Atrial Fibrillation
Atrial Stunning in Echo

Erwan DONAL,
Cardiologie, CHU Rennes, France
erwan.donal@chu-rennes.fr
A Case Report

- Miss H, 64 year old
- Medical background: only hypertension
- First hospitalization for palpitations and dyspnea,
- initially rapid Afib
Symptoms and rapid Afib >> TEE

- Very large LAA 17 cm²
- SEC and low emptying flow velocities
- OK for a cardioversion
Cardioversion >>> Sinus rhythm >>> back home BUT

ACUTE PULMONARY OEDEMA after less than 2 days at home

ECG Image
Cardiac CT

- Thrombus in a very large LAA

CRM

- CRM = no thrombus
Multi-disciplinary decision of a surgical extraction of the LAA
Role of Echocardiography in the Management of Atrial fibrillation patients: rather limited according to guidelines

Thrombo-embolic risk evaluation based on: CHA₂DS₂VASC

- Echocardiography required for assessing the presence of a LV dysfunction
  But:
- No recommendation about the LA size or LA function

LA SIZE

• LA size is associated with mortality

• LA size associated with the risk of A Fib,
  – Recurrence
  – Risk of embolism

Cut-off values:
LA area > 18 cm²/m²
LA diameter > 16 mm/m²
the most relevant:
→ LA volume > 34 ml/m²

Moller et al. Circulation 2003; 107: 2207
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Total Mean ± SD</th>
<th>Total 2 SD range</th>
<th>Male Mean ± SD</th>
<th>Female Mean ± SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasternal long-axis view</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA diameter, mm</td>
<td>33.6 ± 4.3</td>
<td>26.7–41.0</td>
<td>35.1 ± 4.1</td>
<td>32.4 ± 4.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Apical views</td>
<td></td>
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<tr>
<td>Apical four-chamber view</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>LA minor length, mm</td>
<td>39.2 ± 4.7</td>
<td>31.0–47.5</td>
<td>40.1 ± 4.5</td>
<td>38.5 ± 4.8</td>
<td>0.001</td>
</tr>
<tr>
<td>LA major length, mm</td>
<td>47.6 ± 5.5</td>
<td>38.5–57.0</td>
<td>48.8 ± 5.4</td>
<td>46.6 ± 5.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LA area, cm²</td>
<td>16.5 ± 3.2</td>
<td>11.5–21.9</td>
<td>17.2 ± 3.1</td>
<td>15.8 ± 3.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Normalized to BSA</td>
<td></td>
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</tr>
<tr>
<td>Parasternal long-axis view</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA diameter, mm/m²</td>
<td>18.7 ± 2.4</td>
<td>15.0–22.8</td>
<td>18.1 ± 2.3</td>
<td>19.2 ± 2.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Apical views</td>
<td></td>
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<tr>
<td>Apical four-chamber view</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LA area, cm²/m²</td>
<td>9.1 ± 1.6</td>
<td>6.5–11.8</td>
<td>8.9 ± 1.5</td>
<td>9.3 ± 1.7</td>
<td>0.008</td>
</tr>
<tr>
<td>LA volume area-length, mL/m²</td>
<td>27.1 ± 7.5</td>
<td>14.9–40.3</td>
<td>27.0 ± 7.0</td>
<td>27.3 ± 7.9</td>
<td>0.733</td>
</tr>
<tr>
<td>LA volume Simpson, mL/m²</td>
<td>24.8 ± 6.8</td>
<td>13.7–36.9</td>
<td>24.5 ± 6.4</td>
<td>25.1 ± 7.2</td>
<td>0.462</td>
</tr>
<tr>
<td>Apical two-chamber view</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA area, cm²/m²</td>
<td>9.5 ± 1.5</td>
<td>7.1–12.1</td>
<td>9.3 ± 1.6</td>
<td>9.6 ± 1.4</td>
<td>0.126</td>
</tr>
<tr>
<td>LA volume area-length, mL/m²</td>
<td>28.3 ± 7.8</td>
<td>17.5–43.1</td>
<td>28.9 ± 8.5</td>
<td>28.0 ± 7.3</td>
<td>0.263</td>
</tr>
<tr>
<td>LA volume Simpson, mL/m²</td>
<td>26.6 ± 7.2</td>
<td>16.1–40.1</td>
<td>27.1 ± 7.9</td>
<td>26.1 ± 6.7</td>
<td>0.189</td>
</tr>
<tr>
<td>Biplane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA volume area-length, mL/m²</td>
<td>28.6 ± 6.7</td>
<td>19.3–41.5</td>
<td>28.9 ± 7.0</td>
<td>28.3 ± 6.5</td>
<td>0.376</td>
</tr>
</tbody>
</table>

