

Fascicular VT

Young Keun On, MD, PhD, FHRS

Samsung Medical Center

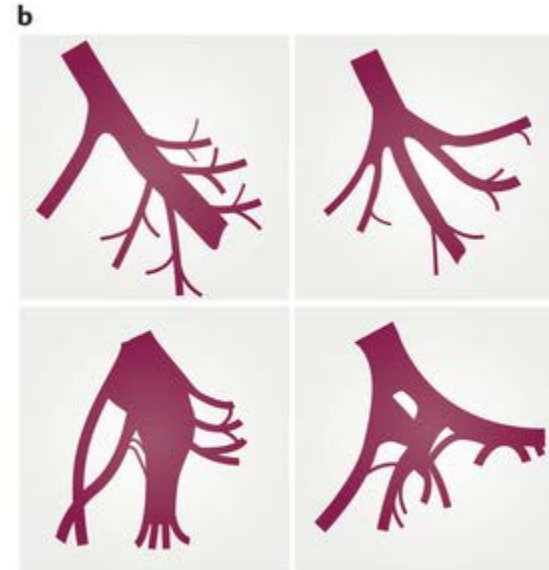
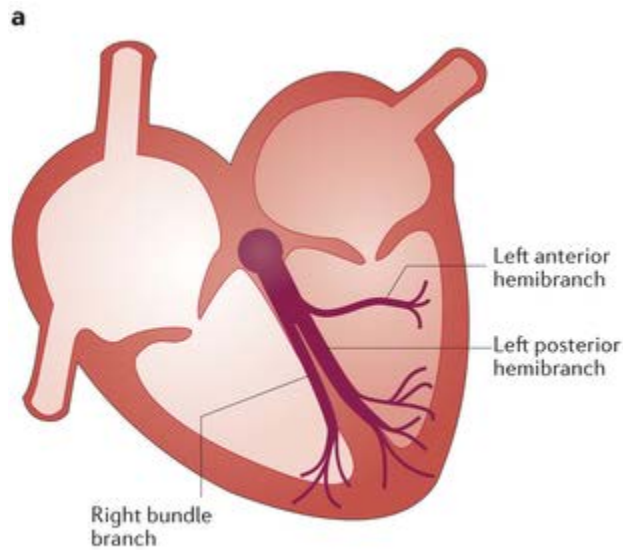
Sungkyunkwan University School of Medicine

Idiopathic Monomorphic Ventricular Tachycardia

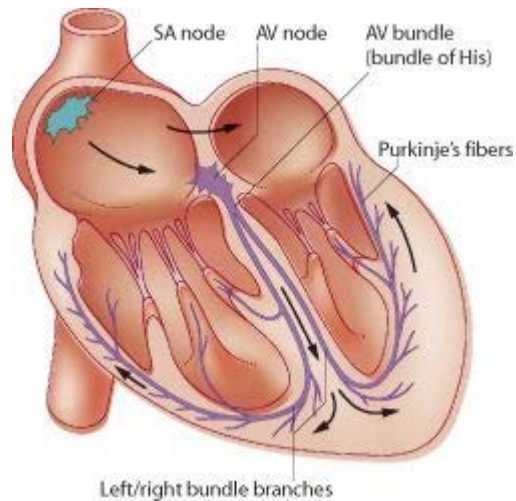
	Adenosine-sensitive	Verapamil-sensitive	Propranolol-sensitive
Mech	<i>(Triggered activity)</i>	<i>(Fascicular reentry)</i>	<i>(Automaticity)</i>
	1) Exercise-induced 2) Repetitive monomorphic	Fascicular	1) Exercise-induced 2) Incessant
Induction	PES c/s catecholamine	PES c/s catecholamine	Catecholamine
ECG	LBBB with inferior axis RBBB with inferior axis	RBBB with superior axis RBBB with rt inferior axis	RBBB, LBBB, Polymorphic
Origin	RVOT/LVOT	Lt posterior fascicle Lt anterior fascicle	RV/LV
Entrainment	No	Yes	No
Adenosine	Terminate	No effect	Transient suppression
Verapamil	Terminate	Terminate	No effect
Propranolol	Terminate	No effect	Terminate/Transient supp

Fascicular VT

- Belhassen's ventricular tachycardia (*Br Heart J. 1981; 46: 679*)
- Verapamil-sensitive ventricular tachycardia
- Idiopathic fascicular left ventricular tachycardia
: VT in the absence of clinically apparent structural heart disease
- Intrafascicular tachycardia

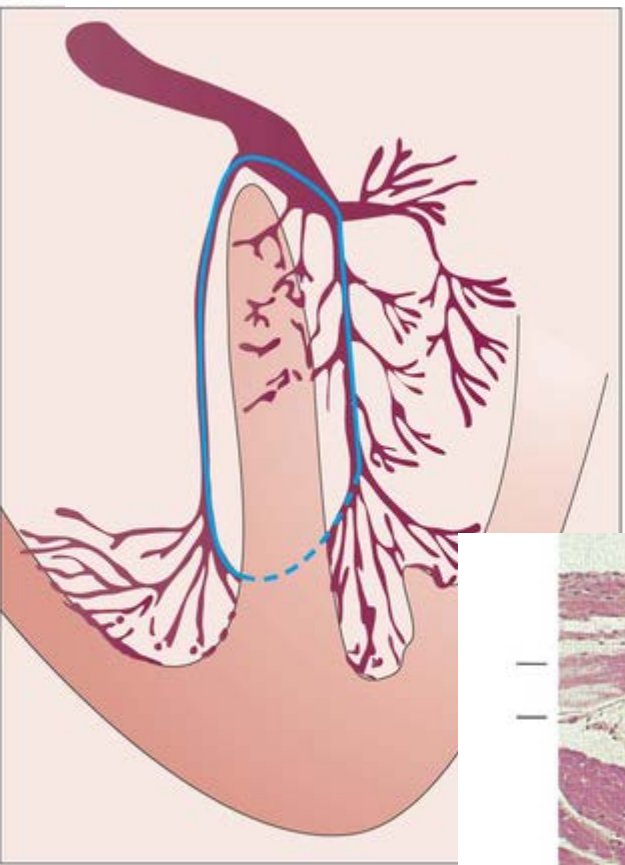


Nature Reviews | Cardiology



- The ventricular myocardium :
‘working’ cardiomyocytes
2% of ‘conducting’ Purkinje fibers
- The **Purkinje fibers** : the specialized ventricular conduction system for rapid and synchronous activation of the ventricles

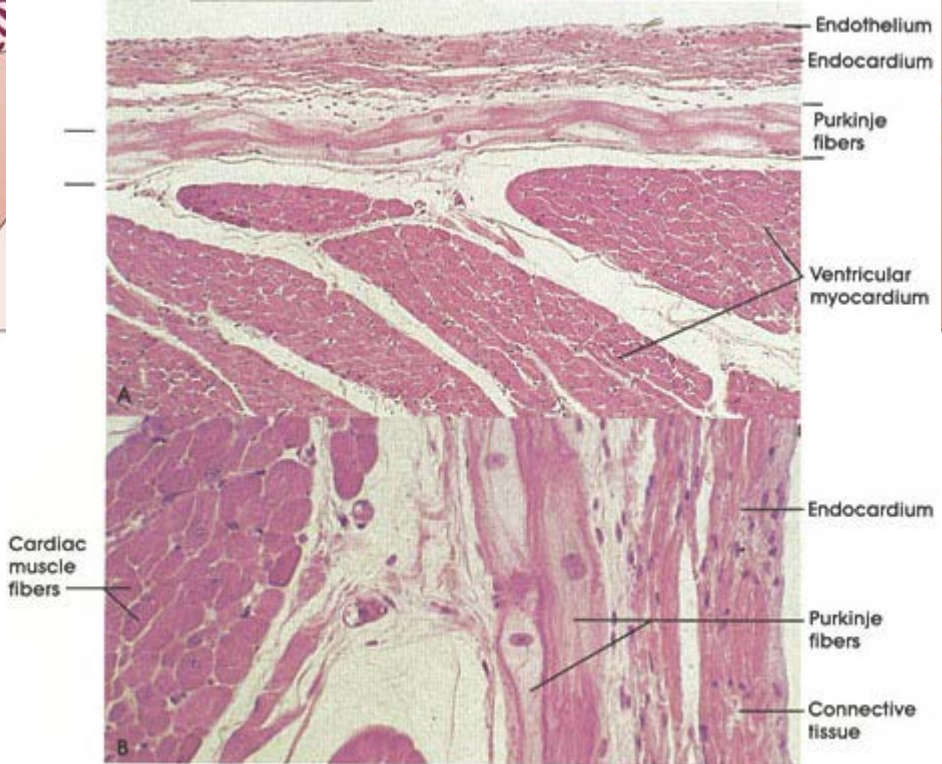
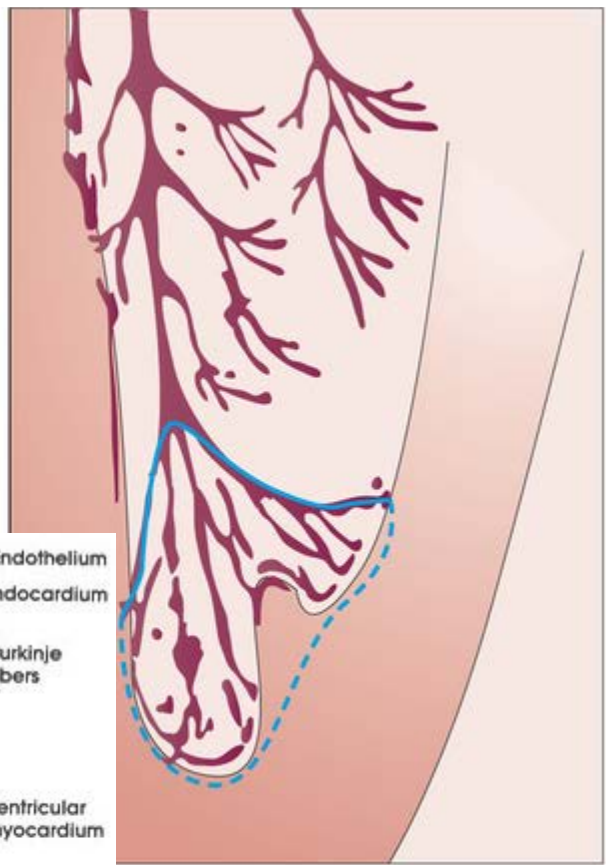
a Bundle branch re-entry



