POLITECNICO DI MILANO

HRV – ventricular response during atrial fibrillation

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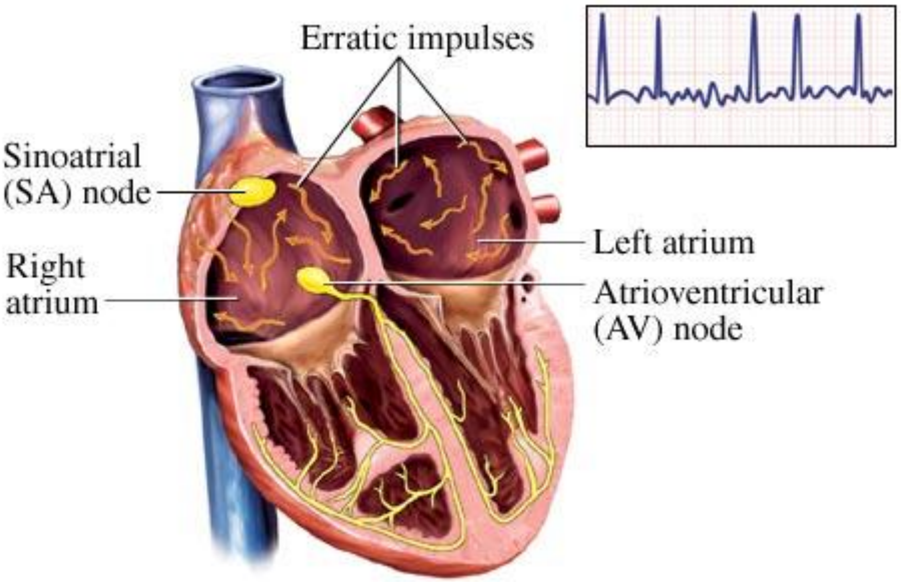
Outline

- AF – clinical background
- Methods:
    1. Time domain parameters
    2. Spectral analysis
- Applications:
    1. Evaluation of Exercise and Flecainide Effects
    2. Variability of Blood Pressure Variability
- Future work – ideas and help

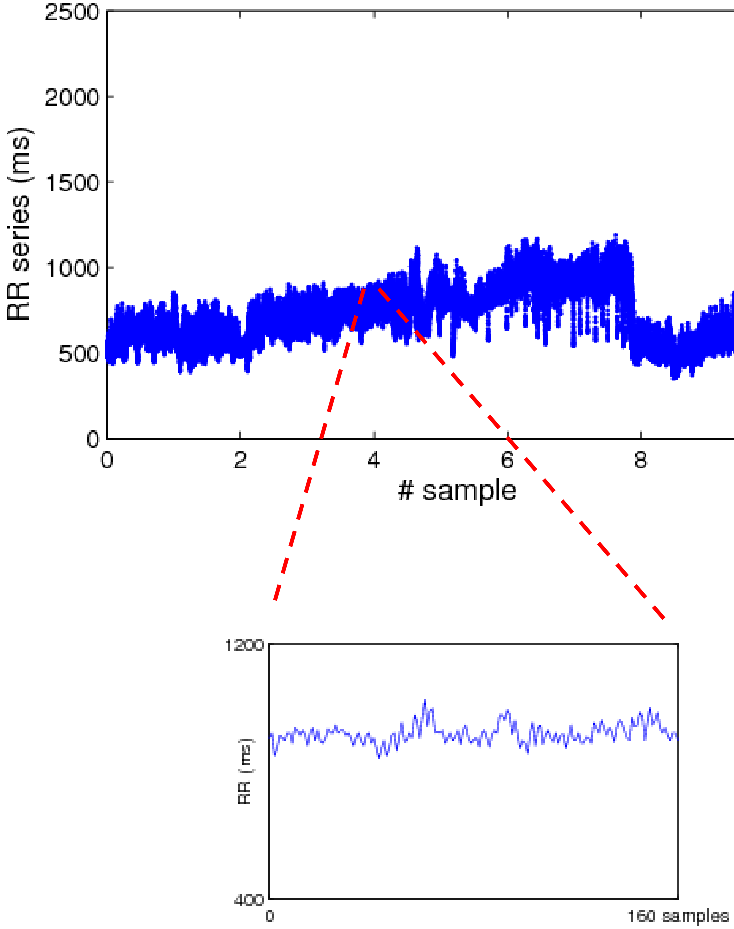
AF clinical background

- The most common arrhythmia
- Increased morbidity and mortality
- Irregular atrial depolarization: no P waves
- Irregular **ventricular rate**: 90-160 bpm
- Many AF influencing mechanisms: **the ANS**