Kou et al. NORRE study. EHJcvim 2014; 15, 680–69
Left Atrial Volume = \( \frac{8}{3\pi}(A_1)(A_2)/(L) \) *  

* (L) is the shortest of either the A4C or A2C length

<table>
<thead>
<tr>
<th>LA volume (ml)</th>
<th>22–52</th>
<th>53–62</th>
<th>63–72</th>
<th>≥73</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA volume/BSA (ml/m²)</td>
<td>22±6</td>
<td>29–33</td>
<td>34–39</td>
<td>≥40</td>
</tr>
</tbody>
</table>
Patients who maintain sinus rhythm after RF, a significant reverse remodeling and functional improvement of the left atrium is observed using RT3DE.
Acute study: 1222 patients: security & feasibility of the cardioversion after TEE checking for the absence of thrombus / cardioversion after > 3 weeks of effective anticoagulation.

13.8% thrombi in Afib > 48h in that study


Nowadays +-7%
Different LAA morphologies. 
(A) Chicken wing. 
(B) Windsock. 
(C) Cauliflower. 
(D) Cactus
ECG

P

T

LAA

Aortic & mitral valve Doppler

E

D

A

Rev

Pulmonary veinous Doppler

S

D

E

D
Rythme Sinusal

Fibrillation Atriale
LAA thrombus with severe spontaneous echocontrast

Corresponding LAA very weak emptying flows (0.15 ms)
In an animal model; difficult to monitor the stunning in the human being...
Atrial Fibrillation
LAA & PVF

Sinus Rhythm

↑ S (pvf) 
(reservoir function) 
& weak A rev 
(atrial booster pump function)

Donal et al. Am J Cardiol 2005
Logan et al (Lancet 1965; ii: 471): description of the absence of A wave of the LA pressure recording after a cardioversion (« stunning »)

Manning et al (JACC 1994; 23:1535): + longer is the Afib, longer is the stunning and the weakness of LA systolic function

(24h pour ≈ 2 sem. vs > 1 mois pour une durée > 6 sem)

“stunning”: intra myocardial cells calcium overload
Acute improvement of atrial mechanical stunning after electrical cardioversion of persistent atrial fibrillation: comparison between biatrial and single atrial pacing

M Takagi, A Doi, N Shirai, K Hirata, Y Takemoto, K Takeuchi, J Yoshikawa


Objective: To evaluate the acute effects of atrial pacing at different pacing sites on mechanical stunning after cardioversion of atrial fibrillation (AF).
Setting: Tertiary referral centre.
Patients: 20 patients with persistent AF were studied.
Interventions: Spontaneous echo contrast (SEC), left atrial appendage emptying velocity (LAAEV), and left atrial appendage emptying fraction (LAAEF) were assessed by transoesophageal echocardiography (TOE) during AF, after conversion to sinus rhythm, and during atrial pacing from the right atrial appendage, left lateral atrium, and both atria simultaneously. Transmitral inflow velocity of the atrial wave (TMIF-A) by TOE and the maximum P wave duration in 12 lead ECG were also measured during sinus rhythm and atrial pacing.
Main outcome measures: Comparison of atrial mechanical function and P wave duration in 12 lead ECG during atrial pacing from different sites after cardioversion of AF.
Results: Compared with sinus rhythm, atrial pacing at 80 beats/min increased LAAEV from mean (SD) 14.6 (10.1) to 33.4 (19.8) cm/s (p = 0.001), LAAEF from 13.8 (8.5) to 32.1 (11.2)% (p < 0.001), and TMIF-A from 24.6 (11.9) to 45.6 (21.0) cm/s (p < 0.001) and reduced SEC grade from 2.6 (1.0) to 1.6 (0.9) (p < 0.001). These effects had a positive force–frequency relation. Biatrial pacing produced the shortest P wave duration and resulted in the most significant improvement in atrial function (LAAEV, 33.2 (19.3) v 53.7 (23.9) cm/s, p = 0.0001; LAAEF, 31.9 (11.1) v 46.2 (12.6)% p < 0.0001; TMIF-A, 37.7 (18.3) v 54.1 (21.2) cm/s, p < 0.001; SEC grade, 1.4 (1.1) v 0.8 (0.9). p = 0.001, right atrial appendage versus biatrial pacing).
Conclusions: Atrial pacing at increased rates can improve atrial mechanical function after cardioversion of persistent AF. Biatrial pacing may be the most effective technique to reverse atrial mechanical stunning.
After the cardioversion, there is a important increase in LA mean Pressure