b Fascicular VT



distal Purkinje-muscle re-entry

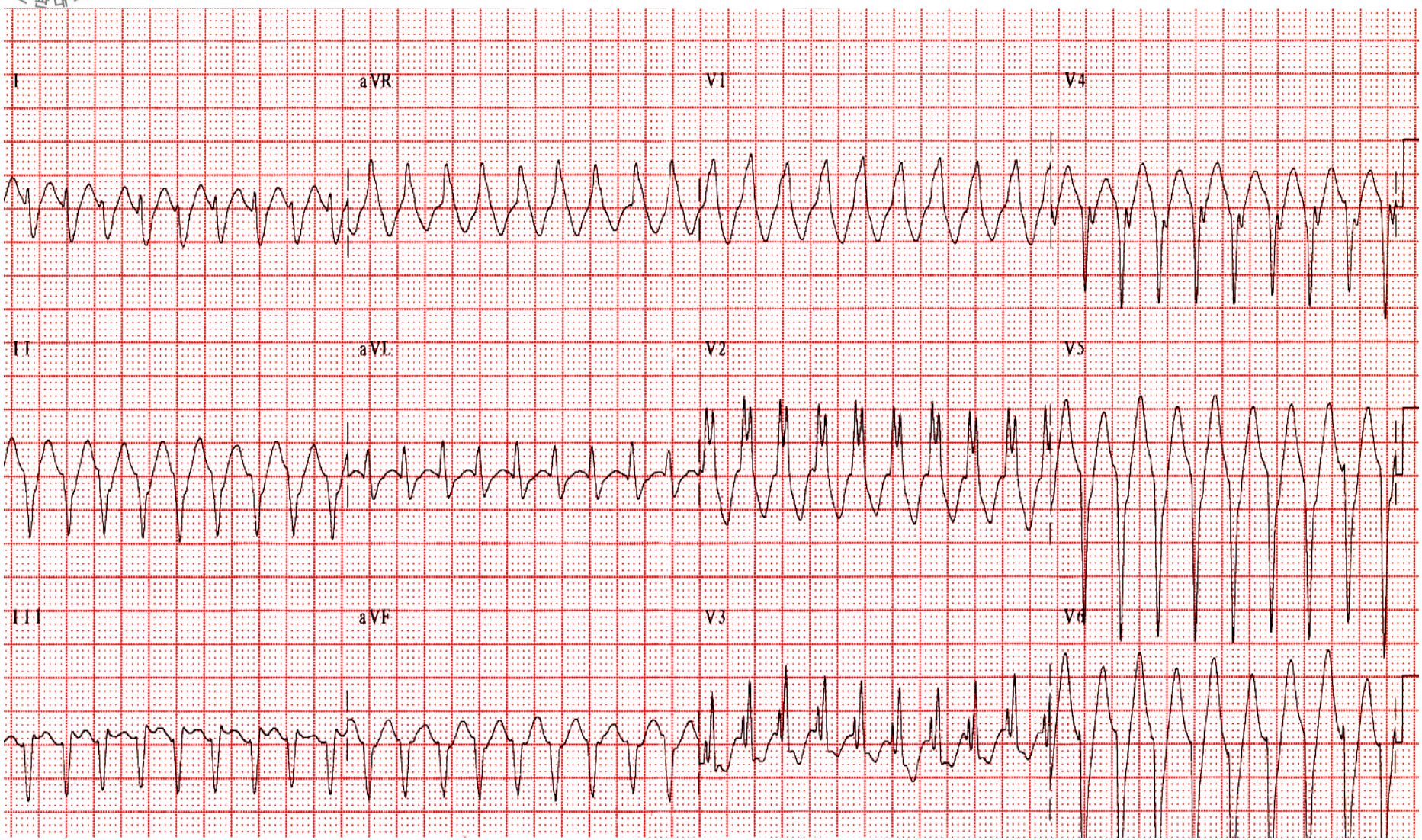


A 100 μm

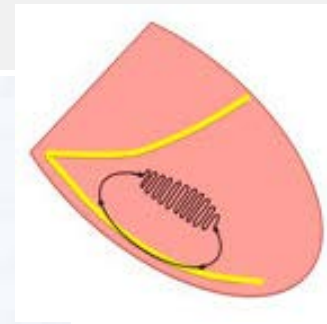
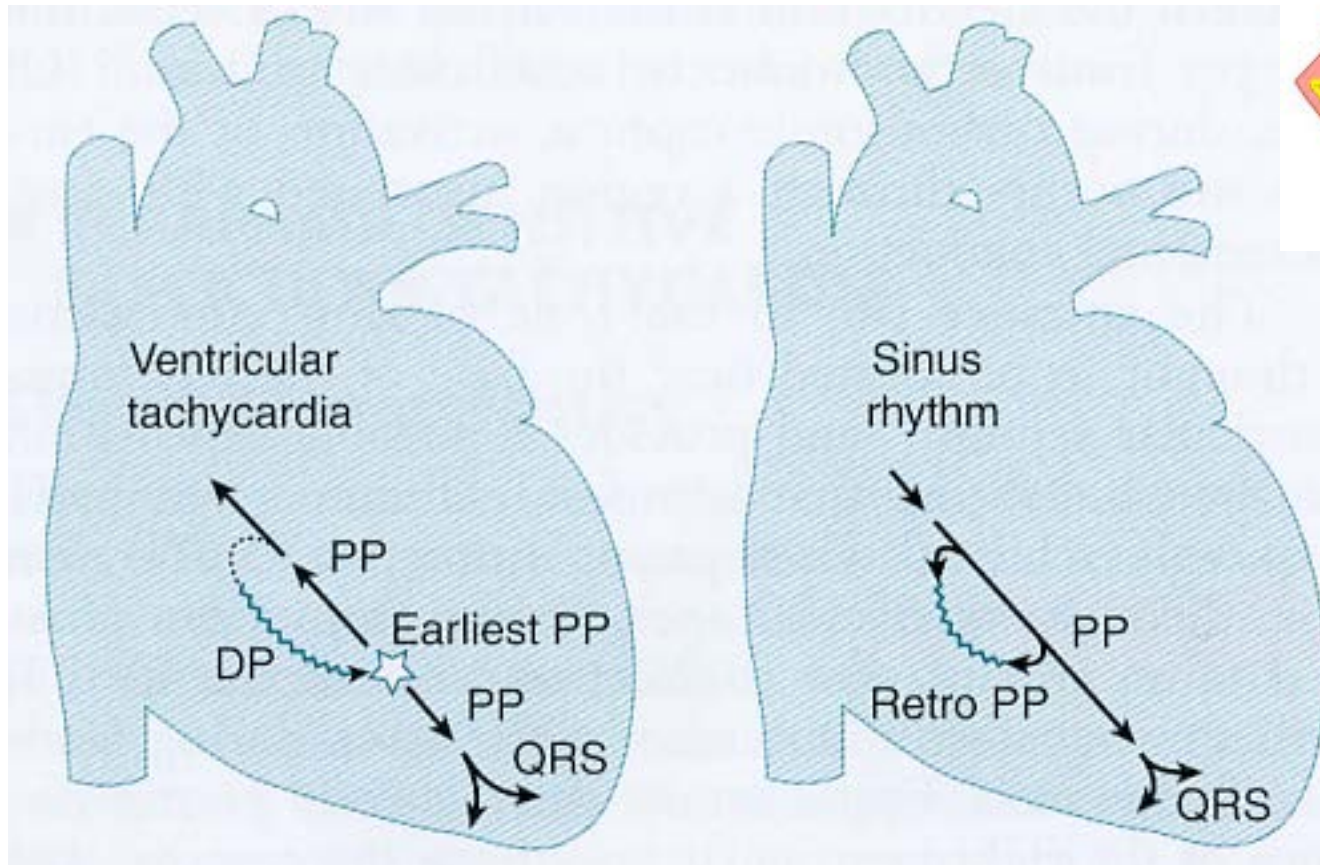
B 50 μm

LV Fascicular Tachycardia

- Ages of **15~40 yrs**
- More frequent in **men** (60~80%)
- **RBBB with left superior axis (LAD):**
 - Lt posterior fascicle (90~95%), inferoposterior LV septum
- **RBBB with right inferior axis (RAD):**
 - Lt anterior fascicle (5~10%), anterosuperior LV septum
- Arrhythmia episodes
 - ; sensitive to catecholamines (exercise or postexercise) or emotional stress

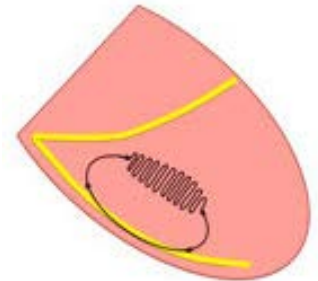


- ILVT reentry may be a small **macroreentrant circuit**.
- **Anterograde limb**: abnormal Purkinje tissue, slow decremental conduction, verapamil-sensitive diastolic potential along the midseptum
- **Retrograde limb** : Purkinje tissue from the left posterior fascicle, Purkinje potential



