Basic Mechanisms of Atrial Fibrillation Relative to Ablation

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Pathophysiology of AF

Multiple Wavelet Reentry

Moe, 1962

Vagal stimulation increases ERP dispersion by 300% and potentiates the substrate.

Sympathetic stimulation increases focal firing and potentiates the initiator.

Initiator (premature beat)
Substrate (anisotropopnic tissue)
Triggering factors (autonomic imbalance)

Pre-existent tachycardia, electrolyte imbalance
Critical atrial mass is needed to sustain multiple wavelet reentry

Atrial compartmentalization can eliminate atrial fibrillation
1991

Surgical Maze

Success 90%

Can not be done without a concomitant indication of cardiac surgery
1992-1997

**Transcatheter Maze**

Right atrial only procedures

- Limited or no success

Combined right and left atrial procedures

- Prolonged procedural times up to 12 hours
- Up to 70% success
1998

Groundbreaking observation by Haissaguerre team: AF comes from the PVs

This observation has energised Electrophysiology and industry
Myocardium

Myocardial sleeve
Myocardial sleeves

Cabrera et al., 2002
Chen et al., 1999

Relatively long ERP
Slow conduction
Decrimental conduction
Function of Myocardial sleeves

1- **Throttle valve action**: The venous sphincters and sleeves exert a valve action that prevents reflux of blood from the atrium into the veins (*Burch & Romney, 1954*).

2- **Active expulsion of blood into left atrium (PV → LA → LV)**: *Carrow and Calhoun* suggested that a peristaltic or "milking" action toward the heart was produced by the contractions of the myocardial fibers which run from the atrium over the vein and back to the atrium again (*Carrow & Calhoun, 1964*).

3- **Regulation of pulmonary venous pressure** and blood flow, through the basic tone of the striated muscle and its possible changes due to various physiological conditions (*Kuramoto & Rodbard, 1962*).
Myocardial sleeves contain the initiating foci

As much as 94% of the atrial ectopic foci are located in the PVs
Myocardial sleeves contain the reentry substrate

They contain muscle fascicles running in all directions

Heterogenity of conduction and refractoriness at the PV ostia,

Reentry substrate
Myocardial sleeves contain the reentry substrate

They contain muscle fascicles running in all directions
Heterogeneity of conduction and refractoriness at the PV ostia,
Myocardial sleeves contain the source of autonomic imbalance

Are densely supplied by autonomic nerves (ganglionated plexuses) that are the source of autonomic imbalance
The interplay between different pathophysiological mechanisms of AF

ACE inhibitors, AT\(_1\) blockers

Angiotensin II

MAPKs

Fibrosis

Substrate

Intrinsic determinants (APD)

Intrinsic determinants (APD)

Sodium-calcium exchange upregulation

Pulmonary veins (stretch?)

Substrate

Trigger

Trigger

Heterogeneous ERP, WL

\(\downarrow I_{Ca}\)

\(\downarrow I_{Na}\)

Single-circuit re-entry

Ectopic focus

Multiple-circuit re-entry

Pathophysiology

Therapies and potential therapies

Ablation

Class I drugs

Mibefradil

Ascorbic acid?

Ca loading

Atrial remodelling
Approaches to PV ablation

- **Focal PV ablation**
  - Success: 62%
  - PV stenosis: 40%
- **Segmental ostial PV ablation**
  - Success: 73-80%
  - Needs Lasso mapping
- **Circumferential ostial PV ablation**
  - Success: 80-85%
  - Needs 3D system

 providence map
Atrial Fibrillation Begets Atrial Fibrillation
Sinus Rhythm Maintains Sinus Rhythm

Atrial Remodeling

Electric remodeling

Structural remodeling
Electric remodeling

Down regulation of Ca channels $\rightarrow$ reduction of plateau phase $\rightarrow$
reduction of action potential duration and refractory period
Structural remodeling

Normal atrial tissused

Chronic AF

Loss of banding pattern and integrity of contractile elements, expanded vacuoles, interstitial fibrosis, loss of mitochondria (Everett et al., 2000).

“Beyond the Pulmonary Veins”

Inflammatory makers

O species

RAAS

MAPKs
Persistent AF

Atrial fibrosis

Substrate outside the PVs

Atrial remodeling

Adding linear lesions can optimize the outcome
Adding linear lesions to PV ablation

3 dimensional electroanatomic mapping system
Ablation of AF targets its basic mechanisms through the following:

- It eliminates the triggers (automatic or rotors)
- Isolates the arrhythmogenic sleeves around the PVs
- Eliminates GP: The source of autonomic imbalance
- Compartmentalizes the critical atrial mass needed to sustain reentry
Thank You

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