

AF Mechanisms:

Focal Drivers

and/or

Multiple Wavelets

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No Conflicts of Interest to Disclose

During the Last Years,
You Have Been Told that
the Multiple Wavelets Hypothesis
is **Wrong** ...

... and that Atrial Fibrillation is
Maintained by One or More
'Drivers' (Rotors or Foci).

However...

High-Resolution Direct-Contact Mapping
has Been Unable to Find Stable Rotors in
Patients with Longstanding Atrial Fibrillation

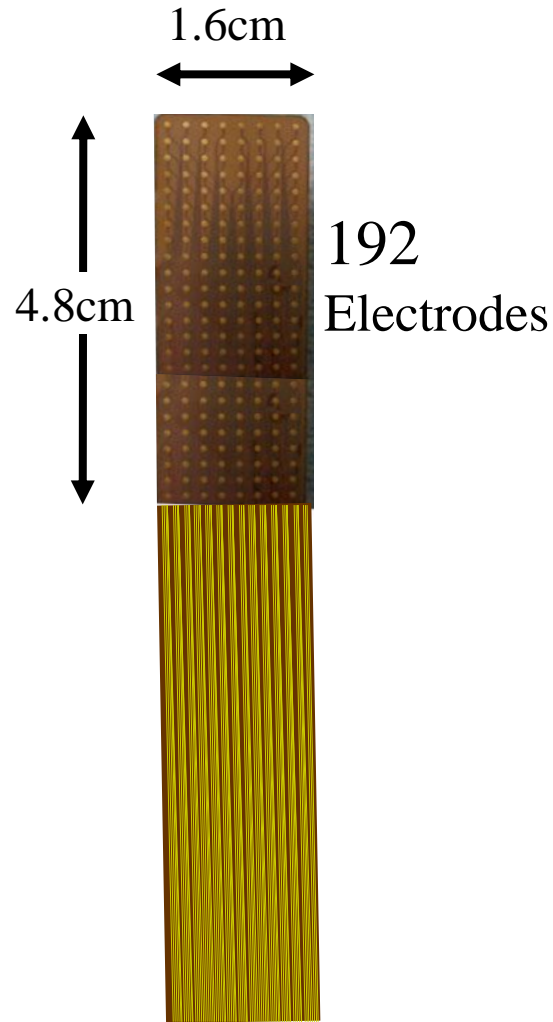
Allessie et al. CircAE 2010

De Groot et al. Circulation 2010

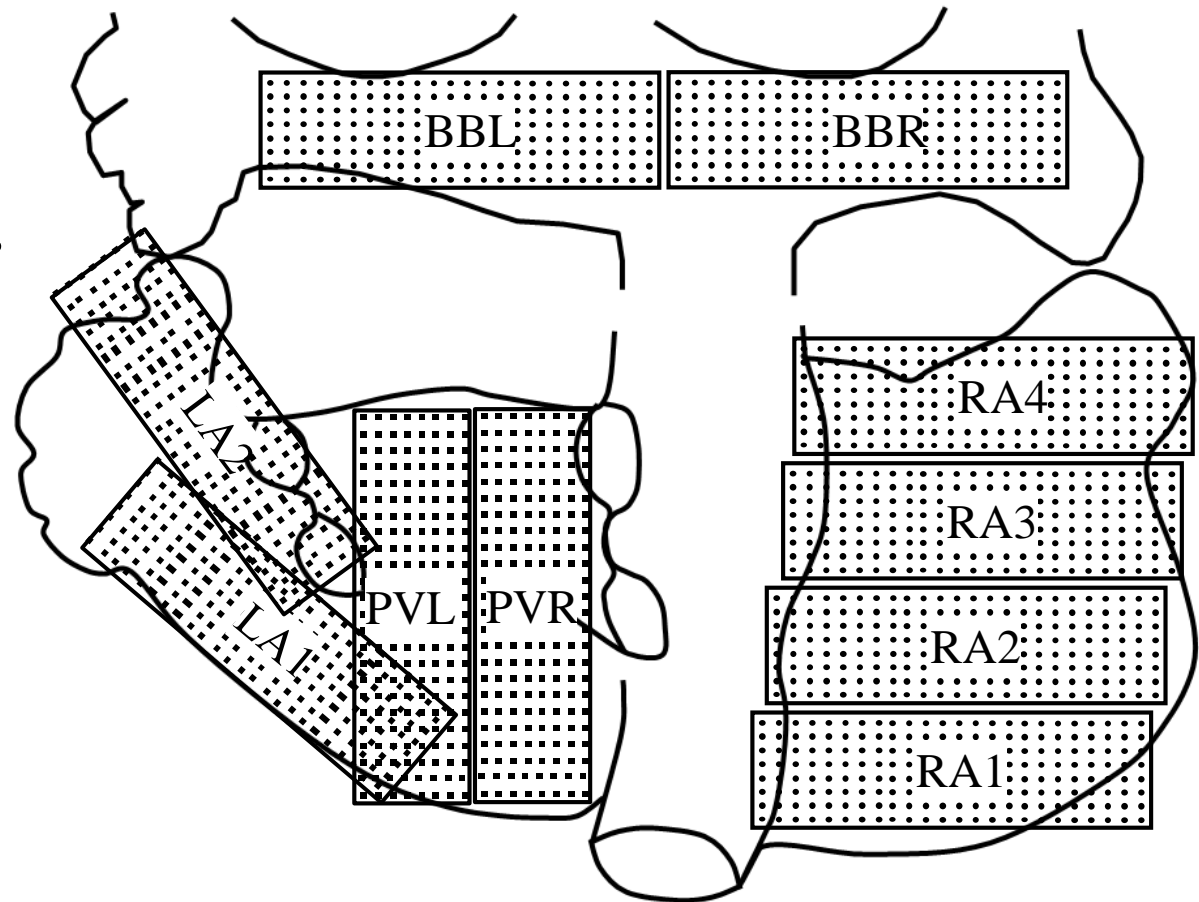
Lee, Kalman et al. Eur Heart J 2013

Lee, Waldo et al. Circulation 2015

Complete High-Density Epicardial Mapping of AF in Rotterdam



Flex-Tape



Construction of Fibrillation Maps

Times

		35	38	25	27		
27	31	32	21	24	27	27	
32	27	26	17	20	23	26	31
19	21	14	16	19	22	25	29
9	10	12	16	19	22	25	27
5	8	36	24	19	18	19	20
6	7	41	23	20	19	18	17
3	2	0	23	23	21	79	80
3	4	3	31	34	76	75	80
7	7	5	103	98	78	73	77
10	9	8	102	99	79	74	75
14	12	9	103	84	79	78	105
17	15	109	95	84	83	110	107
20	18	109	125	88	114	112	109
23	122	120	118	116	116	114	111
129	118	115	121	120	118	116	140
118	115	107	124	123	121	136	139
117	118	110	112	125	132	135	136
116	122	115	119	129	131	134	125
118	122	122	116	125	129	129	126
125	126	125	120	124	127	130	129
124	126	128	123	124	128	132	132
123	123	123	125	127	129	135	136
121	123	125	129	135	136		