Mesure des dimensions atriales
Cardioversion success rate & LAA emptying flows recorded in AFib

- e > 40 cm/s:
  - 56 % sensitivity
  - 80 % specificity
  - 68 % accuracy

For a one-year follow-up

Antonielli et al J Am Coll Cardiol 2002; 39: 1443
In Sinus rhythm, just after the cardioversion
Take Home messages

Stunning, not taking into account in most our practices, rare are the Acute Pulmonary Edema post cardioversion

Complexity of the LAA anatomy and necessity, today, to use a 3D TEE +- CT approach (percutaneous closure)

The risk of recurrence of AFIB could be indirectly assess by the LA size but also function assessment,

+++Value of LAA function+++
The Left Atrial Appendage, a Small, Blind-Ended Structure*: A Review of Its Echocardiographic Evaluation and Its Clinical Role

The pseudorestrictive pattern of transmitral Doppler flow pattern after conversion of atrial fibrillation to sinus rhythm: Is atrial or ventricular dysfunction to blame?

Hirotsugu Yamada, MD, PhD, Erwan Donal, MD, Yong-Jin Kim, MD, Deborah A Agler, RCT, RDCS, Youhua Zhang, MD, Neil L Greenberg, PhD, FACC, Todor N Mazgalev, PhD, FACC, James D Thomas, MD, FACC, Richard A Grimm, DO, FACC

Journal of the American Society of Echocardiography
Volume 17, Issue 8, Pages 813-818 (August 2004)
DOI: 10.1016/j.echo.2004.04.021
AF begets AF

Control

burst pacing —— AF —— Sinus Rhythm

Duration of Fibrillation

5 sec

after 24 hours

>24 hours

after 2 weeks

20 sec

Amyloid Deposition / Atrial remodeling with AF

- Patients with long-standing AF have a very high prevalence of atrial amyloidosis, especially in the Left atrium.

- BNP level is correlated to the risk of developing an AF and BNP level decreases with AF reduction and ARA II prescription.

Wozakowska-Kapton et al. Am J Cardiol 2004; 93: 1555
TEE Performed for Evaluation Prior to Cardioversion

LAA Thrombus Present

- No: Findings Suspicious for the Presence of Thrombi
  - No: Consider Administration of Echo Contrast for Further Evaluation
    - No: Doppler Evaluation of LAA Velocities: > 40 cm/s
      - No: Safe to Perform Cardioversion* (Yes)
      - Yes: Safe to Perform Cardioversion* (Yes)
  - Yes: Do Not Proceed with Cardioversion (Yes)
<table>
<thead>
<tr>
<th>Pathophysiology</th>
<th>Echocardiographic Appearance</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC</td>
<td>Low blood flow velocities.</td>
<td>Swirling echodensity within the atrium.</td>
</tr>
<tr>
<td>Sludge</td>
<td>Low blood flow velocities.</td>
<td>Viscous, gelatinous morphology, not well formed. Represents an intermediate stage between SEC and formed thrombus.</td>
</tr>
<tr>
<td>Pectinate muscle</td>
<td>Part of the normal LAA morphology.</td>
<td></td>
</tr>
</tbody>
</table>