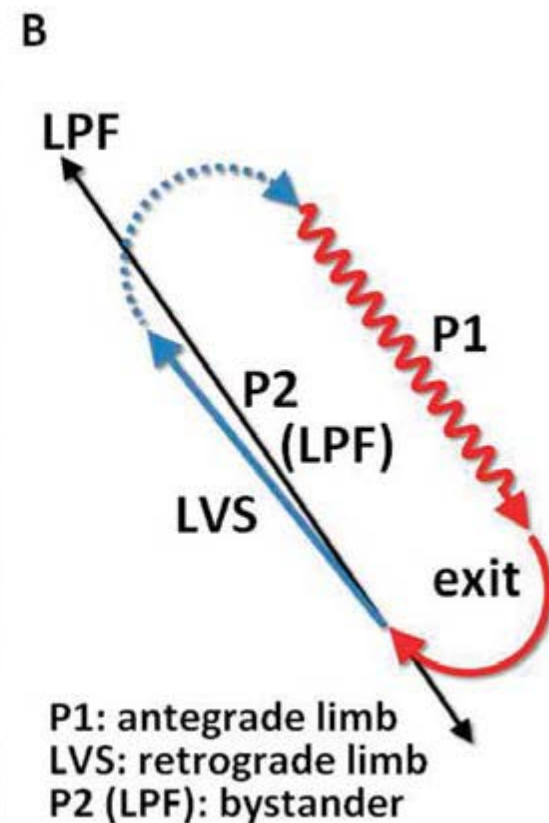
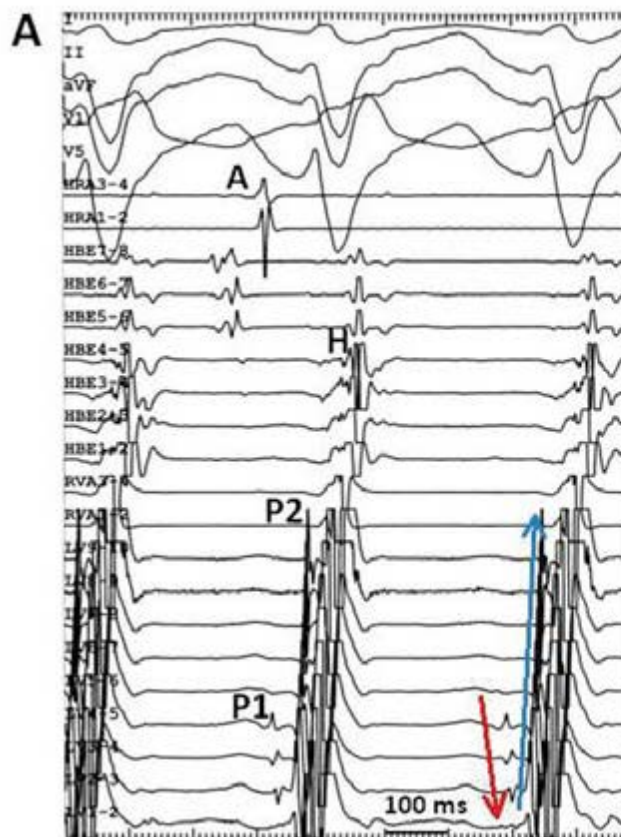
Mechanism of LV Fascicular Tachycardia

- **Macroreentry** : with an anterograde and a retrograde limb
- **Microreentry** : located in the left posterior fascicular fibers
fragmented delayed potentials during NSR and
continuous diastolic activity during tachycardia
- **Focal** origin



Left posterior type LV Fascicular Tachycardia

ECG : RBBB and superior axis
 From the left posterior septum, a diastolic potential (P1) and presystolic Purkinje potential (P2) were recorded.

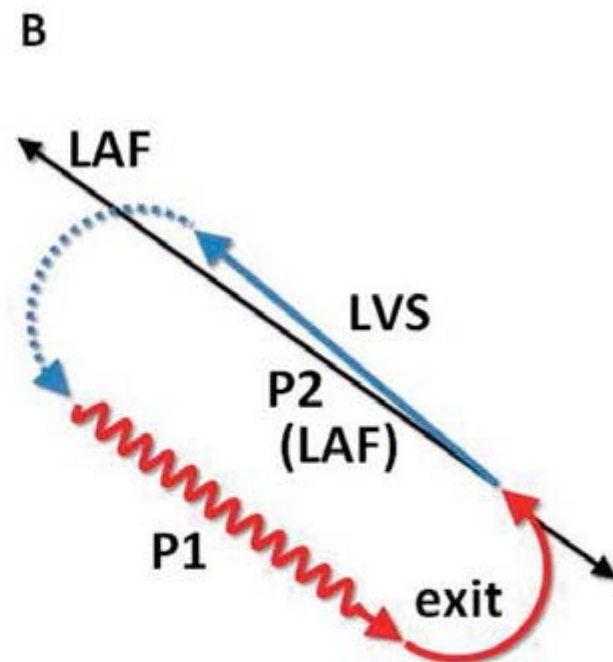
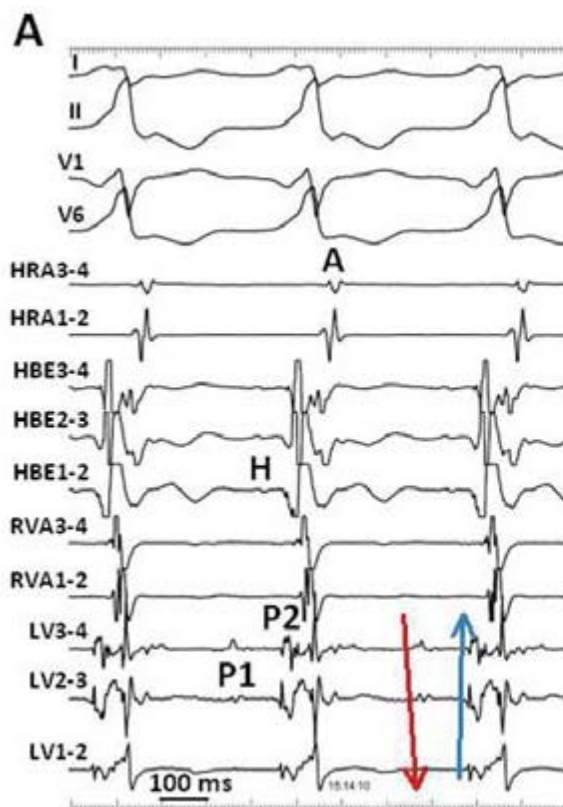


LPFVT can still develop in patients with preexisting LPF block, and
 The vast majority of patients remained arrhythmia free after LPFVT ablation without developing new-onset LPF block,
 would suggest that the **LPF does not participate in LPFVT circuit.**

Left anterior type LV Fascicular Tachycardia

ECG : RBBB and inferior axis

From the left anterior septum, a diastolic potential (P1) and presystolic Purkinje potential (P2) were recorded.



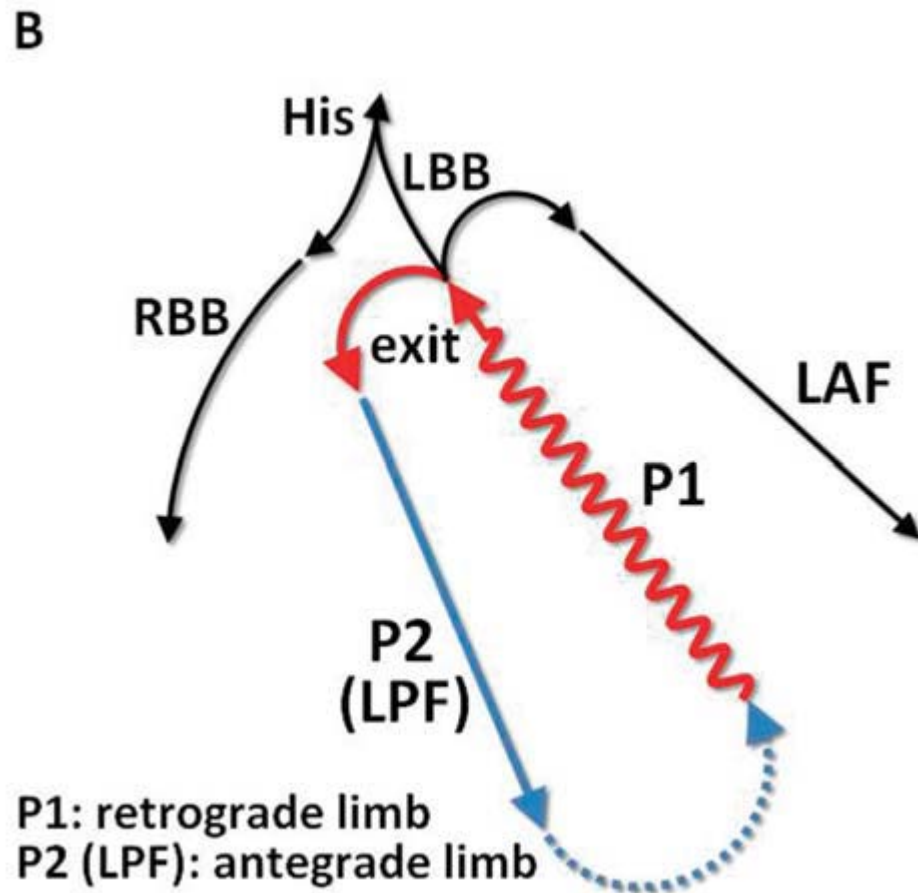
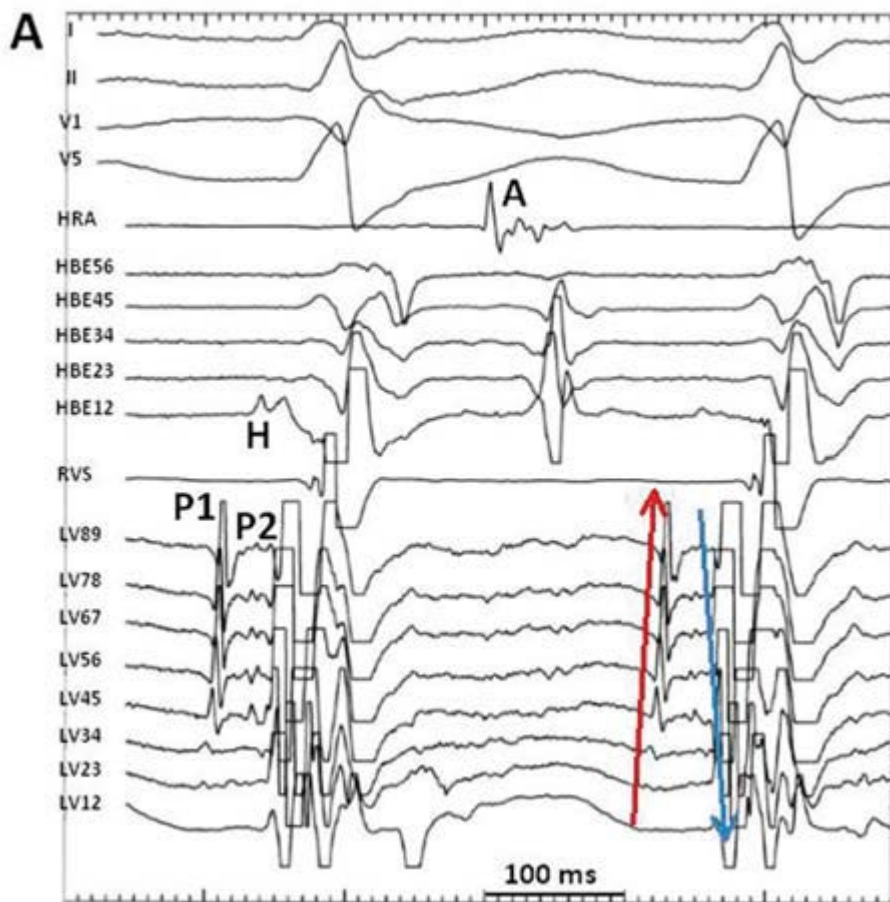
P1: antegrade limb
LVS: retrograde limb
P2 (LAF): bystander

Left upper septal type LV Fascicular Tachycardia

ECG : **narrow QRS and inferior axis**

From the left midseptum, a diastolic potential (P1) and presystolic Purkinje potential (P2) were recorded.