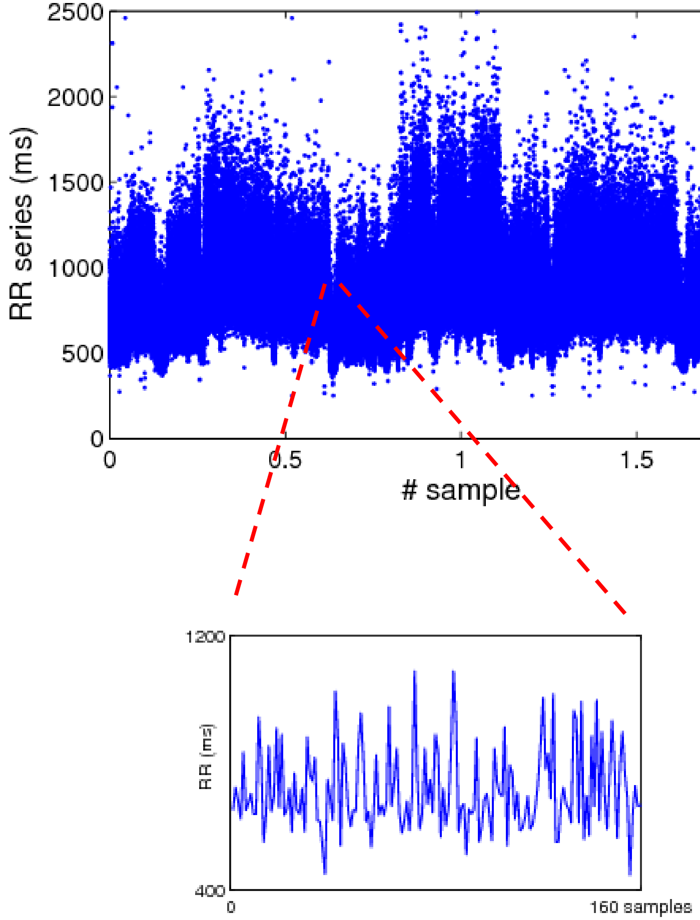


AF clinical background

Sinus rhythm

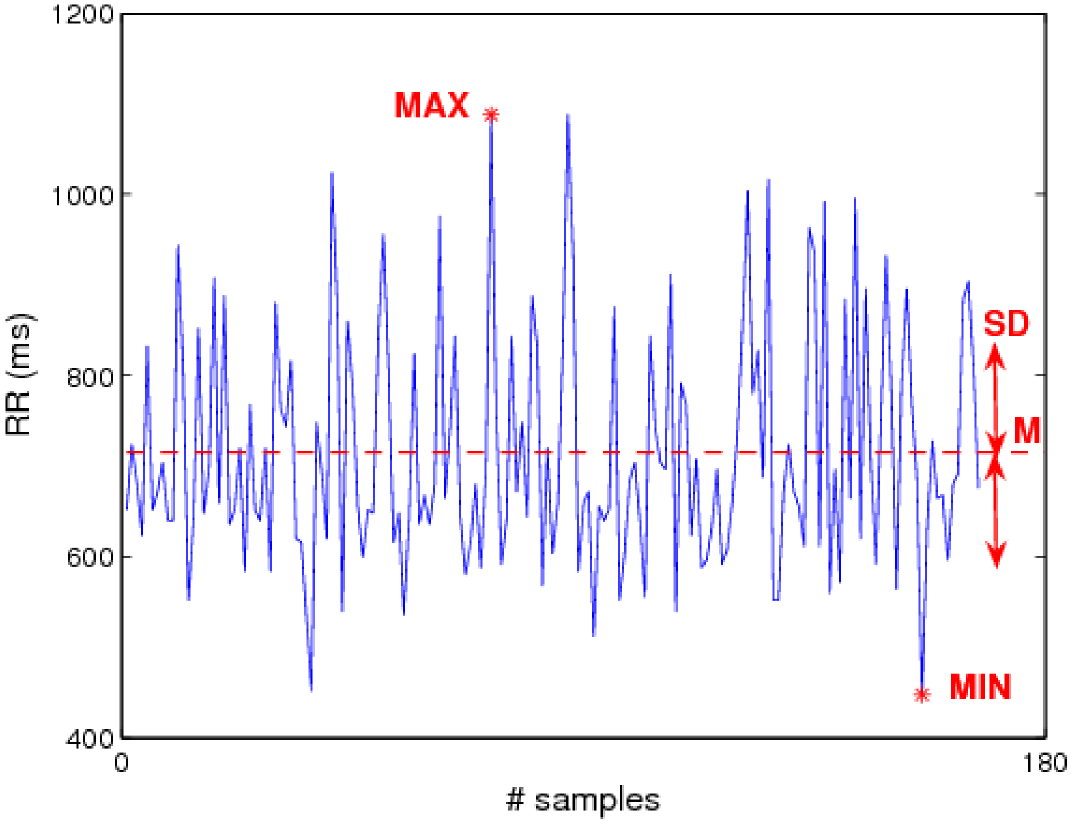


AF



Time domain parameters - Methods

- Mean NN
- SDNN
- Min
- Max
- pNN50 the % of interval differences of successive NN >50 ms
- rMSSD the square root of the mean squared differences of successive NN