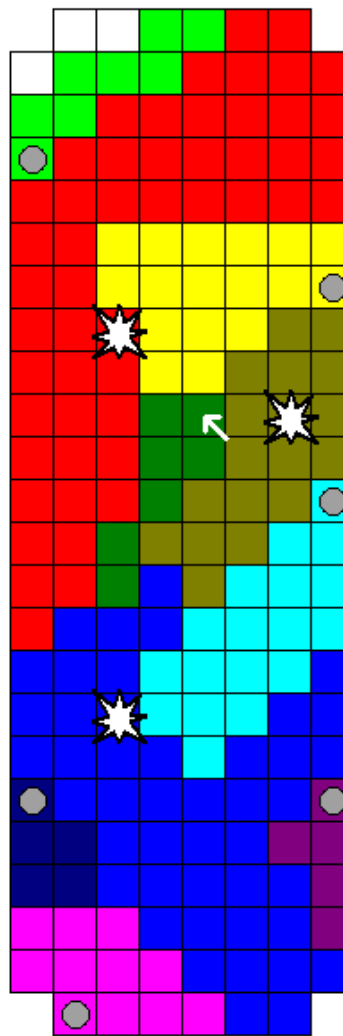
4.8 cm



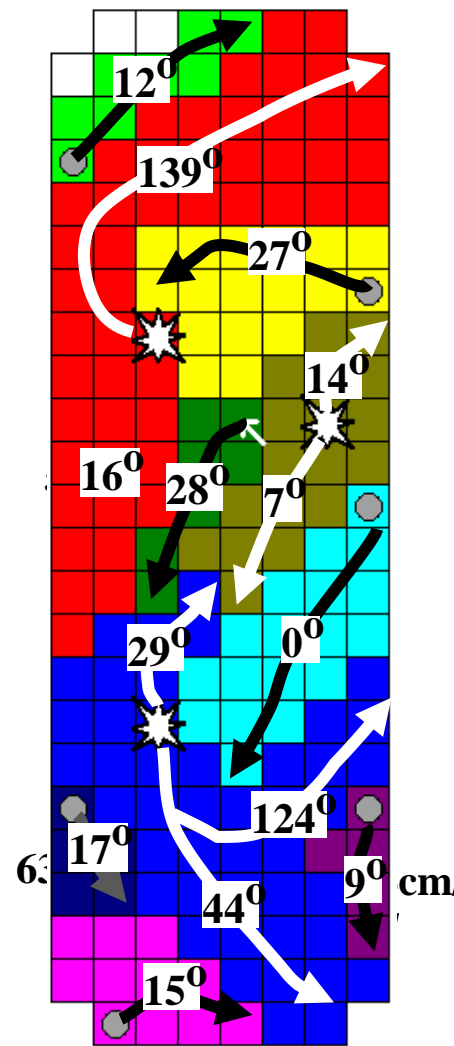
Isochrones



Waves



Turning



In Each Patient:

- **>1700** Epicardial Fibrillation **Electrograms**
(Unipolar, 10 Seconds each)
- **500 - 700** High-Density Fibrillation **Maps**
(4.8 x 1.6 cm)
- **4000 - 6000** Individual Fibrillation **Waves**

In Search for a 'Driver' of AF:

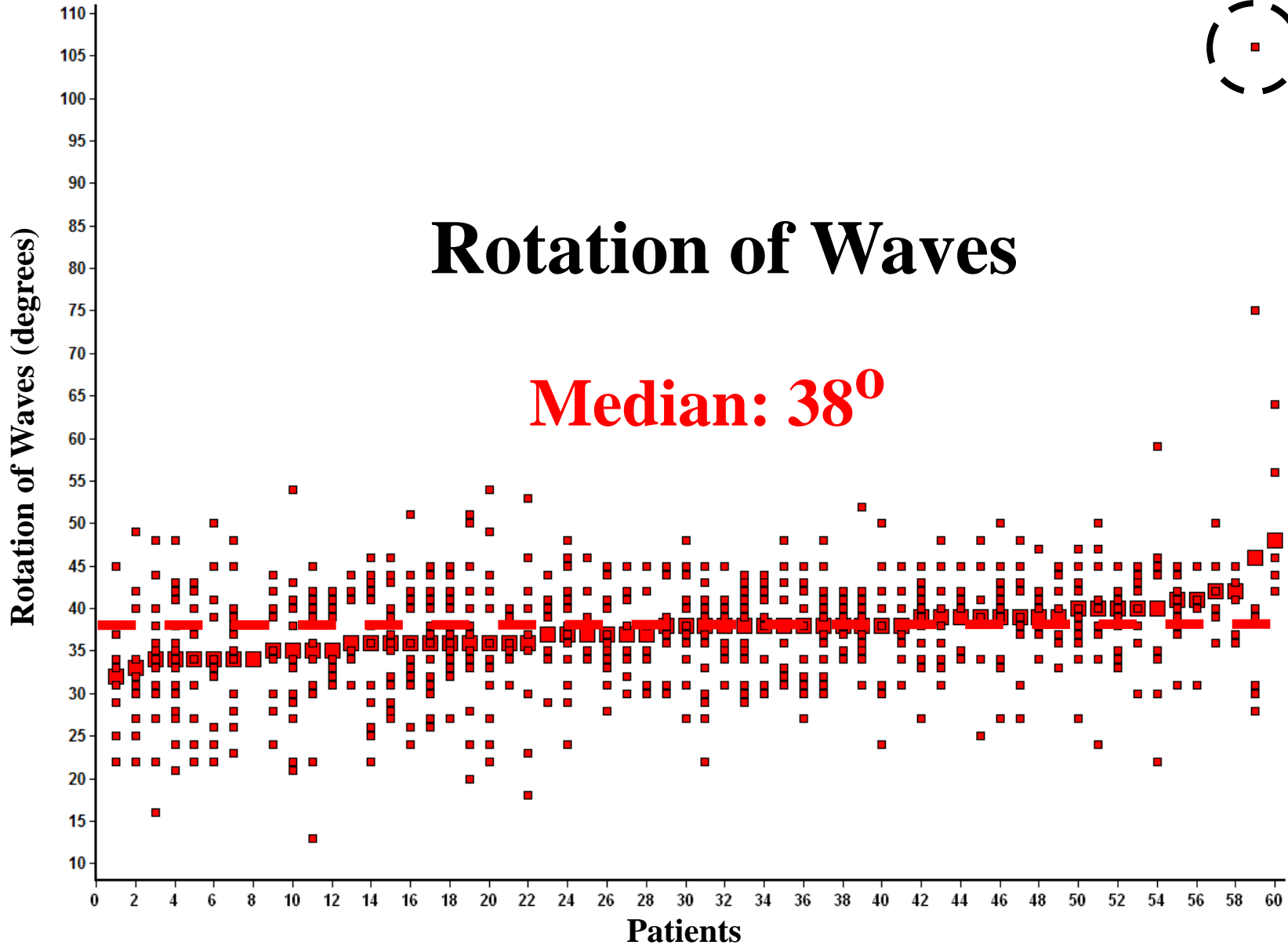
- Rotors?
- Pivot Points?
- Foci?

60 Patients with Persistent AF:

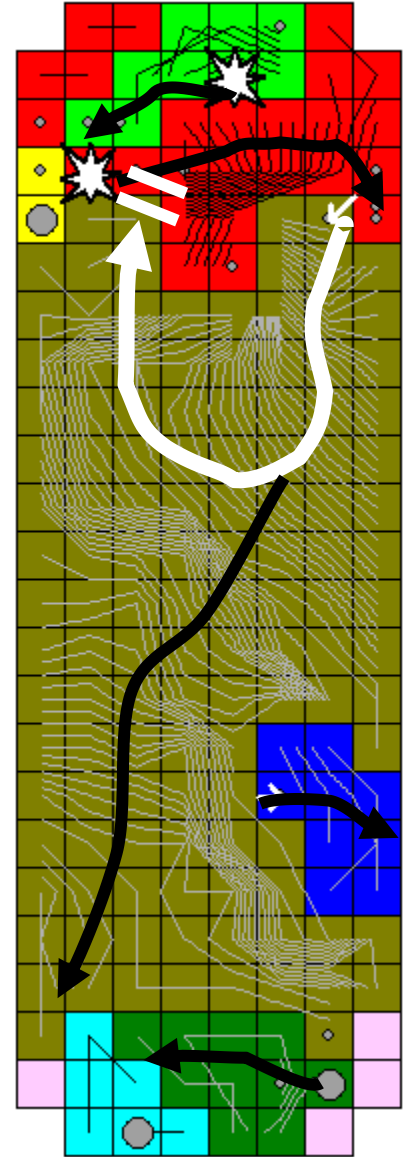
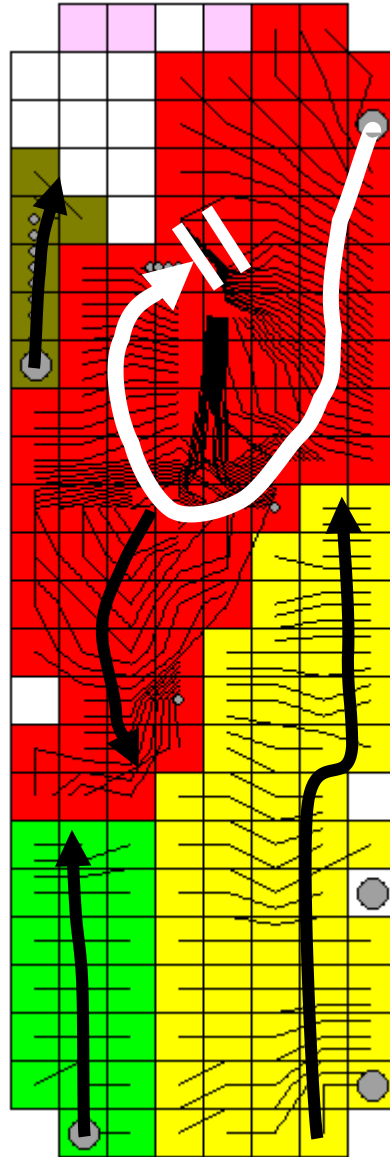
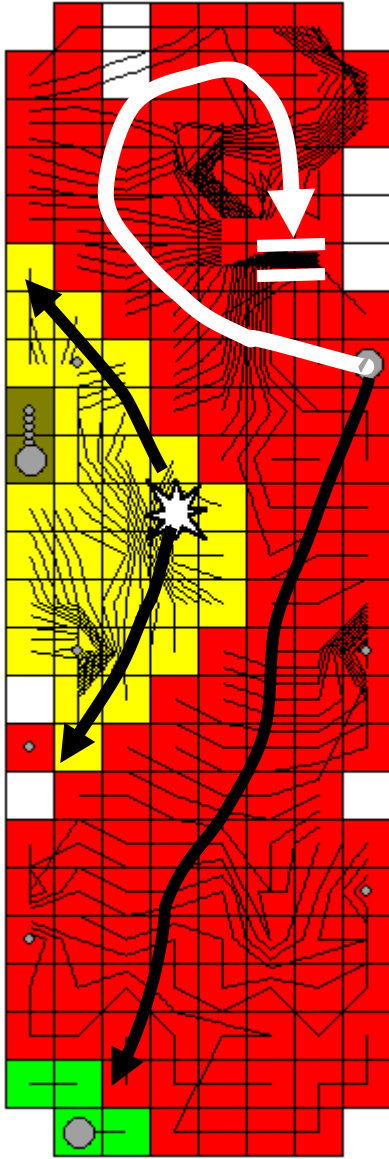
106°