P1 was recorded earlier from the distal than the proximal electrodes and P2 was recorded earlier from the proximal than the distal electrodes.



TX of LV Fascicular Tachycardia

- Acute management :

Verapamil IV administration of 10 mg (given for over 1 minute)

Usually **not** respond to vagal maneuvers, adenosine or beta-blockers

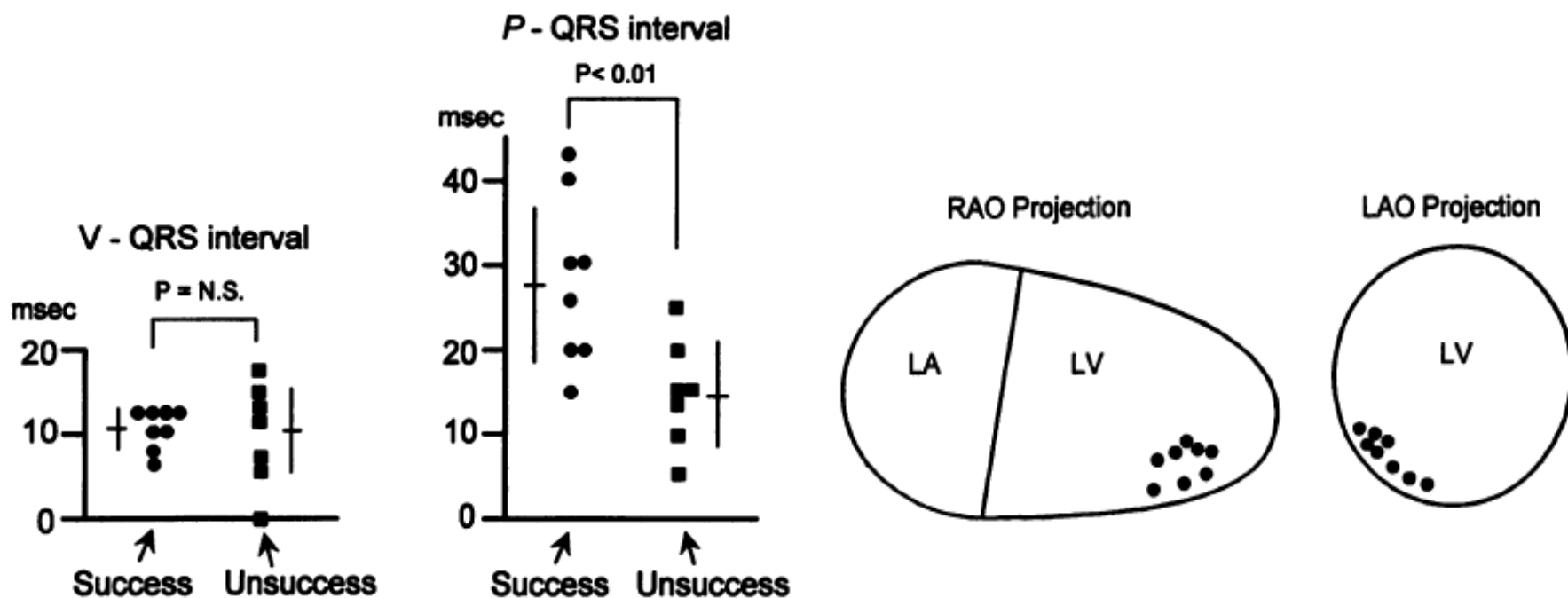
Electrical cardioversion in tachycardia intolerance

- Long-term management :

Verapamil in patients with mild symptoms

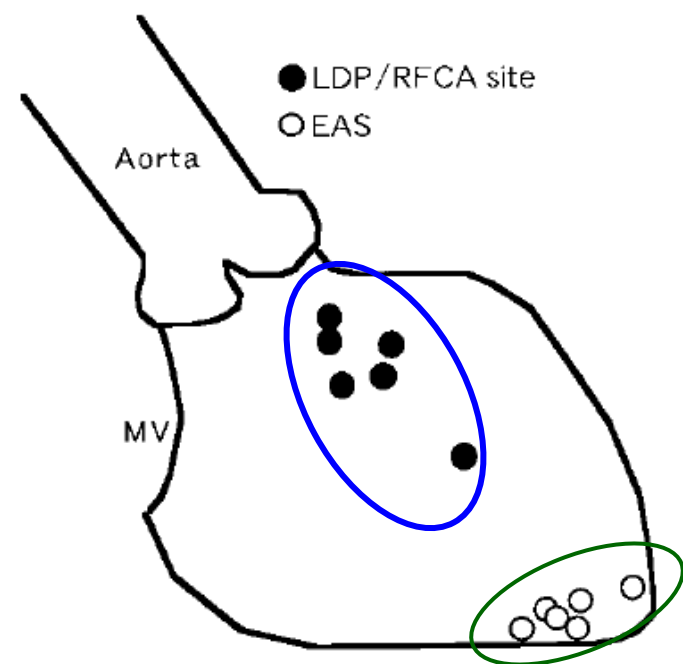
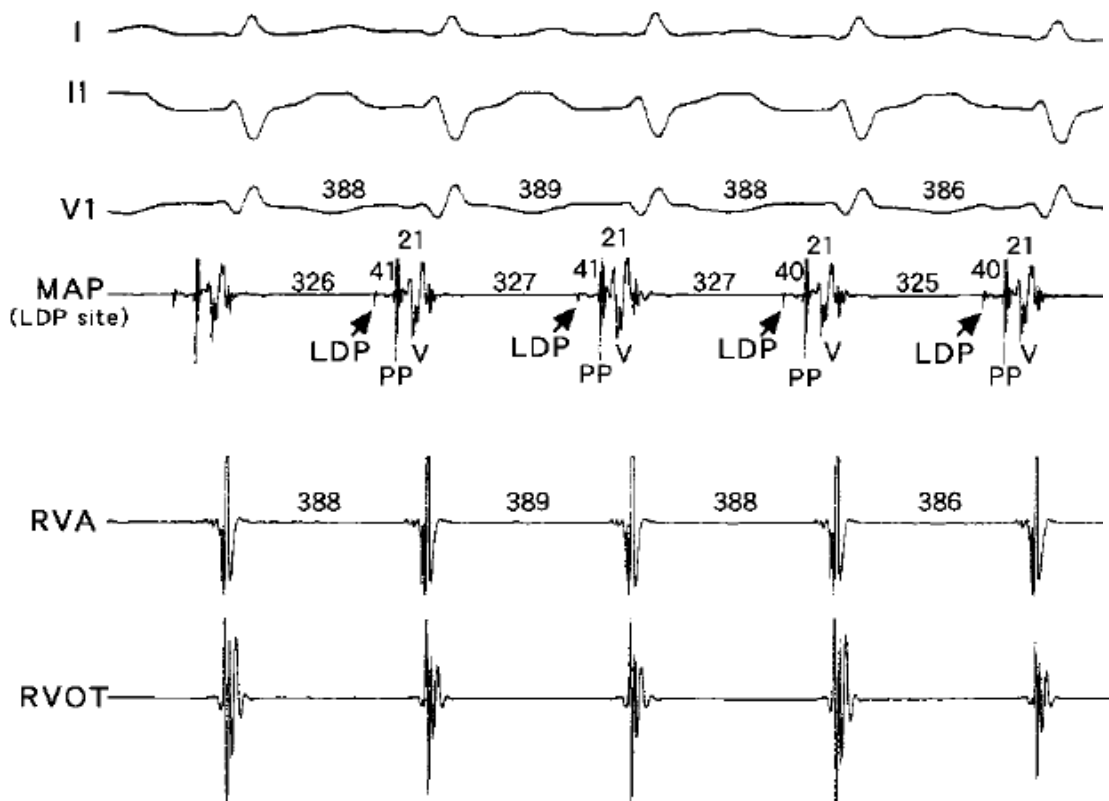
Catheter ablation (success 80~95%)

RFCA of idiopathic LV VT guided by a Purkinje potential



- Ablation should be directed at sites with **isolated P potentials** preceding the QRS complex by 30~40 milliseconds.
- PP represents the fascicular potentials.