Time domain parameters - Applications

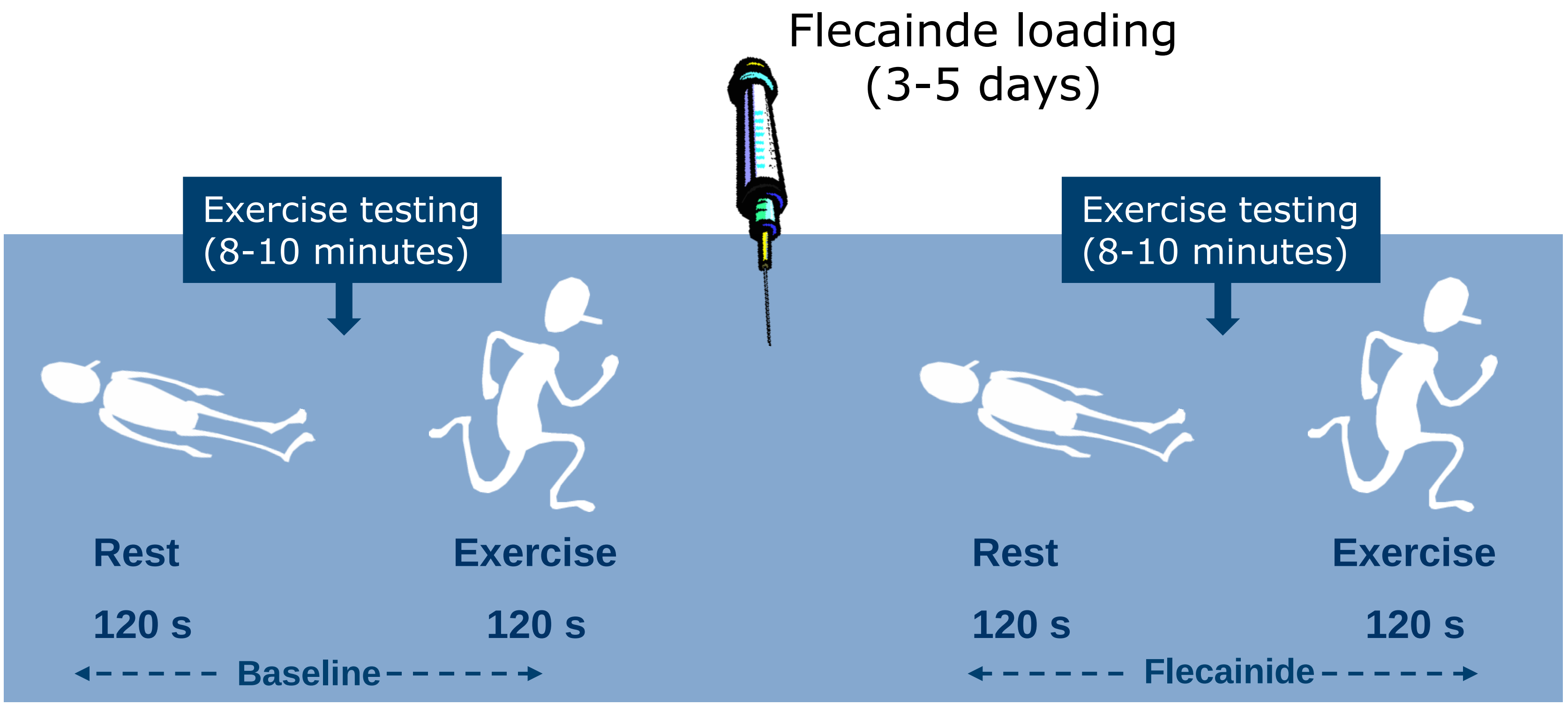
AIM

1. To characterize the ventricular response to changes of the autonomic balance induced by exercise testing considered as an ANS stimulus
2. To elucidate the influence of a commonly used anti-arrhythmic drug, flecainide, on ventricular response

