1.003–1.089) | 0.034 | 1.008 (0.931–1091) | 0.840 | 1.004 (0.926–1.088) | 0.930 |
| LA | 1.245 (1.083–1.430) | 0.002 | 1.878 (0.948–3.718) | 0.071 | 1.574 (0.807–3.070) | 0.183 |
| DM | 1.531 (0.584–4.008) | 0.386 | 2.038 (0.233–17.844) | 0.520 | 0.284 (0.022–3.665) | 0.335 |
| HT | 0.936 (0.284–3.081) | 0.913 | 50.380 (1.349–188.644) | 0.034 | 84.635 (2.679–267.235) | 0.012 |
| CAD | 3.087 (1.253–7.606) | 0.014 | 0.039 (0.003–0.448) | 0.009 | 0.032 (0.002–0.423) | 0.009 |
| Smoking | 1.315 (0.493–3.505) | 0.584 | 0.978 (0.153–6.259) | 0.981 | 1.729 (0.189–15.824) | 0.628 |
| HL | 1.696 (0.701–4.103) | 0.241 | 9.731 (1.010–93.718) | 0.049 | 10.433 (0.898–121.139) | 0.061 |

Bayar, N et al. Anatol J Cardiol 2016; 16: 572-8

# Evaluation of the association between stroke/transient ischemic attack and atrial electromechanical delay in patients with paroxysmal atrial fibrillation

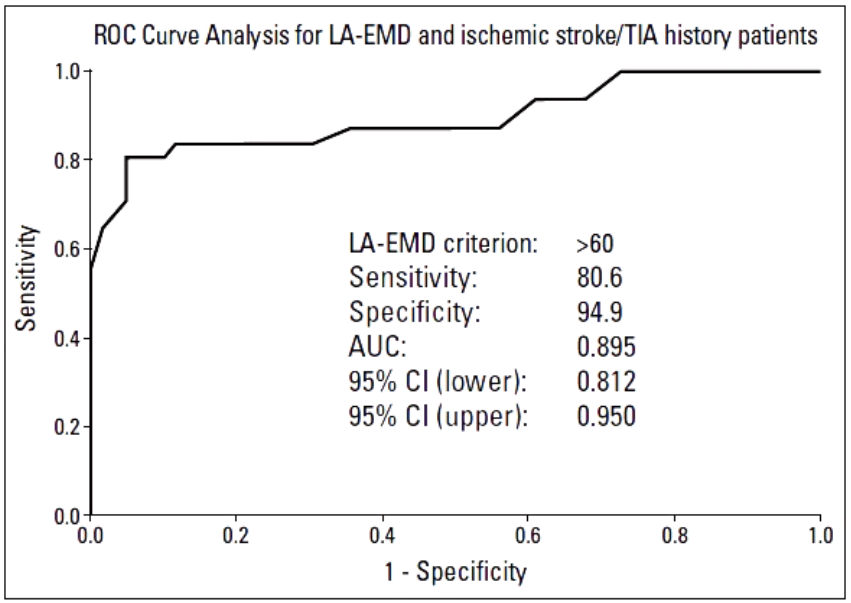



**Figure 2. Receiver operating characteristics curve of intra-left atrial EMD for predicting stroke/TIA in patients with PAF**

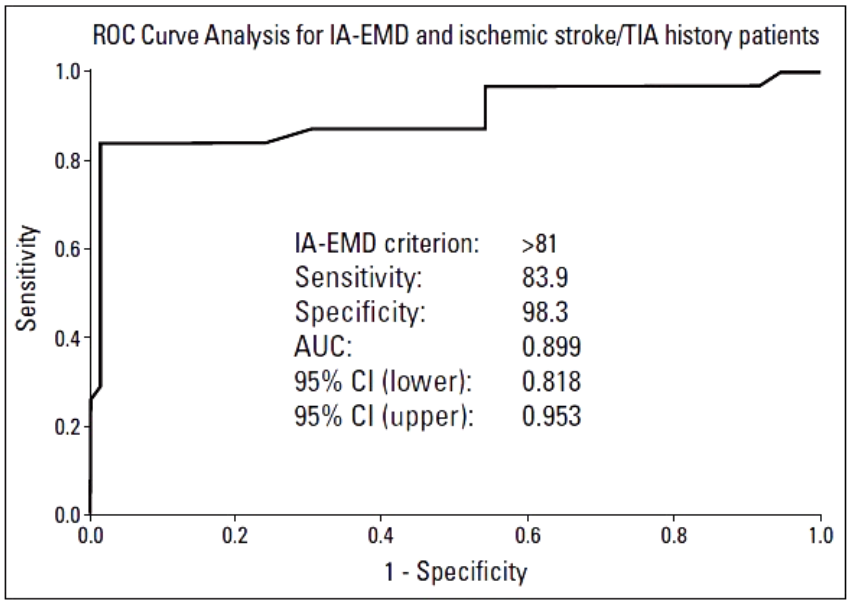
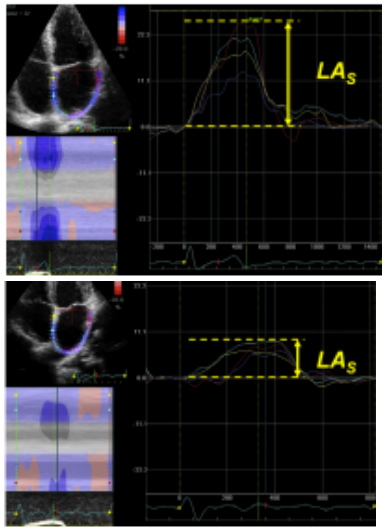