Late Diastolic Potential Preceding Purkinje Potential in Idiopathic LV Tachycardia



LDP recording sites and earliest ventricular activation sites (EAS)

Case

36세 남자

CC; palpitation

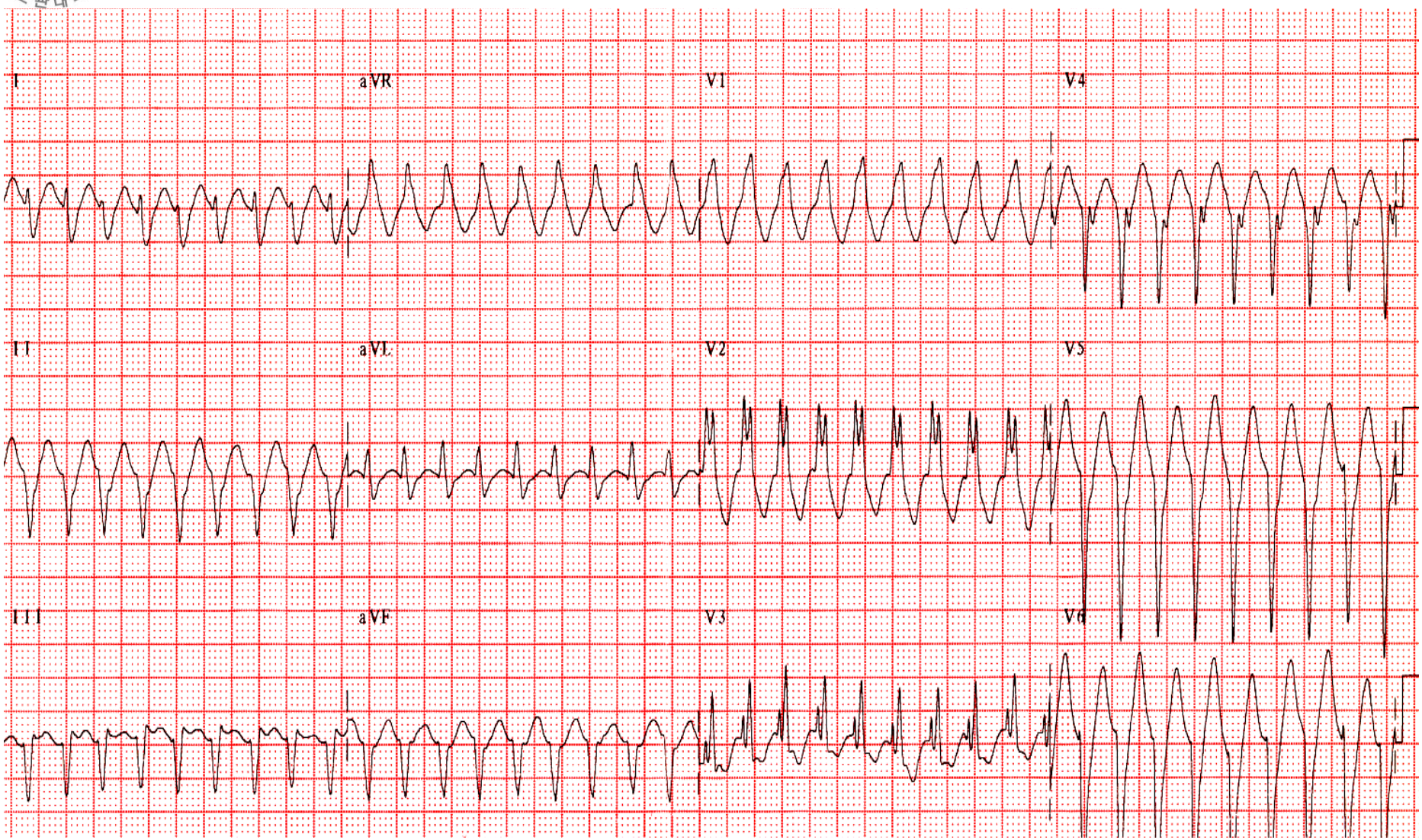
PI; 2005년 6월 등산 직후 palpitation 발생 30분 지속

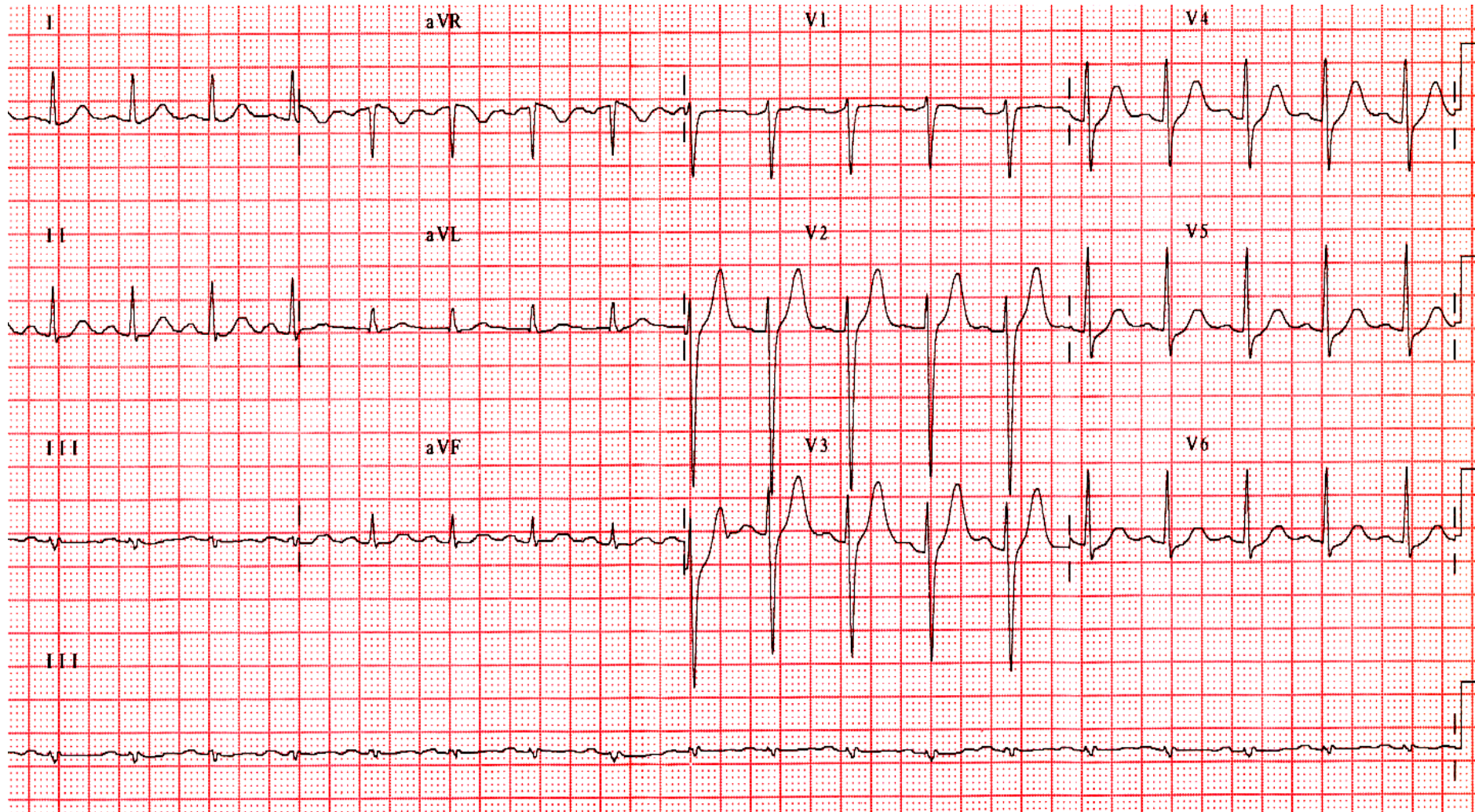
2005년 9월 25일 등산 중 palpitation 발생 1시간 지속

2006년 6월 28일 샤워 후 palpitation 발생 1시간 지속

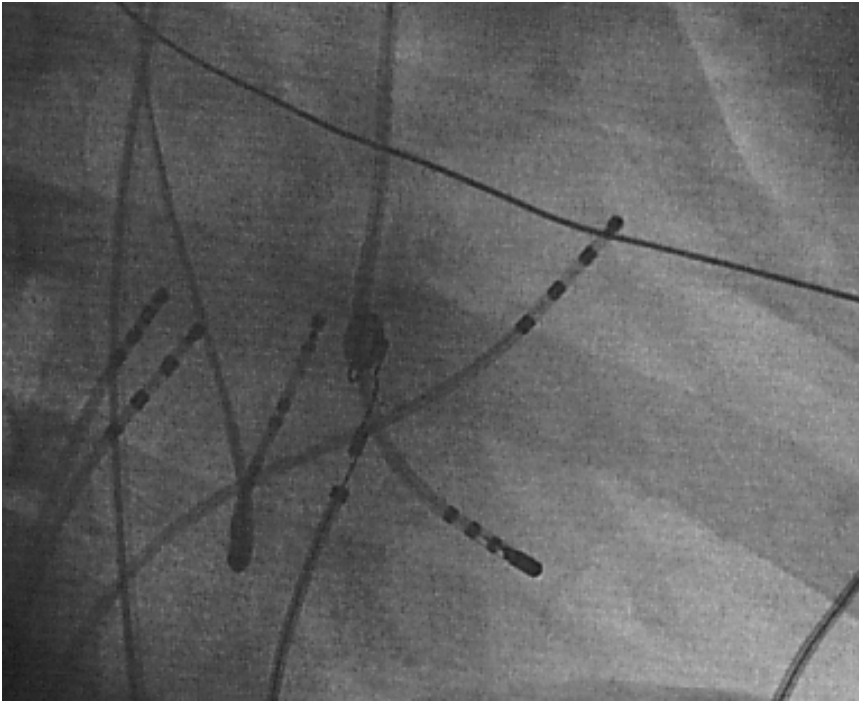
응급실 방문

가족력; 없음.