Time domain parameters - Applications

DATA

15 patients with persistent AF



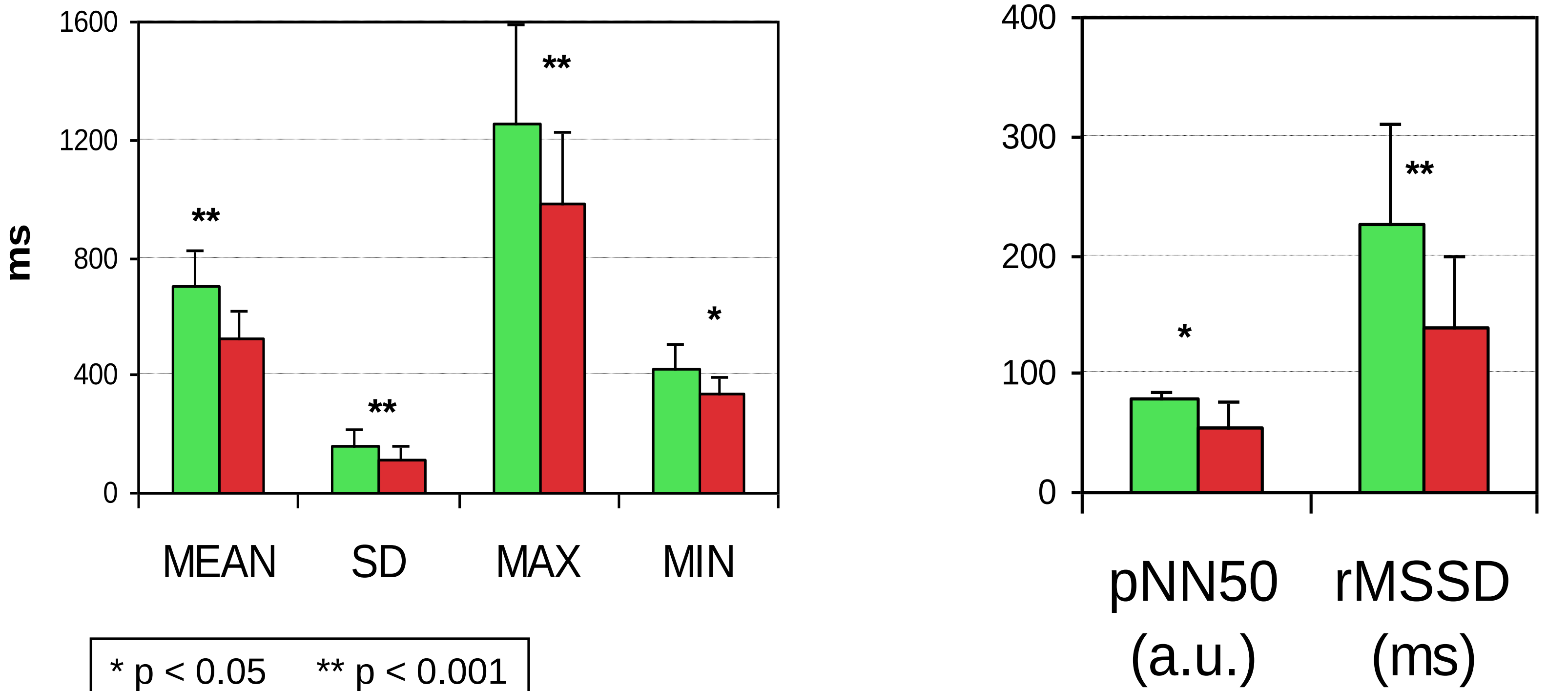
Time domain parameters - Applications

RESULTS

Exercise Effects

Same trend at Baseline and after Flecainide Loading

Rest	Exercise	Rest	Exercise
Baseline		Flecainide	



* $p < 0.05$ ** $p < 0.001$

Time domain parameters - Applications

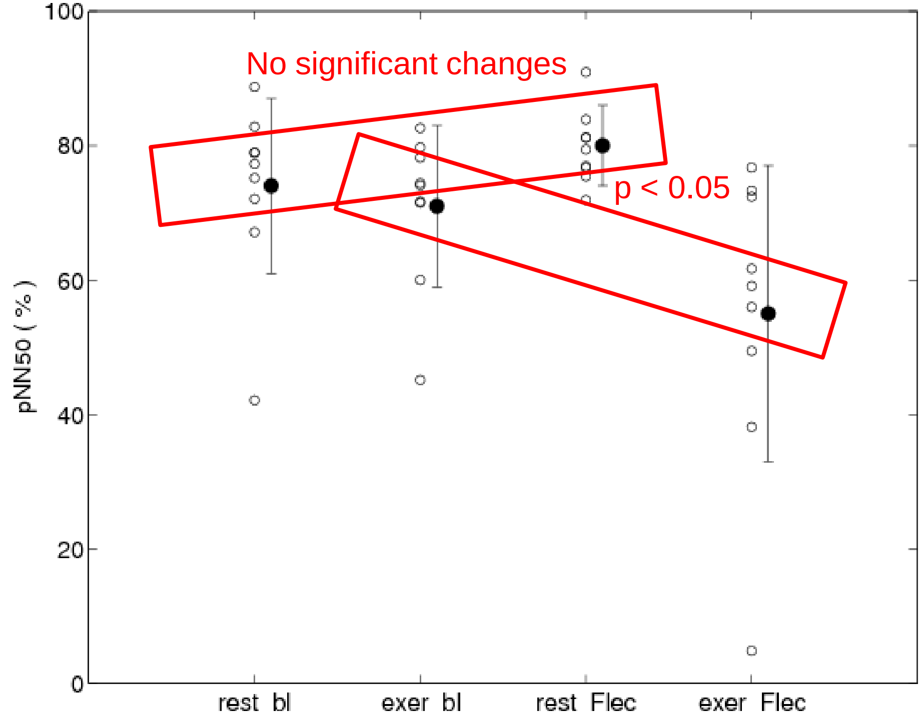
RESULTS

Rest | Exercise
Baseline

Rest | Exercise
Flecainide

Flecainide Effects

- under resting conditions VR parameters not altered
- during exercise:



Vagolitic effect of flecainide during exercise phase

Time domain parameters - Applications

CONCLUSION

Exercise Effect

n AF

Exercise testing

may unmask autonomic tone changes

due to antiarrhytmic drug

Flec

Changes in autonomic tone

Vagolytic effect highlighted during exercise

Spectral Analysis - Methods

1. Autoregressive spectral analysis

- coefficients estimated using the Levinson Durbin algorithm
- Anderson's test used to check the validity of the model
- the model order selected by use of the Akaike Information Criterion (order 7-20)
- spectral decomposition algorithm

2. Welch periodogram

- 64-sample Hamming window, with 50% overlap

3. LF (0.03-0.15 Hz)

HF (0.15-0.4 Hz)

Spectral Analysis - Applications

AIM

To describe blood pressure variability

in short-term recordings in patients with persistent AF

Spectral Analysis - Applications

DATA

- 26 patients with persistent AF
- ECG + continuous beat-to-beat noninvasive arterial BP
- before and after electrical cardioversion