LAA = left atrial appendage; SEC = spontaneous echocardiographic contrast.
<table>
<thead>
<tr>
<th></th>
<th>MDCT</th>
<th>TEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAA thrombus detection</td>
<td>+</td>
<td>2D/3D ++</td>
</tr>
<tr>
<td>Assessment of LAA function</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>LAA orifice size</td>
<td>++</td>
<td>2D + 3D ++</td>
</tr>
<tr>
<td>LAA morphology</td>
<td>++</td>
<td>2D + 3D ++</td>
</tr>
<tr>
<td>Evaluation of intracardiac</td>
<td>+++</td>
<td>2D + 3D +++</td>
</tr>
<tr>
<td>structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation of extracardiac</td>
<td>+++</td>
<td>-</td>
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<tr>
<td>structures</td>
<td></td>
<td></td>
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<tr>
<td>Intraprocedural guidance</td>
<td>-</td>
<td>2D ++ 3D +++</td>
</tr>
<tr>
<td></td>
<td>TEE</td>
<td>MDCT</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Sensitivity/specificity</td>
<td>92%-100%/98%-99%</td>
<td>96%/92%</td>
</tr>
<tr>
<td>for LAA thrombi detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>0.2-0.5 mm</td>
<td>0.4 mm</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>20-33 ms</td>
<td>70-105 ms</td>
</tr>
<tr>
<td>3D volume rendering</td>
<td>Yes (with 3D)</td>
<td>Yes</td>
</tr>
<tr>
<td>Contrast required</td>
<td>No*</td>
<td>Yes</td>
</tr>
<tr>
<td>Ionizing radiation</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Special considerations</td>
<td>Widely available, provides</td>
<td>Noninvasive, dynamic</td>
</tr>
<tr>
<td></td>
<td>real-time assessment</td>
<td>assessment of LA function</td>
</tr>
<tr>
<td></td>
<td>Semi-invasive</td>
<td>Cannot be performed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>real-time during procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited availability</td>
</tr>
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</table>
Indices of Atriale emptying: 
(not used in clinical routine)

1. LA total emptying volume index = \( \text{LAVI}_{\text{Imax}} \times \text{LAVI}_{\text{Imin}} \),
2. LA passive emptying volume index = \( \text{LAVI}_{\text{Imax}} \times \text{LAVI}_{\text{Ipre-a}} \),
3. LA active emptying volume index = \( \text{LAVI}_{\text{Ipre-a}} \times \text{LAVI}_{\text{Imin}} \).

Reservoir Function: 2 indices:

1. expansion index = \[
\frac{(LAVI_{\text{max}} - LAVI_{\text{min}})}{LAVI_{\text{min}}} \times 100
\]

2. diastolic emptying index = \[
\frac{(LAVI_{\text{max}} - LAVI_{\text{min}})}{LAVI_{\text{max}}} \times 100.
\]

Conduit Function: 2 indices:

1. passive emptying % of total emptying = 
\[
\frac{[(LAVI_{\text{max}} \times LAVI_{\text{pre-a}})/(LAVI_{\text{max}} \times LAVI_{\text{min}})] \times 100}
\]

2. passive emptying index = 
\[
\frac{(LAVI_{\text{max}} \times LAVI_{\text{pre-a}})/LAVI_{\text{max}} \times 100}
\]

Booster pump function:

2 indices:

1. active emptying percentage of total emptying = 
\[
\left( \frac{LAVI_{pre-a} - LAVI_{min}}{LAVI_{max} - LAVI_{min}} \right) \times 100
\]

2. active emptying index = \((LAVI_{pre-a} - LAVI_{min})/LAVI_{pre-a} \times 100\).
Plusieurs indices ont été proposés dans la littérature mais sont peu utiles à notre pratique…

- **Left atrial ejection force:**
  \[ \frac{1}{2} \times \text{Str. Vol.} \times \rho \times \text{Avel}^2 \]

- **Left atrial kinetic energy:**
  Mitral VTI \times OG EF/OG max surf.