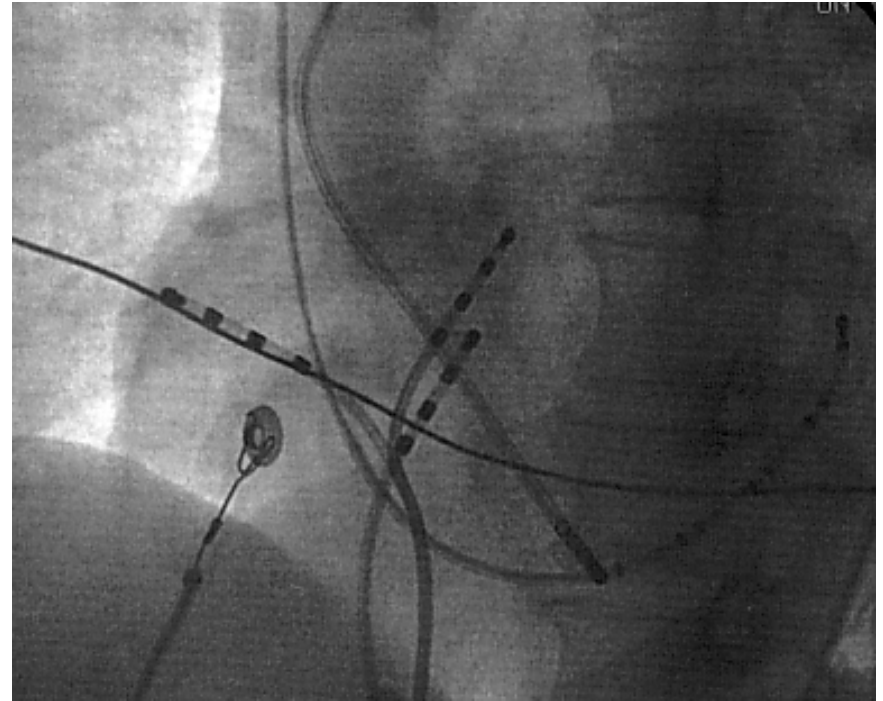




Inferoapical septum

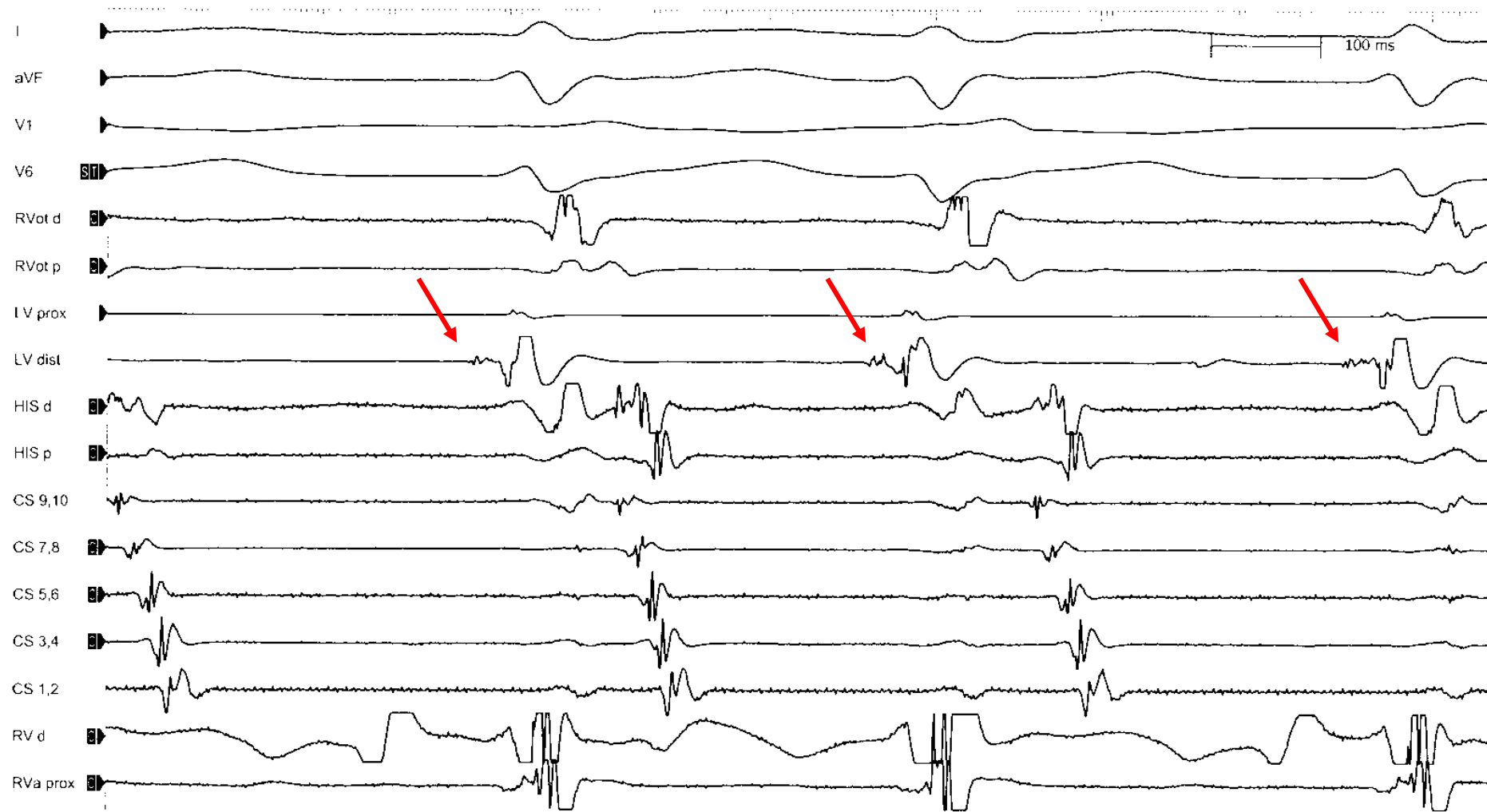


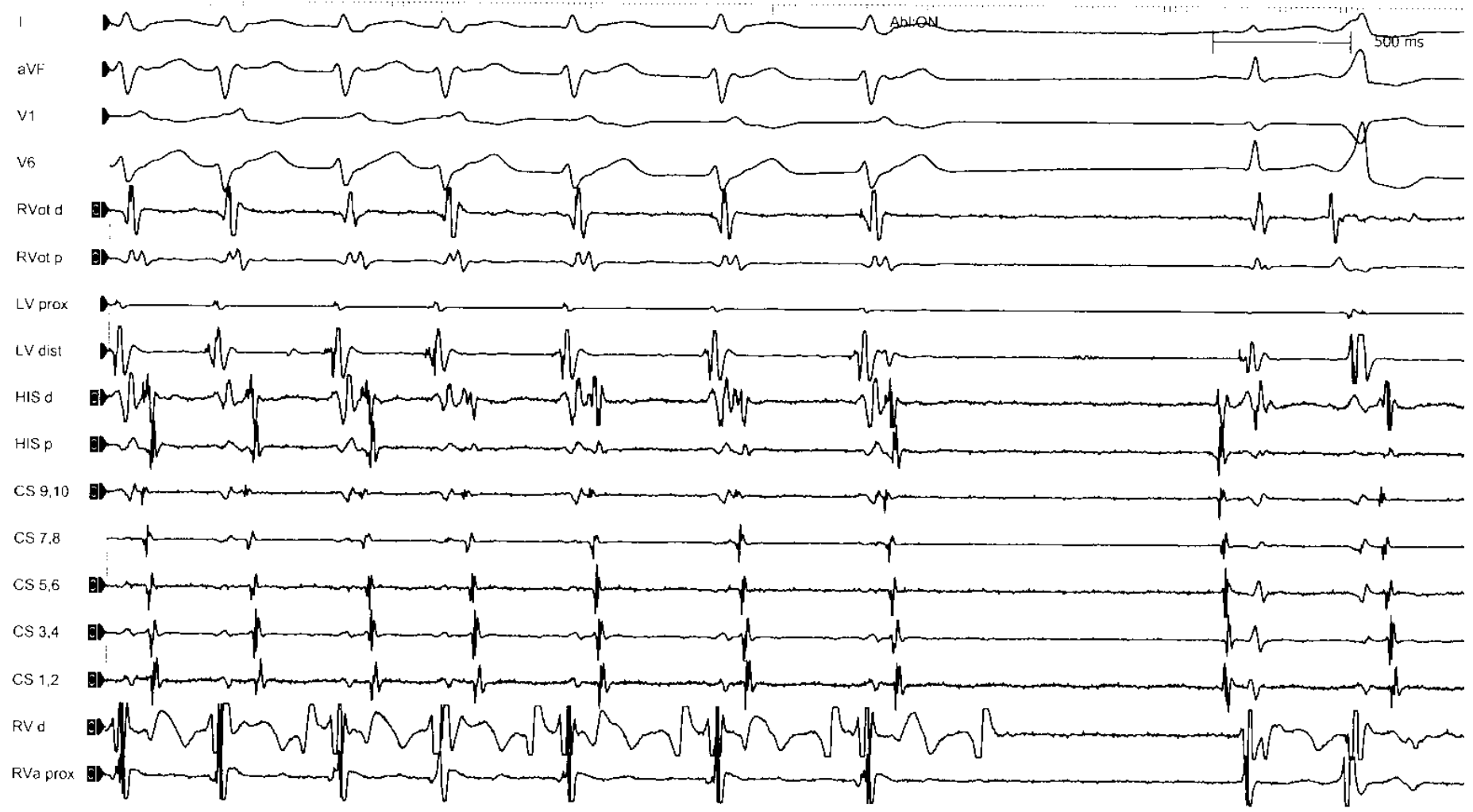
RAO



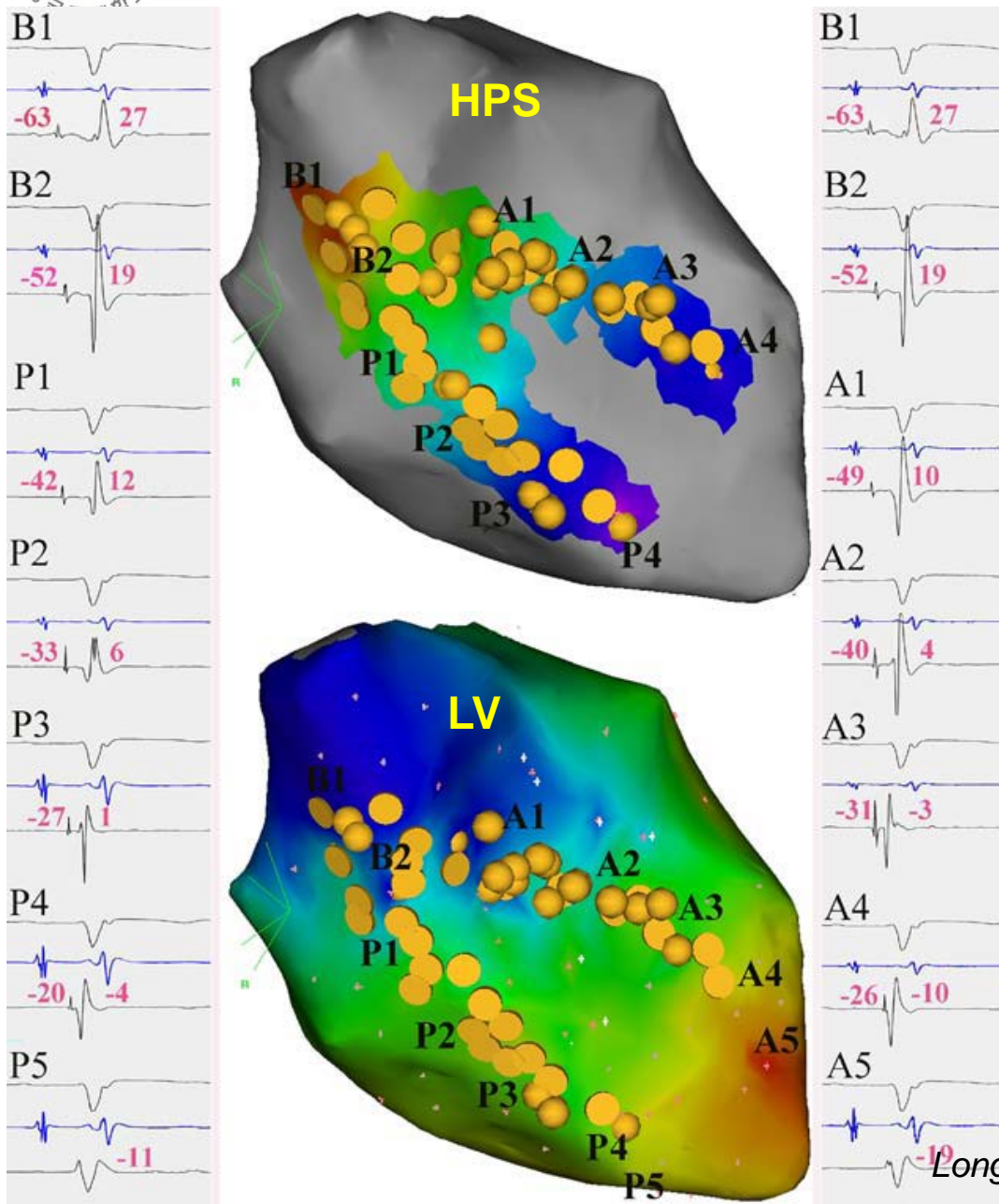
LAO

P-potential





Mapping during sinus rhythm



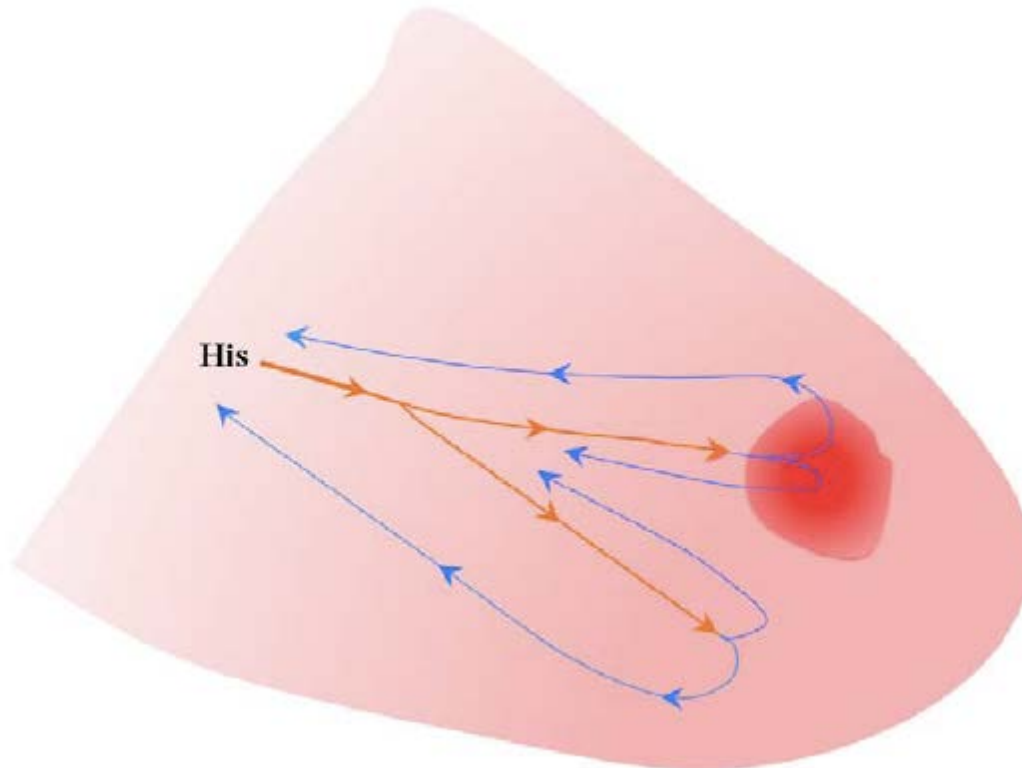
ECG V1 (black tracing),
coronary sinus (blue tracing),
mapping catheter (black tracing)

The common trunk of LBB (B1 and B2),
LAF(A1 to A4), LPF(P1 to P4), the myocardial sites
adjacent to the distal ends of fascicles (A5 and P5)

The **left HPS** : antegrade activation sequence
(middle, top),

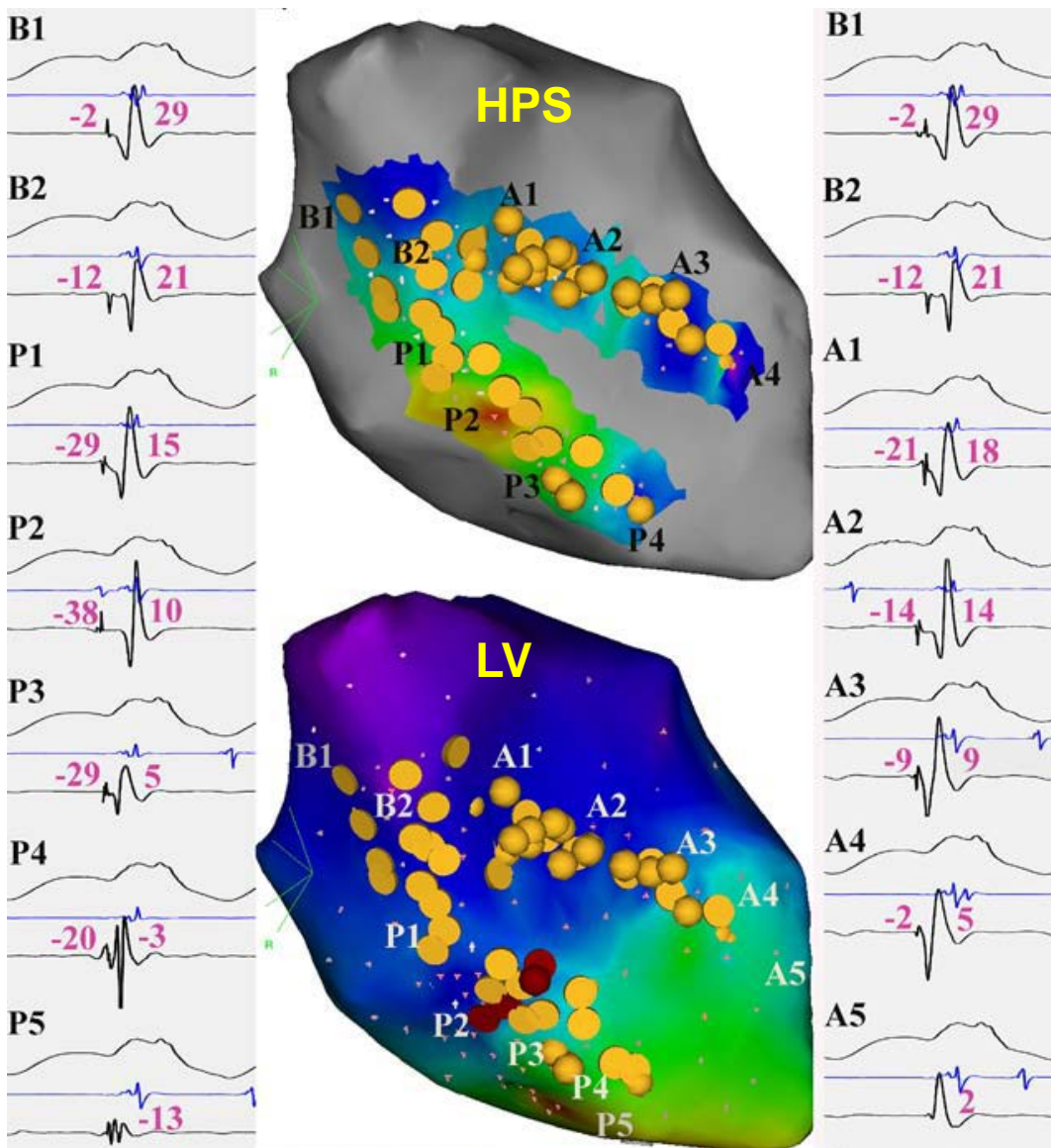
Its surrounding **myocardium** : retrograde activation
sequence (apical to base direction) after HPS
The LV breakthrough site : adjacent to the distal end
of LAF (**middle, bottom**; position A5).

Activation sequences of left HPS and LV myocardium during **sinus rhythm**



- The main branch of **HPS** is **insulated** by connective tissue, and only bridged to the myocardium at its distal end.
- The **HPS** and **surrounding myocardium** resemble the **antegrade** or **retrograde** limb of a reentry. If this half-open conduit becomes closed (abnormal connections at its proximal), a reentry may develop.