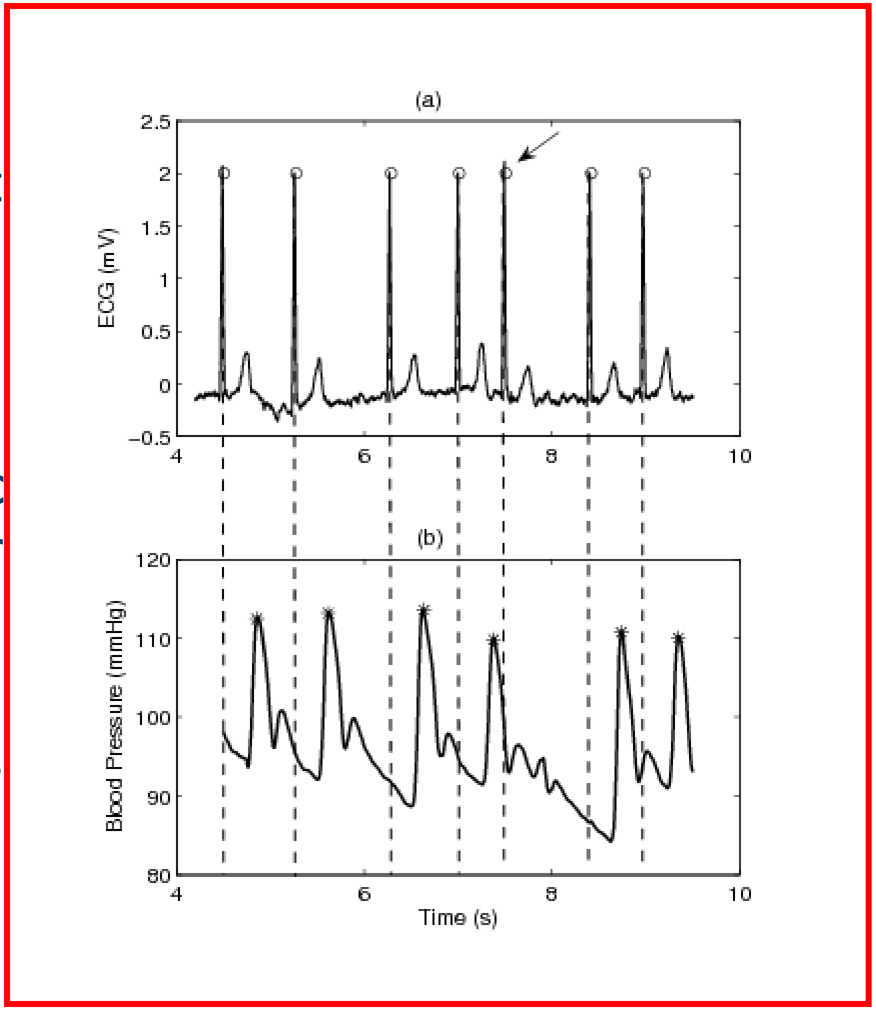
Spectral Analysis - Applications

METHODS

Series extraction

- QRS complex: automatic det
- Systolic BP:
  - BP_1 = Low-pass filtered
  - t_i = BP_1 local maxima
  - Systolic BP values = loc centered on t_i whose cr exceeded the threshold
- Interpolation (cubic splines)