Rotation of Waves

Median: 38°



'Wannabe' Reentry



Complete Epicardial Mapping in 60 Patients with Persistent AF:

Not a Single

Fully Rotating Wave

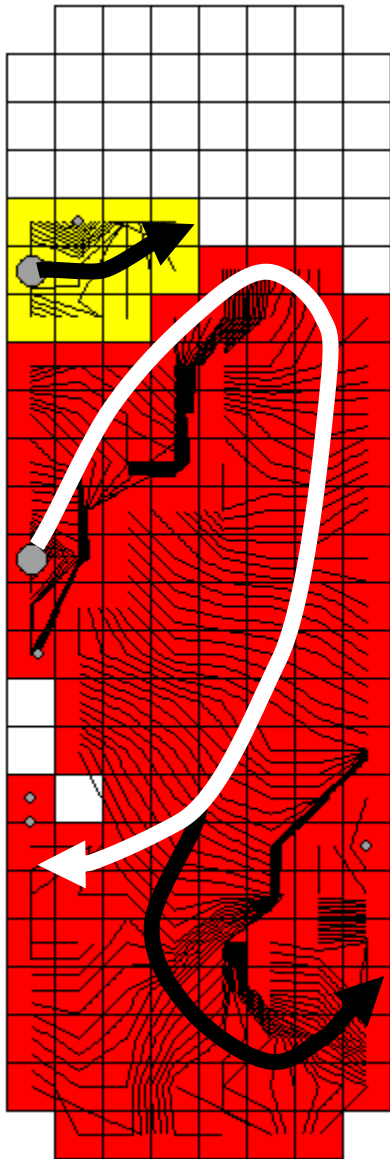
(> 360 degrees)

was Observed

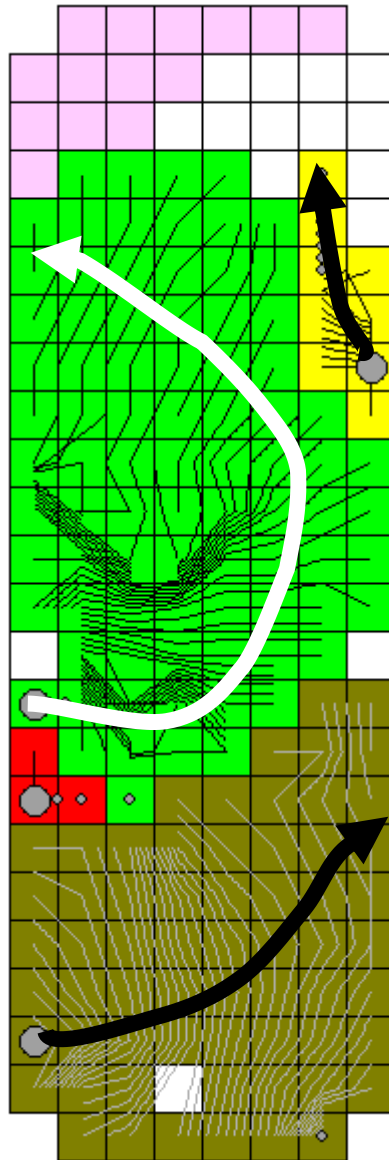
In Search for a Driver of AF:

- Rotors
- Pivot Points?
- Foci

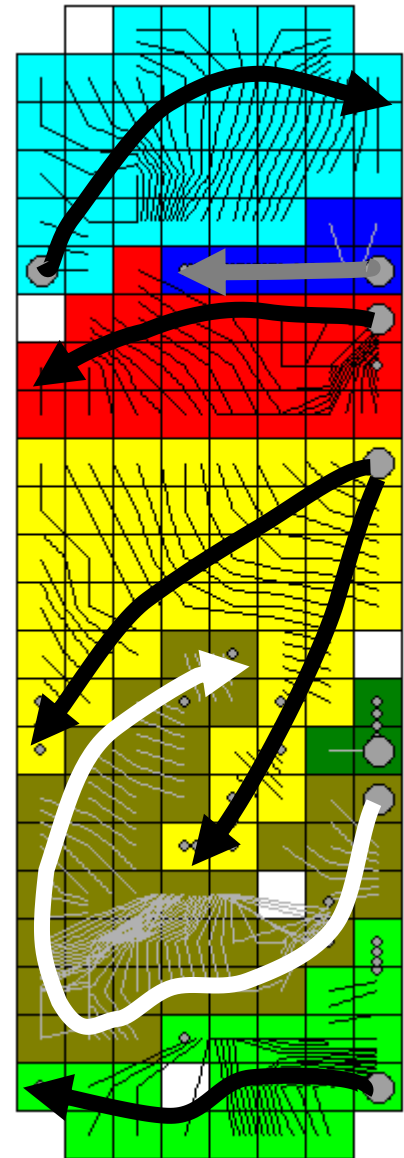
Clockwise Pivot



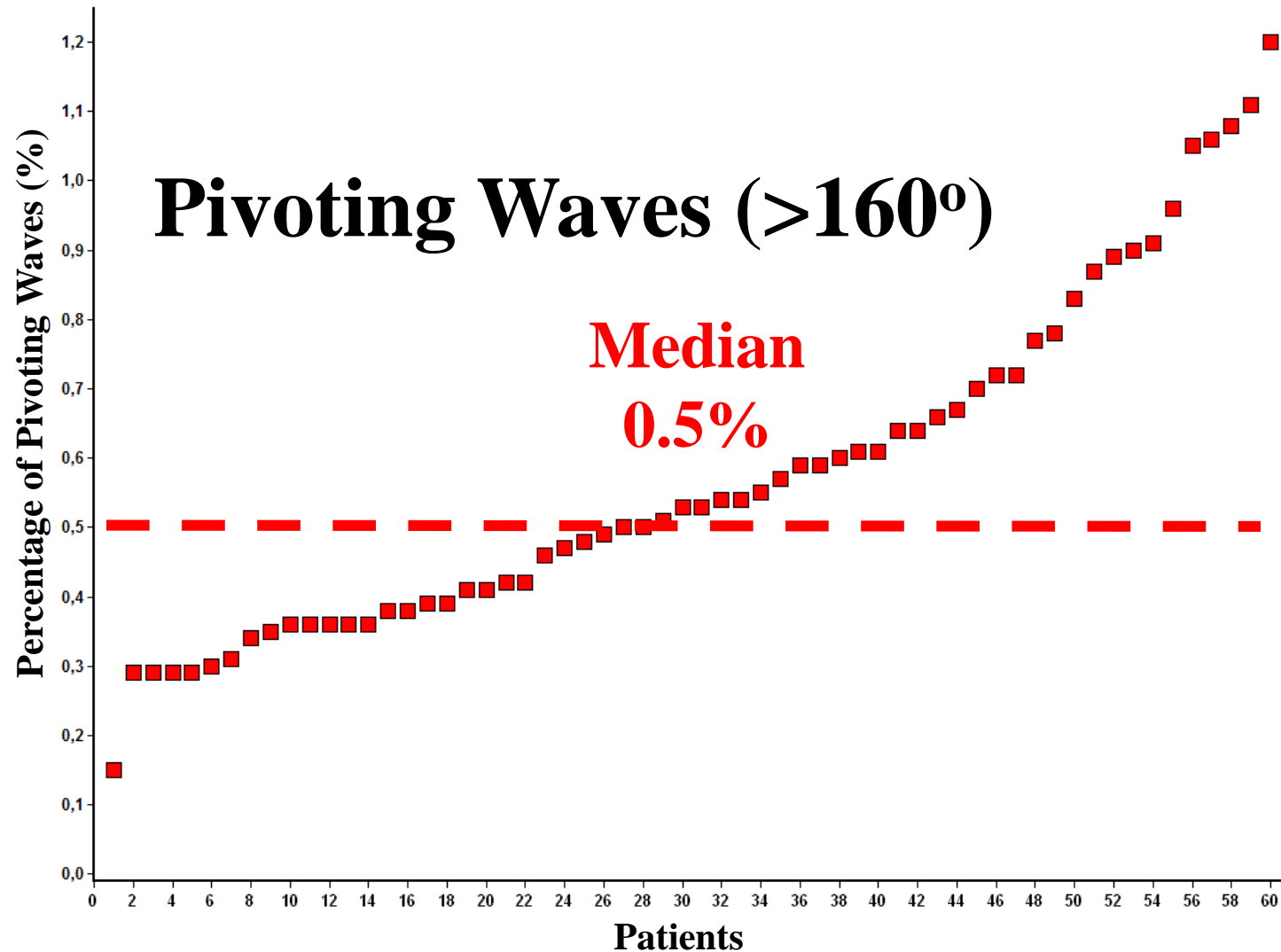
Counter Clockwise



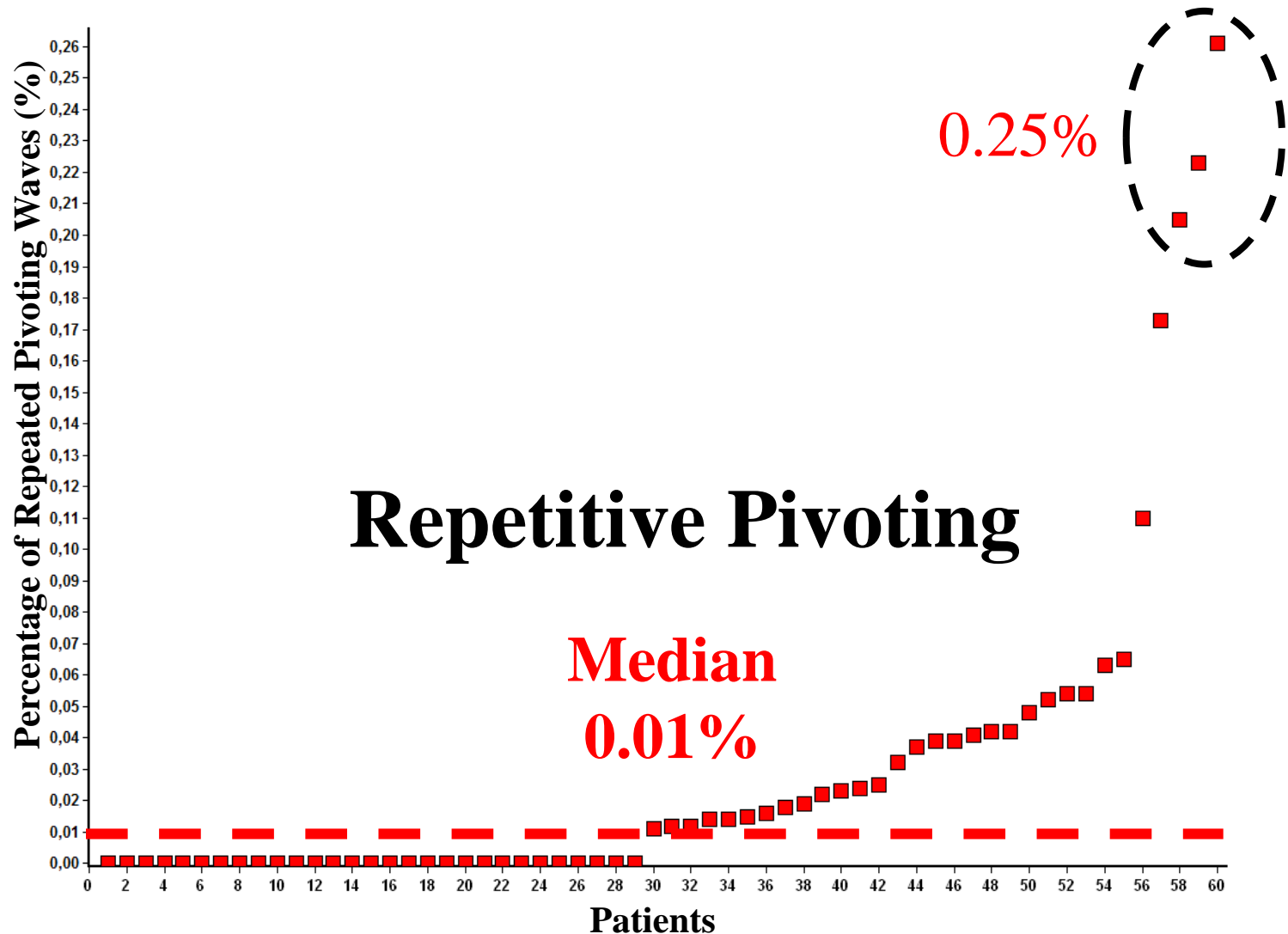
Dead-End Pivot



Percentage of Pivoting Waves in 60 Patients with Persistent AF

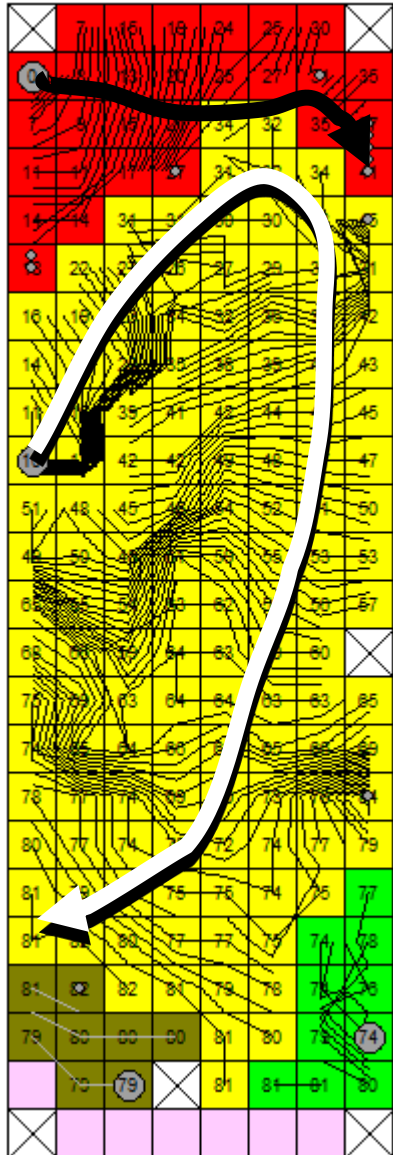