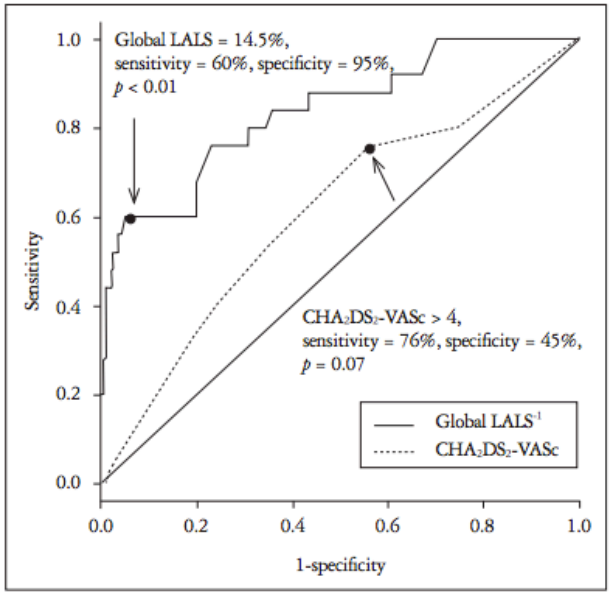

**Figure 3. Receiver operating characteristics curve of interatrial EMD for predicting stroke/TIA in patients with PAF**

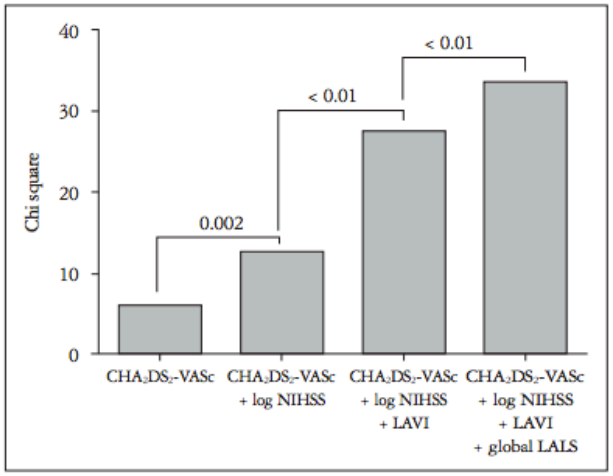
Bayar, N et al. Anatol J Cardiol 2016; 16: 572-8

# Incremental Value of LA Global Longitudinal Strain for Prediction of Post Stroke AF in Patients with Acute Ischemic Stroke

227 pts with acute ischemic stroke without a history of AF
TTE with speckle tracking imaging for global LA longitudinal strain (LALS)




Kim et al. J Cardiovasc Ultrasound 2016;24(1):20-27

# CONCLUSION

TTE is recommended in all AF patients to guide treatment decisions. TTE should be used to identify structural disease and assess LV size and function, atrial size, and right heart function.

Cardiovascular imaging, allowing directly visualization of those alterations which may lead to the formation of intracardiac thrombi, offers itself as a unique tool helping to refine thromboembolic risk stratification.

While the role of TTE is pivotal in the risk stratification of patients with AF, the use of TEE or MDCT and MRI is commonly restricted to patients with additional cardiovascular risk factors (ie, prior stroke) or undergoing specific therapies (electrical cardioversion or catheter ablation).

Diastolic function assessment and LA strain evaluation may improve risk stratification and in predicting thromboembolic risk in patients with NVAF