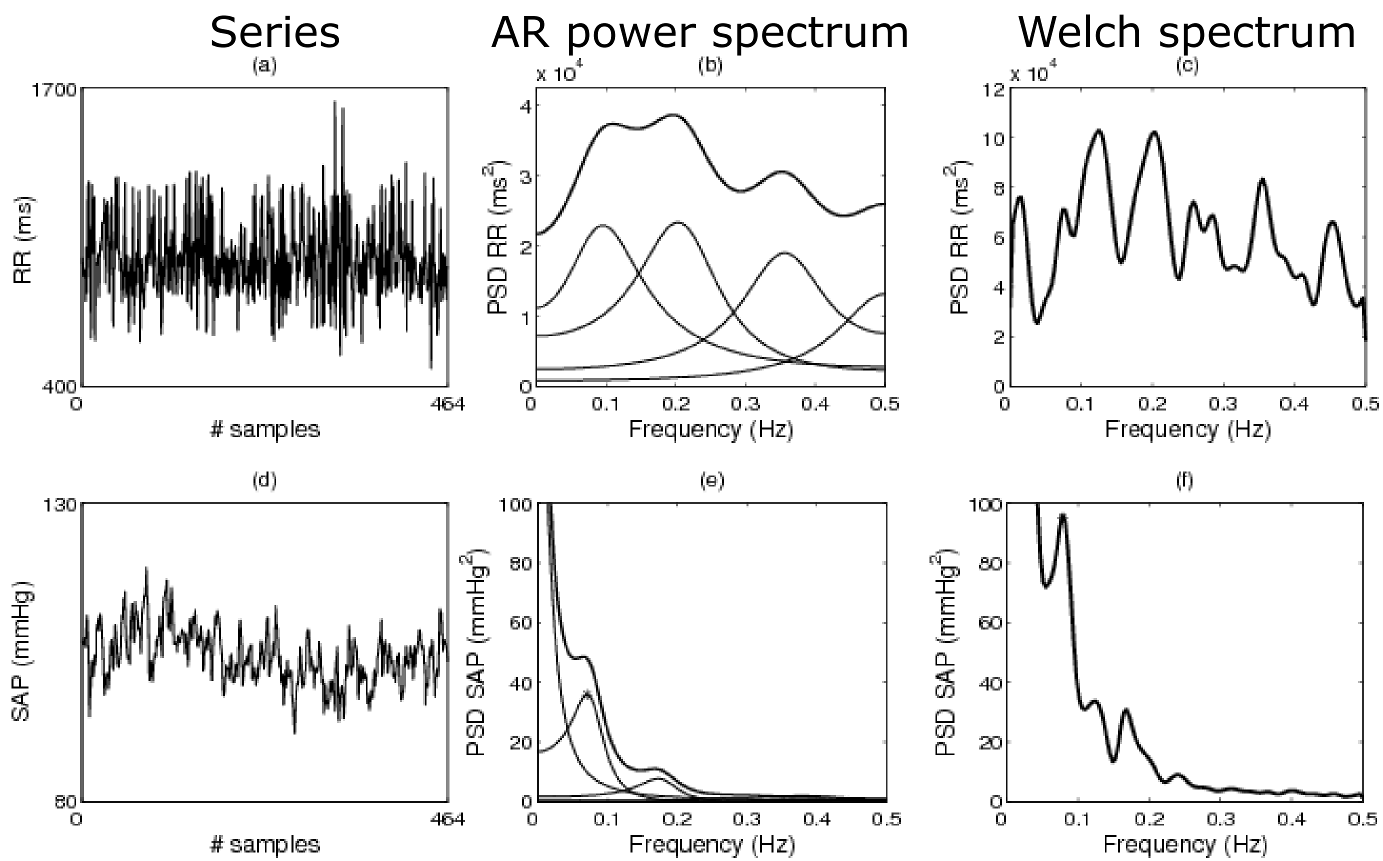
  RR and systolic BP series



Spectral Analysis - Applications

RESULTS

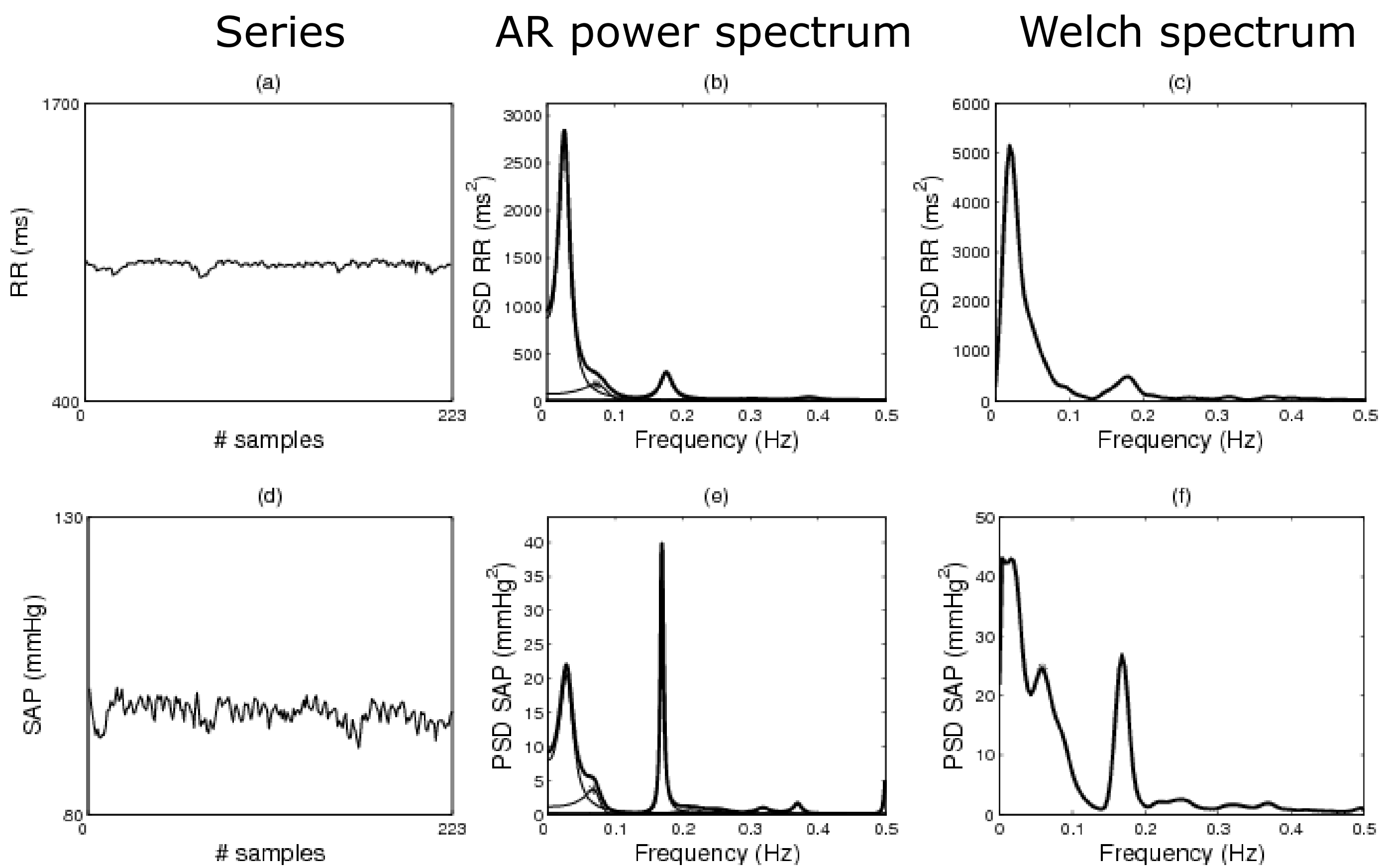
during AF before cardioversion



Spectral Analysis - Applications

RESULTS

during AF after cardioversion



Spectral Analysis - Applications

RESULTS

Systolic Pressure: M ± SD (# of subjects in which the peak was found)

	PRE	POST
AR ANALYSIS		
$Freq_{LF}$ (Hz)	**0.07 ± 0.03 (24)**	**0.06 ± 0.01 (26)**
Pow_{LF} ($mmHg^2$)	**6.08 ± 7.81 (24)**	**2.34 ± 3.79 * (26)**
$Freq_{HF}$ (Hz)	**0.23 ± 0.07 (26)**	**0.21 ± 0.06 (26)**
Pow_{HF} ($mmHg^2$)	**3.04 ± 4.11 (26)**	**0.77 ± 0.69 * (26)**

* $p < 0.05$

Spectral Analysis - Applications

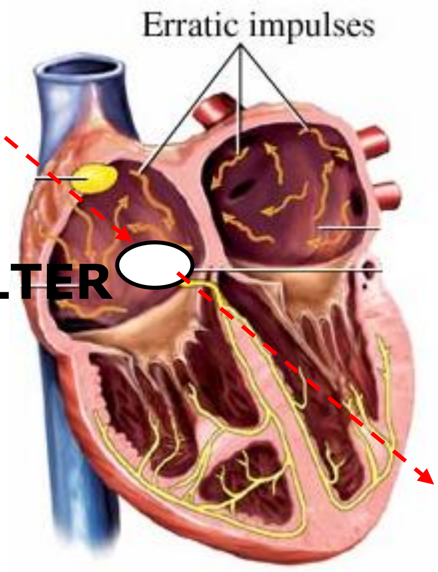
CONCLUSIONS

- Presence of LF component of systolic BP variability in patients with AF