Repetitive Pivoting in 60 Patients with Persistent AF

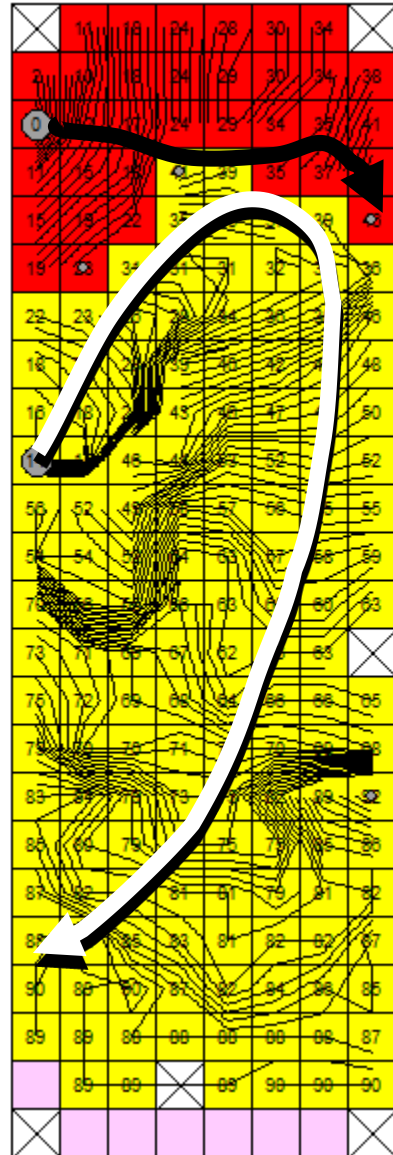


Three Times Max

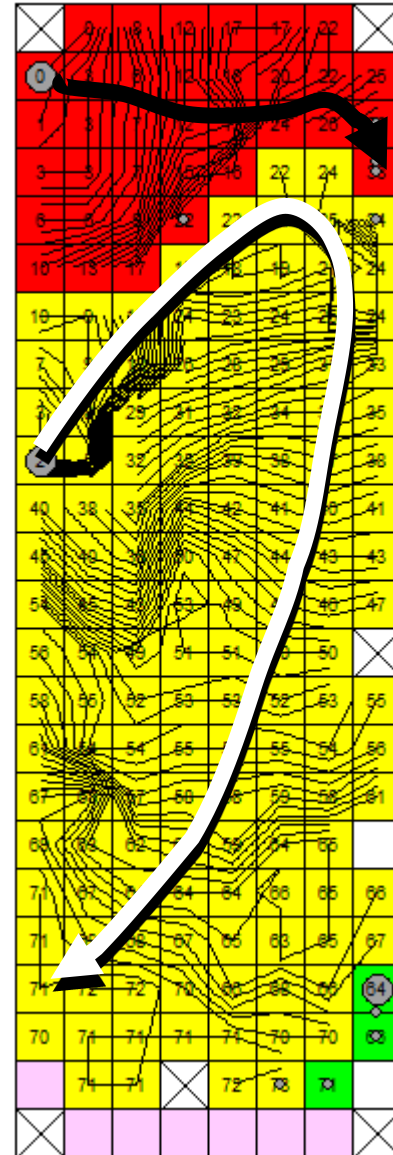
Beat 10



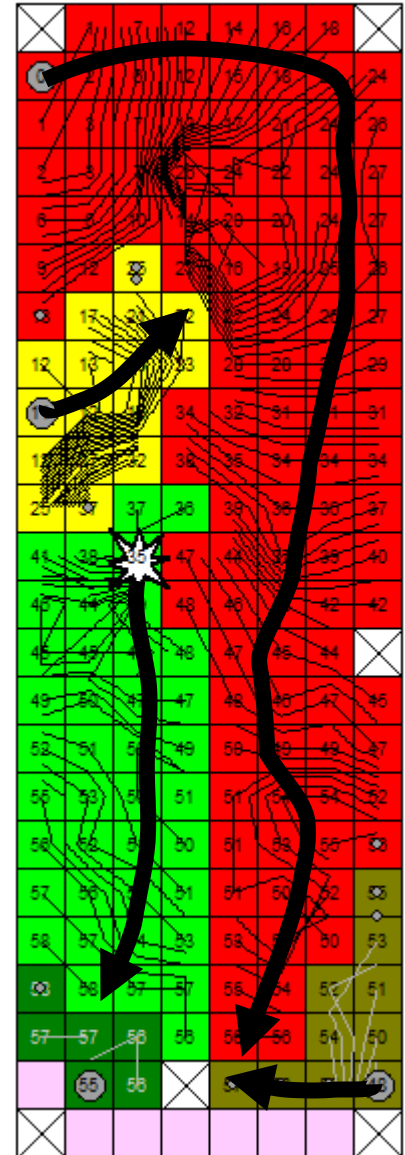
Beat 11



Beat 12



Beat 13



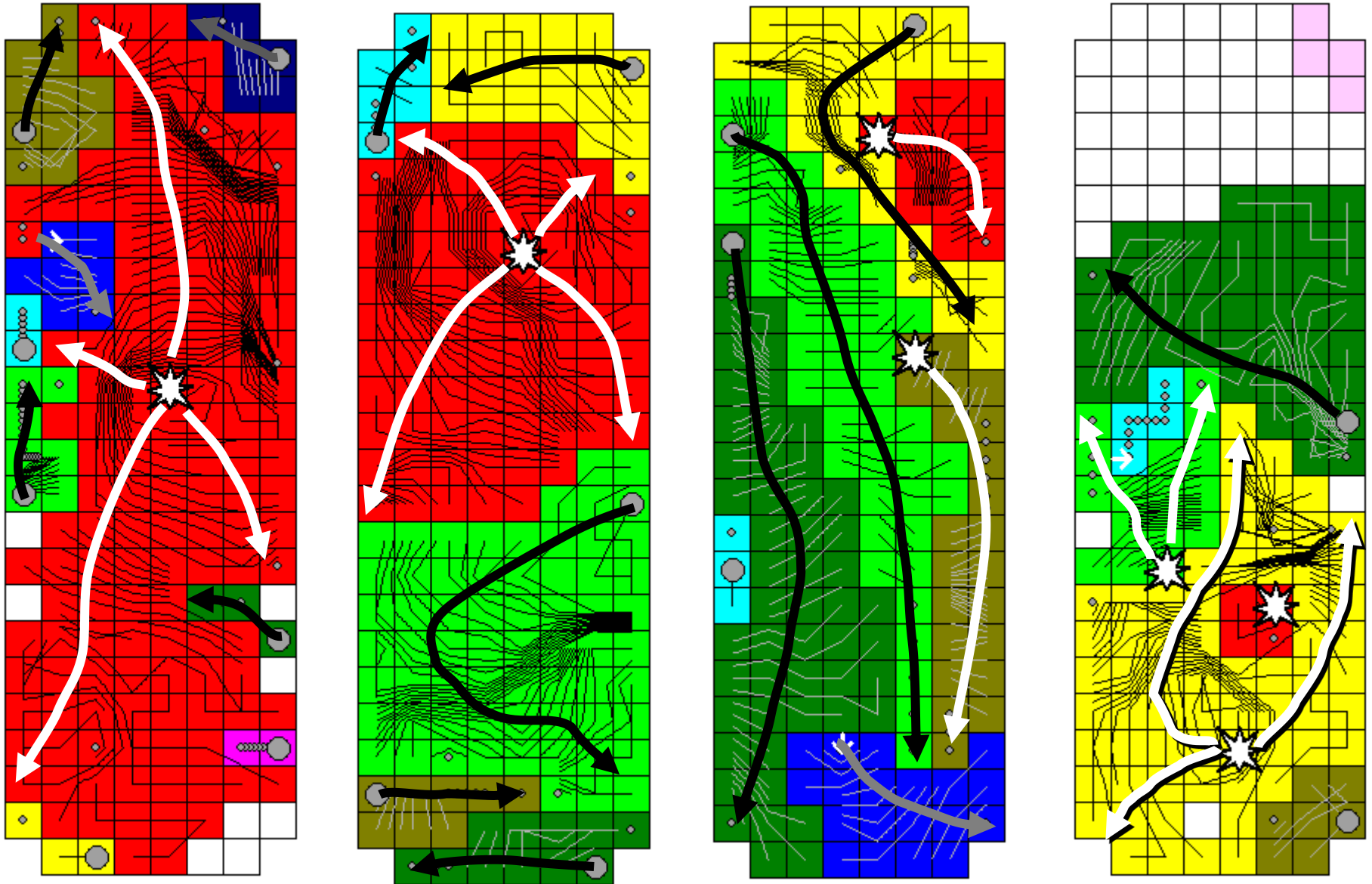
In Patients with Persistent AF:

- Pivoting of Waves is **Rare**
- Repetitive Pivoting is **Very Rare**

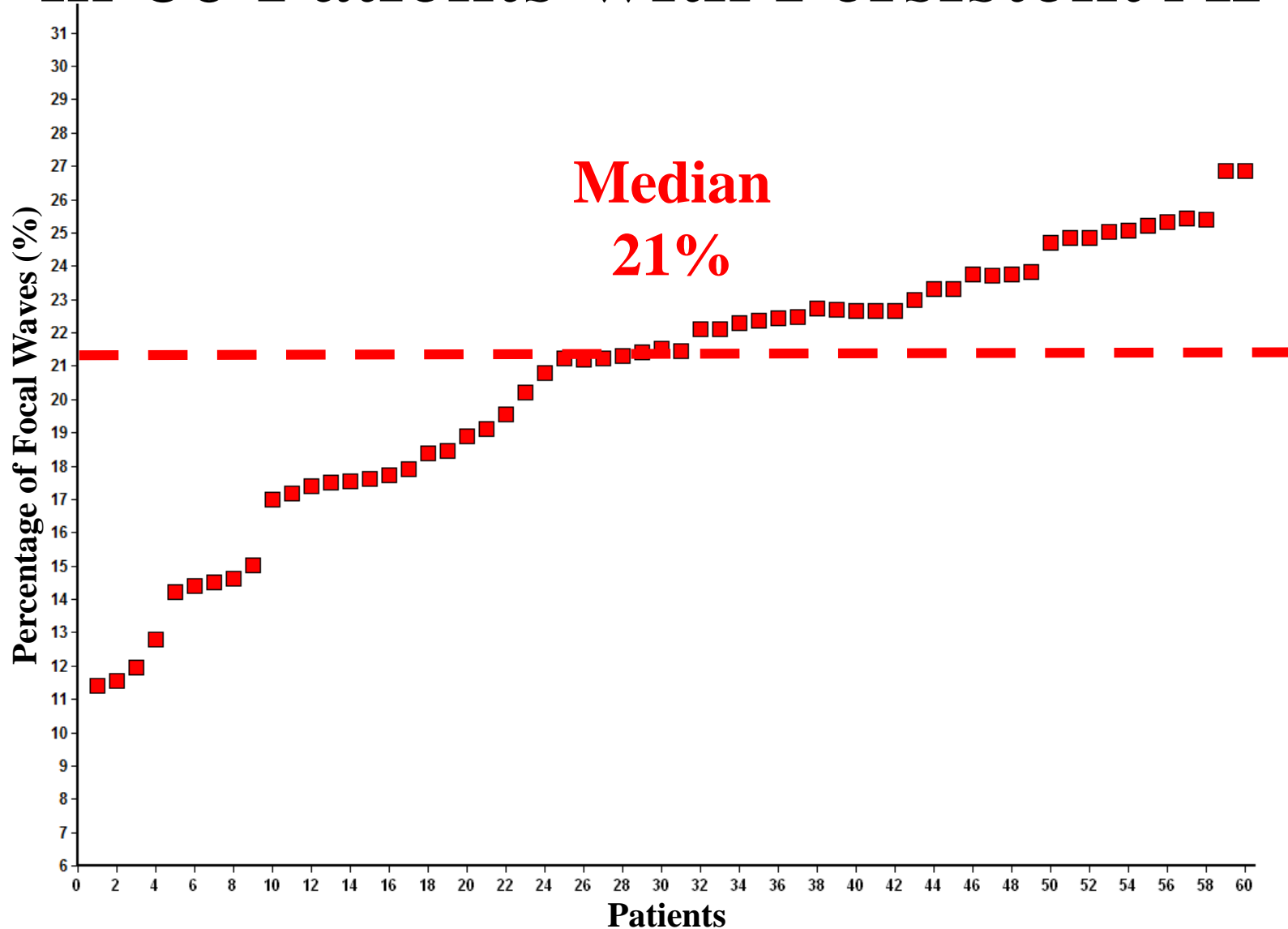
In Search for a Driver of AF:

- Rotors
- Pivot Points
- Foci?

Focal Fibrillation Waves



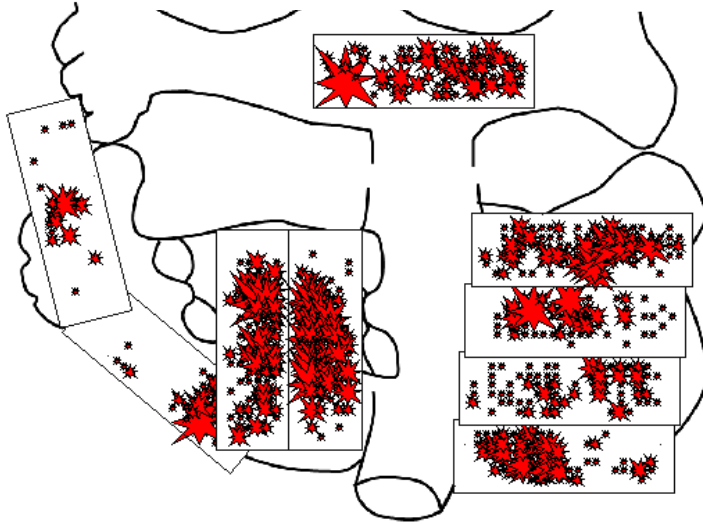
Percentage of Focal Waves in 60 Patients with Persistent AF



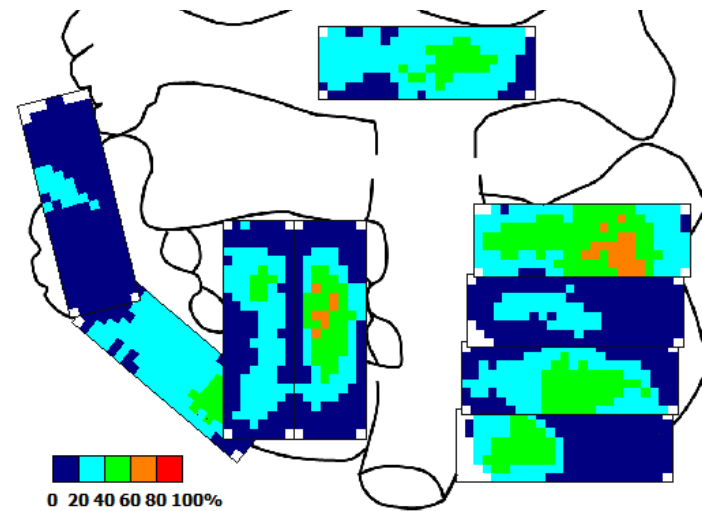
An Average Case

(Focal Waves 22%)

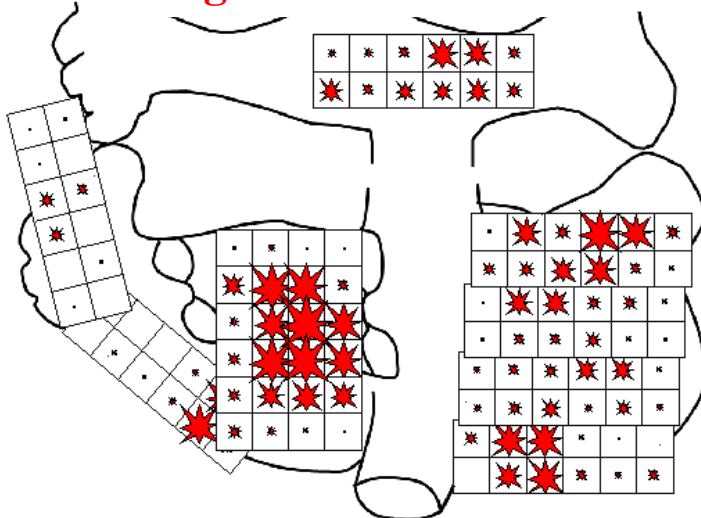
1107 Focal Waves



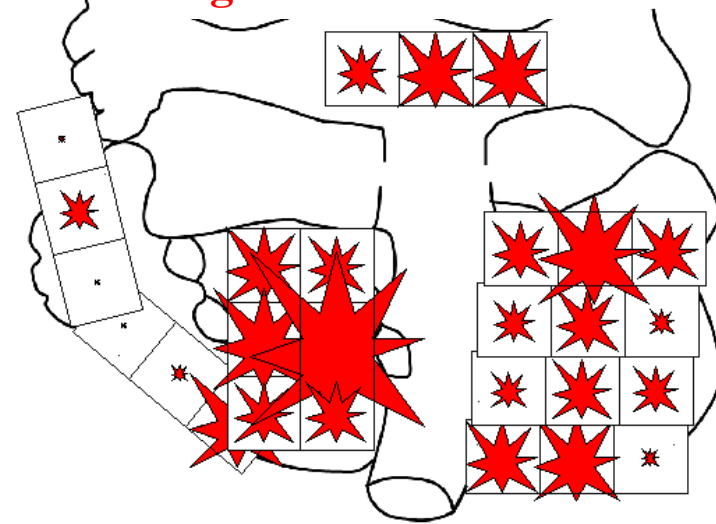
Activated by Focal Waves (24%)