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**Acoustic quantification**

**Prognostic Role of « α' »**

- **S**: reservoir
- **D**: conduit
- **Arev**: booster p

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**Stefanadis et al. Eur H J 2001 & Manning JACC 1993**
Deformation du Myocarde Atrial
Semi-automatic borders detection

Strain (%)

Strain Rate (s⁻¹)
Pic de déformation positif: Expension du tissu atrial pendant la phase Reservoir
Le strain atrial. C’est fiable?

L’étude des déformations (strain) avec le speckle tracking est robuste.

Variabilité Intra-observateur = 8%
Inter-observateur 9.5%

Temps nécessaire pour étude de la fonction atriale: 3.8 minutes

Paraskevaidis IA et al. Heart 2009;95:483-489
CHANGEMENT LIE à L’ÂGE DU STRAIN SYSTOLIQUE (reservoir) ET DU STRAIN RATE DIASTOLIQUE ET CE SURVIENT JUSQU’à UNE DECADE AVANT LES ALTERATONS DES PARAMETRES DE VOLUME
↑volume de l’OG proportionnel au degré de dysfonction diastolique

Augmentation de la fonction booster pump

Déclin progressif de la fonction conduit

vieillissement
Frank–Starling applied to l’oreillette

Roșca M et al. Heart 2011;97:1982
Deformations OG s’altèrent chez les HTA et diabétiques même sans dilatation.

- LA conduit ↘ avec l’âge
- LA reservoir presque constante
- LA booster pump function augmente un peu

Mondillo et al. JASE 2011; 24: 898-908
Boyd et al. Heart 2011; 97: 1513
Index of backscattering

84%

56%

28%

Normal
Cardiomyopathie dilatée

Deformation – Strain (%)

32%

16%

Index of backscattering

Velocity of Deformation – Strain Rate (S⁻¹)
Deformation – Strain (%)

Index of backscattering

36%

18%

Velocity of Deformation – Strain Rate (S⁻¹)

Hypertension
Cardiomyopathie hypertrophique
Remodelage atrial

- Altération de la fonction puis dilatation
- Fibrose interstitielle

**Contrôle**  

**FA**

- Remodelage de la matrice extra-cellulaire
- “TIMP-2 Down-regulation & MMP-2 up-regulation”

*Kumagai. J Am Coll Cardiol. 2003; 41: 2197-204*

*Xu. Circulation. 2004; 109: 363-8*
LA Volumes and Reservoir Function Are Associated With Subclinical Cerebrovascular Disease

The CABL (Cardiovascular Abnormalities and Brain Lesions) Study

CONCLUSIONS Greater LA volumes and reduced LA reservoir function are associated with subclinical cerebrovascular disease detected by brain magnetic resonance imaging in subjects without history of stroke. In particular, LAV_{min} and LAEF are more strongly associated with SBI and WMHV than the more commonly measured LAV_{max}, and their relationship with subclinical brain lesions is independent of other cardiovascular risk factors. (J Am Coll Cardiol Img 2013;6:313–24) © 2013 by the American College of Cardiology Foundation
Comprehensive Assessment of Changes in Left Atrial Volumes and Function after ST-Segment Elevation Acute Myocardial Infarction: Role of Two-Dimensional Speckle-Tracking Strain Imaging

Methods: The study population comprised 407 patients with acute myocardial infarction who were treated with primary percutaneous coronary intervention. At baseline and 12 months, two-dimensional echocardiography was performed to assess LA volumes and function using speckle-tracking strain and strain rate.

Conclusions: LA remodeling occurred in 22% of patients after acute myocardial infarction. In patients without LA remodeling, no changes in LA function were observed, but in patients with LA remodeling, LA function deteriorated significantly. (J Am Soc Echocardiogr 2011;24:1126-33.)
Localisations des thrombi en ETO lors de la fibrillation atriale

Méta-analyse de Mahajan

Compilations de 34 études de patients en FA

Le thrombus était en dehors de l’auricule gauche dans

• 56% des cas dans la FA valvulaire
• 22% des cas dans les cohortes mixtes
• 11% des cas de patients ayant une FA non valvulaire

Importance de la dysfonction ventriculaire gauche qui est associée au risque d’avoir un thrombus dans l’auricule gauche mais aussi en dehors !

Mhajan et al. Heart 2012; 98: 1120