- The 0.1 Hz oscillatory component of systolic BP variability may be present in absence of a correspondent fluctuation in the RR series

New study… AV node modeling

400-600 bpm

AV NODE = FILTER



90-160 bpm

New study… AV node modeling

The first and simplest model (Cohen, 1983)

AV junction = a hypothetical electrically active cell with defined electrical properties (refractory period, automaticity…)

Model with 4 parameters:

- Phase-IV depolarization rate (dVdt)
- Discrete increase in Vm due to atrial impulses (ΔV)
- Refractory period (τ)
- AF frequency (λ) = rate of atrial impulses arrivals at AVJ, with the hypothesis that atrial impulses come from a Poisson distribution

New study… AV node modeling

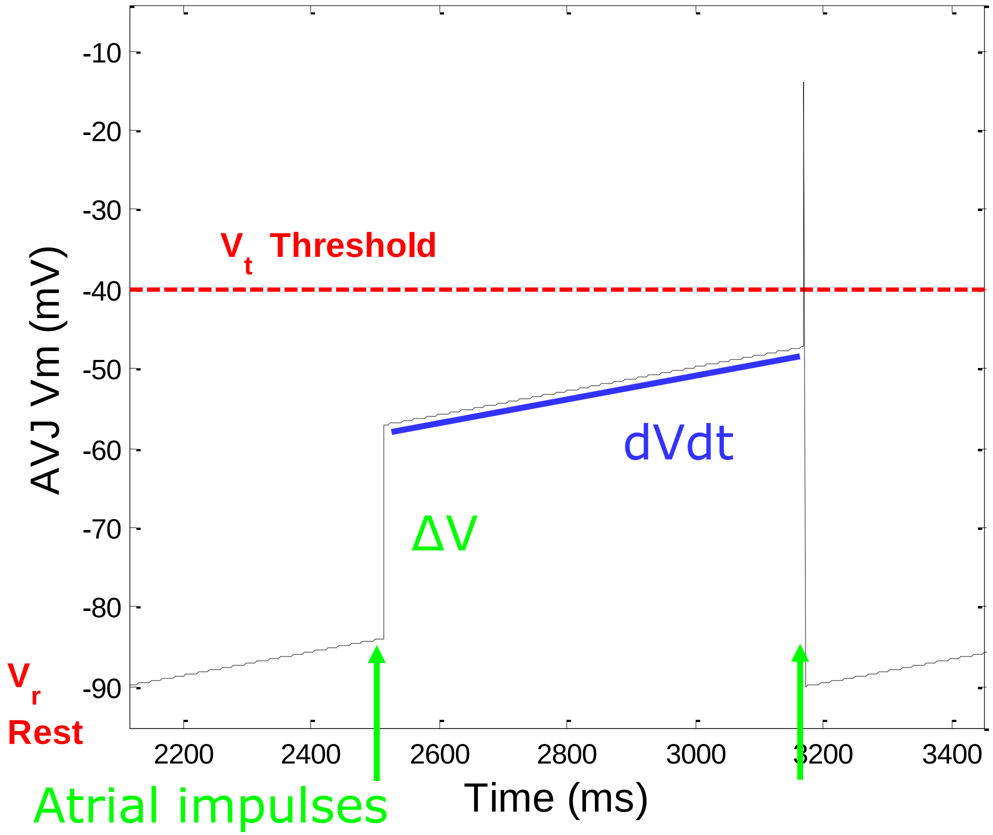
The first and simplest model (Cohen, 1983)