Regional Distribution



Regional Distribution



In Patients with Persistent AF:

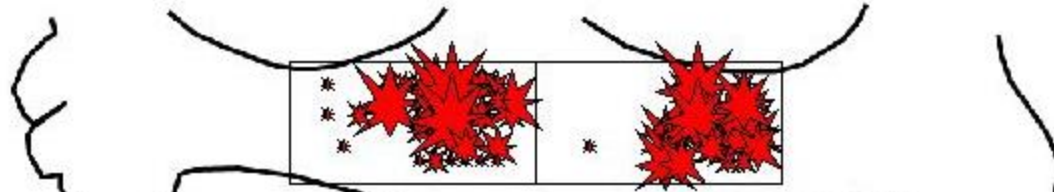
- Focal Waves Are **Abundant**
- Occur over the **Entire** Atrial Wall
- Are **Not** Repetitive
- **Change** on a beat-to-beat Basis

Dilemma for the Ablationist:

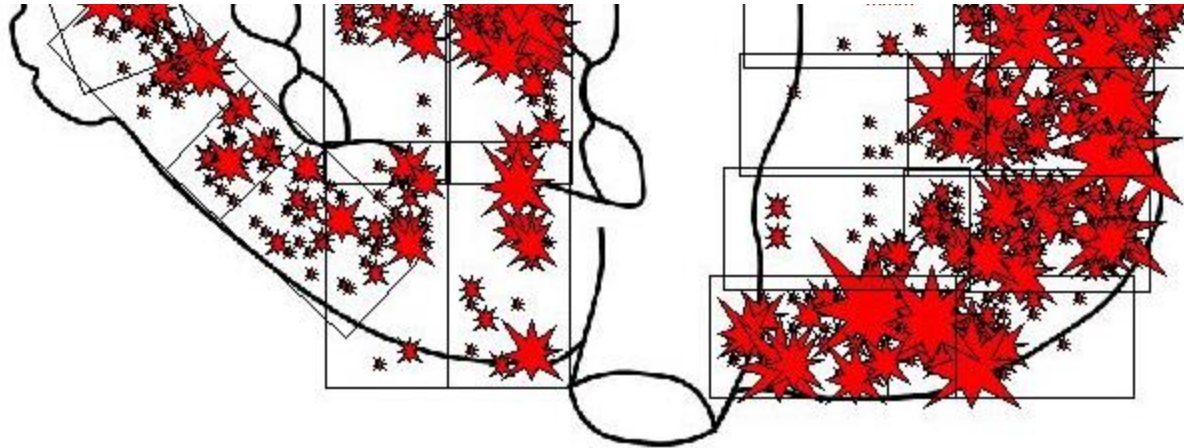
Rotors too Sparse,

Foci too Abundant

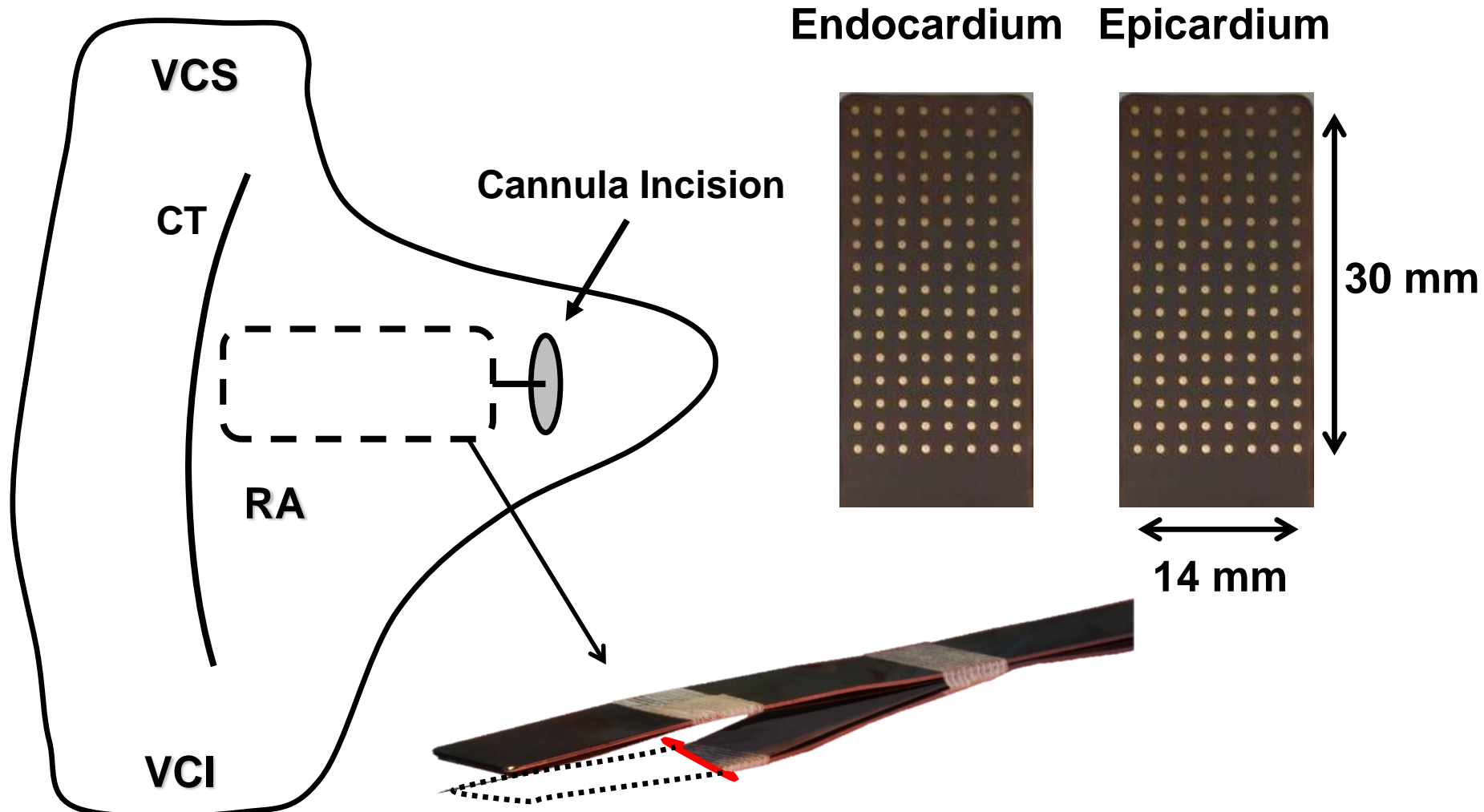
What is the Source of this Amazing Number of Focal Waves