The AVJ's potential (Vm) increases from rest (V_r) to threshold (V_t) due to:

- dVdt
- ΔV

$$V_m = V_r + dVdt \bullet t + n(t)\Delta V$$

$$p_n = \frac{e^{\lambda t}(\lambda t)^n}{n!}$$

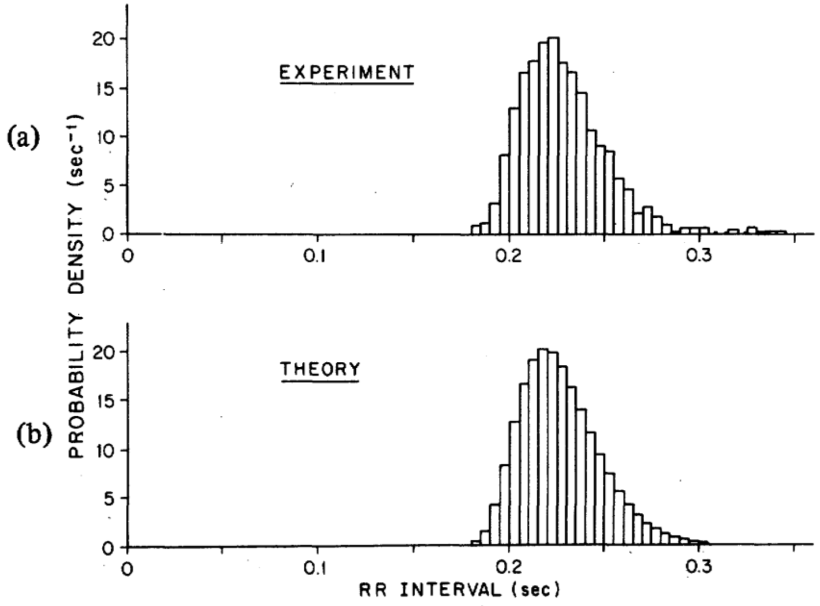


New study… AV node modeling

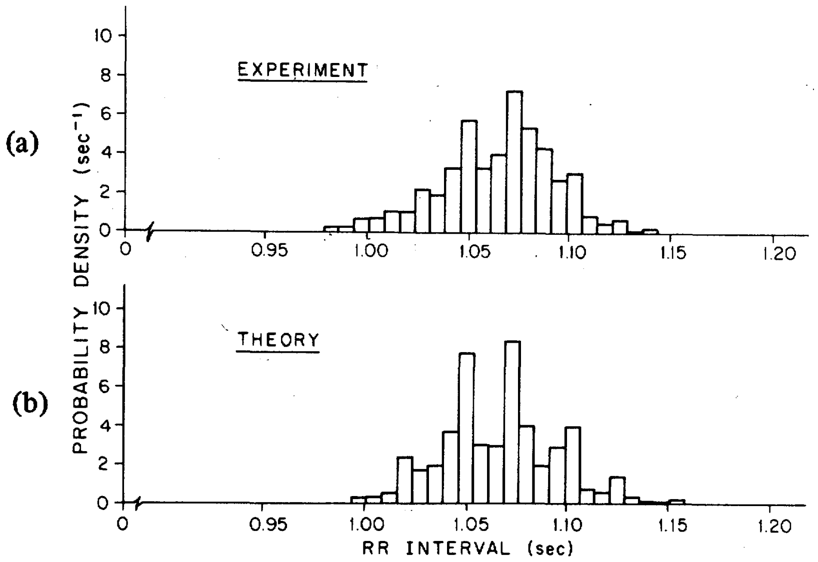
The first and simplest model (Cohen, 1983)

Even with this simple model, Cohen reproduced real data:

Unimodal distribution



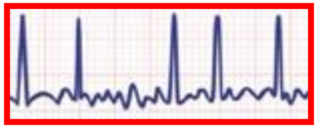
Multimodal distribution



New study… AV node modeling

Our idea:

Input
Patient's ECG



Input
- AF frequency (λ)
- RR series

λ

AV MODEL
(ΔV, dVdt, τ …)

Estimated RR series

optimization

Output
Patient's AV node properties

Real RR series

New study… AV node modeling

The first and simplest model (Cohen, 1983)

Problems:

1. Mathematical solution based on Poisson distribution assumption, is it really physiological?
2. Mathematical solution possible with 4 parameters, and if we add more parameters (AV node delay, concealed conduction, dual pathways…)
3. How to perform optimization?