> 5.000/minute

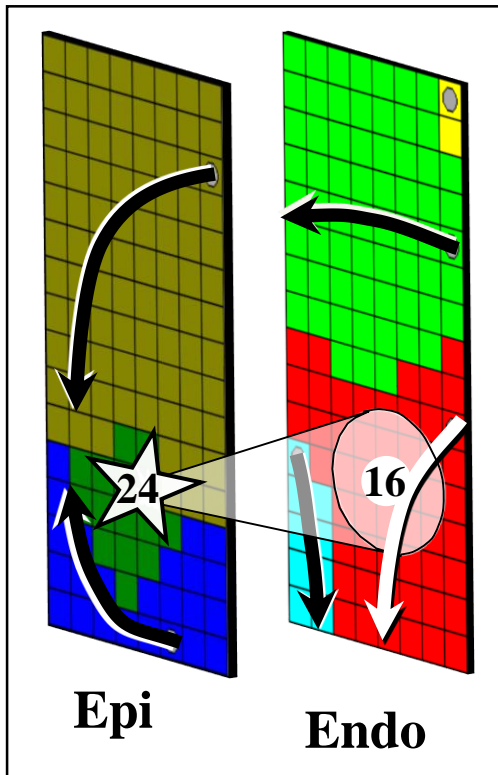


Simultaneous Endo-Epicardial Mapping of Persistent AF during Cardiac Surgery

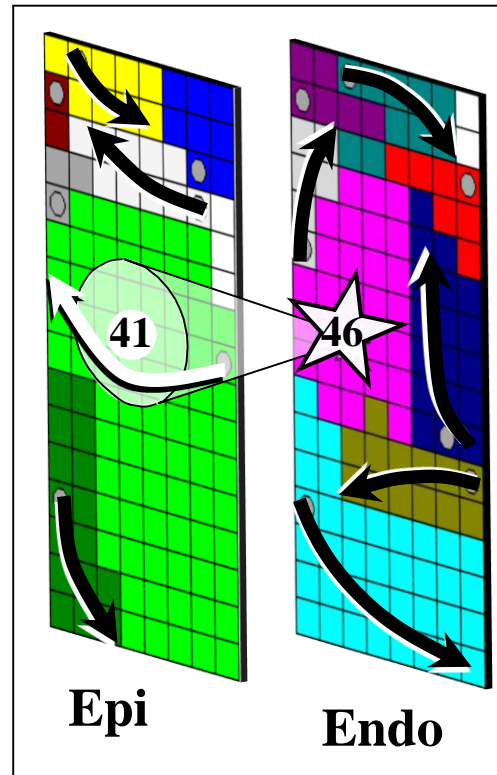


Direct Evidence that Focal Fibrillation Waves are due to Endo-Epicardial Breakthroughs

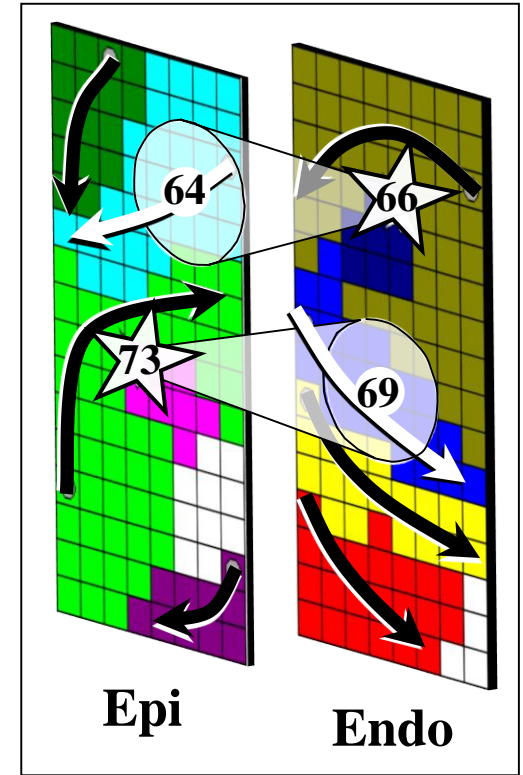
Epicardial Breakthrough



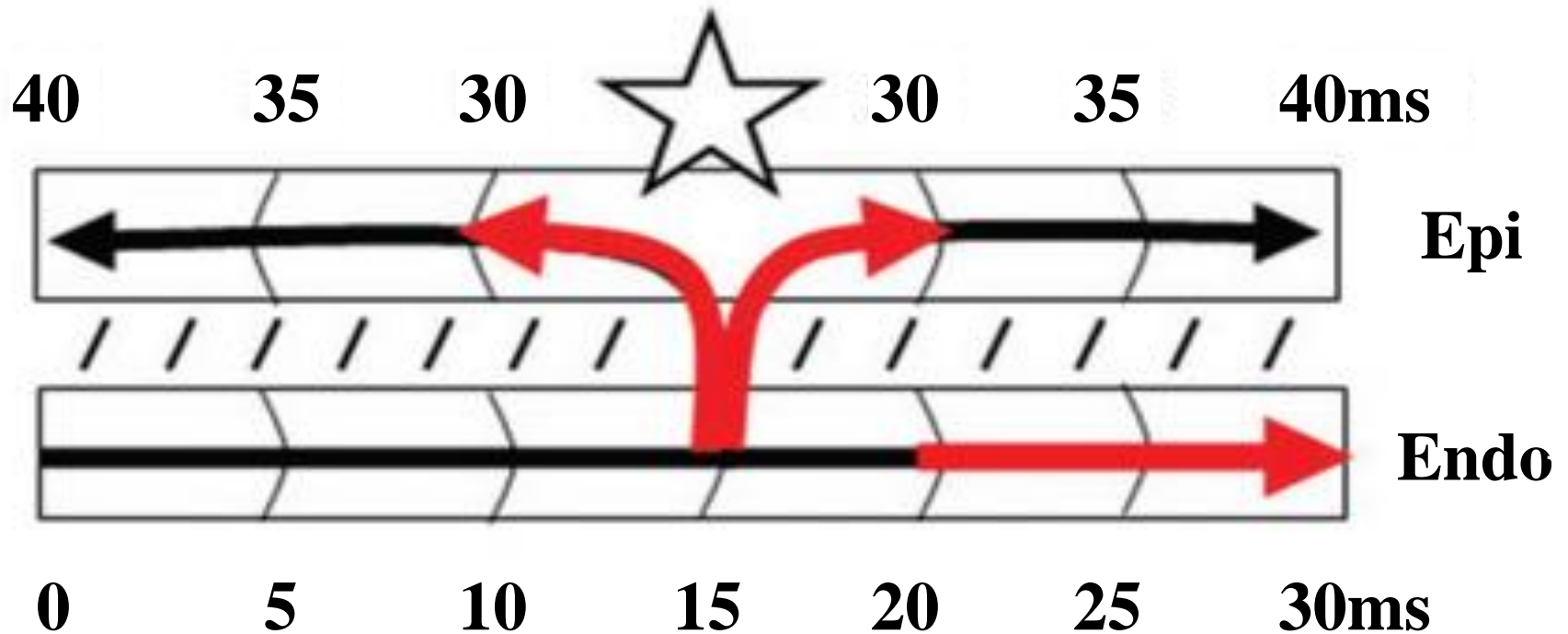
Endocardial Breakthrough



Endo + Epicardial Breakthroughs



Focal Waves Originate as Offshoots
They Represent Bifurcation Sites in a
from Other Waves
Double-Layer of Multiple Wavelets
Propagating in Deeper Layers



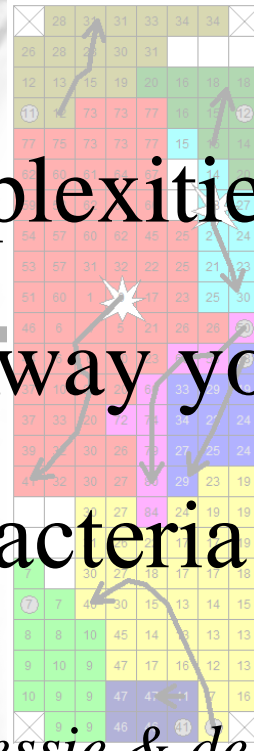
Atrial Fibrillation is **NOT**
Perpetuated by a Stable Rapid
Source, but by the Production
of **Abundant Offspring**

A Double Layer of Multiple Wavelets:

- **No Need** for Rotor- or Focal Activity
- Each Layer Serves as a **Multi-Site Generator** for the Other Layer
- Explains why AF is so **Persistent**

Rotor Detection by Low-Resolution Mapping

“Ignoring the Complexities of Human AF is like Throwing Away your Microscope and Saying that Bacteria Don’t Exist.”



Allessie & de Groot, J Physiol 2015

1.6cm