Mapping during ILVT



ECG V1 (black tracing),
coronary sinus (blue tracing),
mapping catheter (black tracing)

The common trunk of LBB (B1 and B2),
LAF(A1 to A4), LPF(P1 to P4), the myocardial sites
adjacent to the distal ends of fascicles (A5 and P5)

The earliest retrograde presystolic potential (P2) :
at the middle segment of LPF with 38 ms earlier than
the QRS on V1, centrifugally propagated toward the
proximal LPF, and toward the distal LPF, respectively.
It also spread across the bifurcation and activated the
LAF antegradely (middle, top).

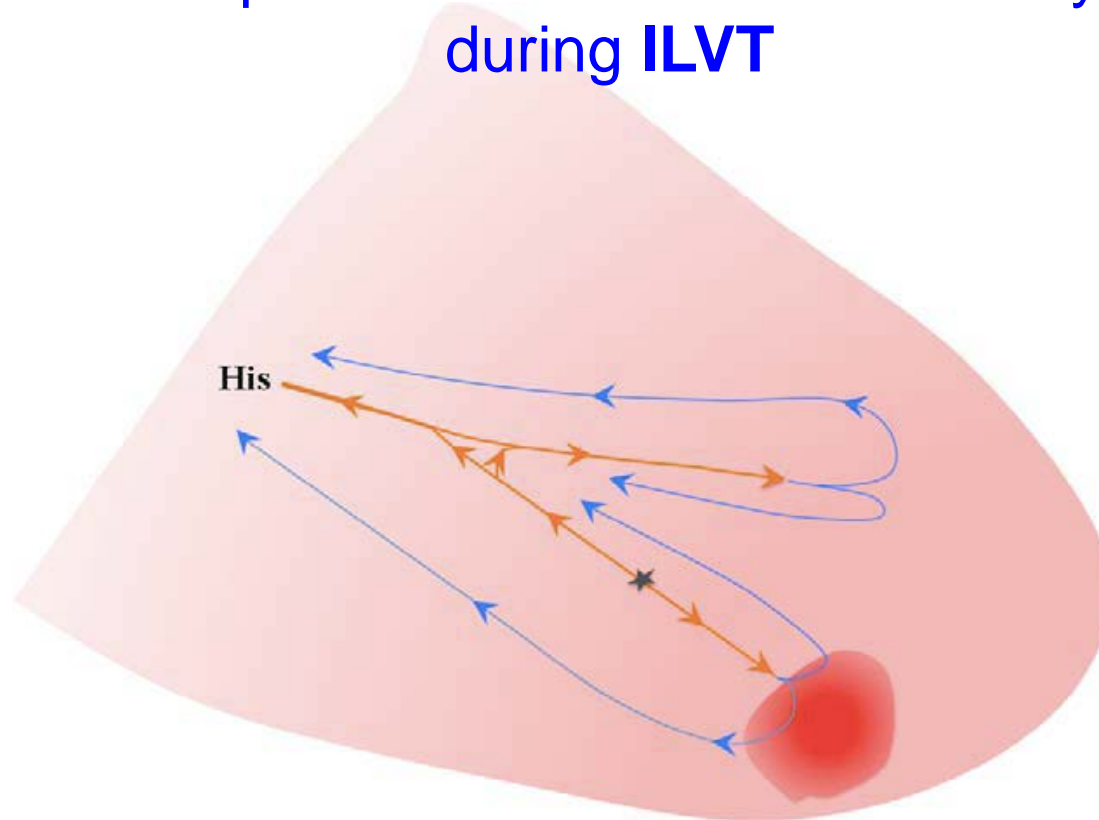
The LV breakthrough site : adjacent to the distal end of
LPF (position P5).

Ventricle septum depolarized retrogradely (middle,
bottom).

The isolated conduction within the left HPS
remained during ILVT

The earliest retrograde PP was recorded along the
predefined LPF and averaged 15 mm away from its
distal end.

Activation sequences of left HPS and LV myocardium during ILVT



- **Depolarization of LAF** begins from the **earliest retrograde presystolic potentials** (black star) and spreads along the fascicle via 2 opposite wavefronts.
- The **LAF** was depolarized **after LAF** and exhibited **antegrade activation** sequence (red lines and arrows).
- **Myocardium breakthrough site** (hot red) was switched to the **distal end of LAF**.
- The **isolated conduction within the left HPS** remained during ILVT.

- The **earliest retrograde PP** was recorded along the predefined LPF and averaged **15 mm away from its distal end**.
- The earliest retrograde PPs were clustered at the **middle segment of LPF** (0.5 ± 0.1).
- All VTs could be successfully abolished by **ablation at the earliest retrograde PP**.
- This indicates not only the **reentry** confined to the **fascicle system**, but also the **earliest retrograde PP** as the crucial site of ILVT.
- **LPF proximal to the earliest retrograde PP** is part of the reentry, whereas the LPF distal to it seems to be the bystander only.

Targets for FVT Ablation

- A diastolic potential (P1) serving as the anterograde limb and a faster conducting, normal fiber that accounts for the PP (P2) serving as the retrograde limb.
- Ventricular myocardium serves as the bridge between the anterograde and retrograde limbs.
- The reentrant FVT can be interrupted at multiple points along the reentrant Circuit : ablation targets namely P1, earliest PP, or even the exit site (site with the earliest ventricular activation)
- **During VT**, the earliest PP (P2 potentials) representing the lower turnaround of the LPFVT circuit.
- The advantages of targeting the earliest PP : more apical locations, reducing the risk of atrioventricular nodal or bundle branch injury and need for fewer radiofrequency energy applications,
diastolic (P1) potentials may not be recorded in all patients

Targets for FVT Ablation

Strategies performed during **sinus rhythm**

- **Purkinje potentials visible after the QRS complex**, which may be characteristic of delayed retrograde activation of abnormal Purkinje fibers
Recordable over a sizeable area of the septum
Would result in a substantial septal area being ablated with the risk of injury to the conducting system
- **Anatomically guided approach** of placing 7 to 15 ablation lesions in a linear pattern, perpendicular to the long axis of the ventricle approximately midway from the base to the apex in mid to **midinferior septum**, guided by the presence of Purkinje potentials and pace mapping
- **The creation of partial or complete LPF block**
LPFVT can still develop in patients with preexisting LPF block, and
The vast majority of patients remained arrhythmia free after LPFVT ablation without developing new-onset LPF block,
*would suggest that the **LPF does not participate in LPFVT circuit.***

Long-Term Clinical Outcomes of Catheter Ablation of Fascicular VT

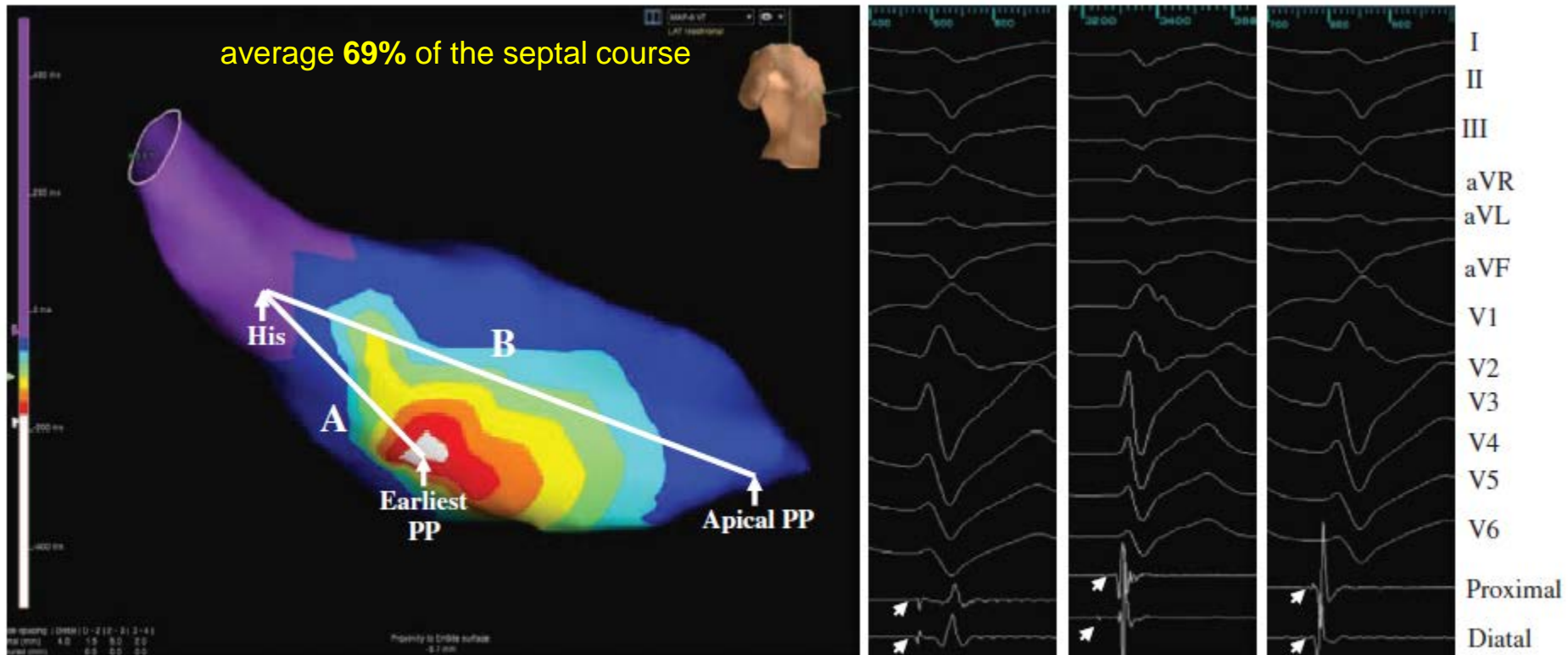
- **120** consecutive patients (mean age, 29.3 ± 12.7 years; 82% men)
- Nanjing Medical University, China
- **LPF** and LAF in 118 and 2 subjects, respectively
- Activation mapping to identify the earliest presystolic Purkinje potential during FVT
- Acutely successful in 117 patients, non inducible in 3 patients
- Median follow-up of 55.7 months
- 17 patients (**15%**) : FVT recurrence involving the same fascicle successfully ablated.

Shorter VT cycle length : predictor of FVT recurrence ($P=0.03$)

- Six other patients (**5%**) developed new-onset upper septal FVT :
3 successfully ablated.

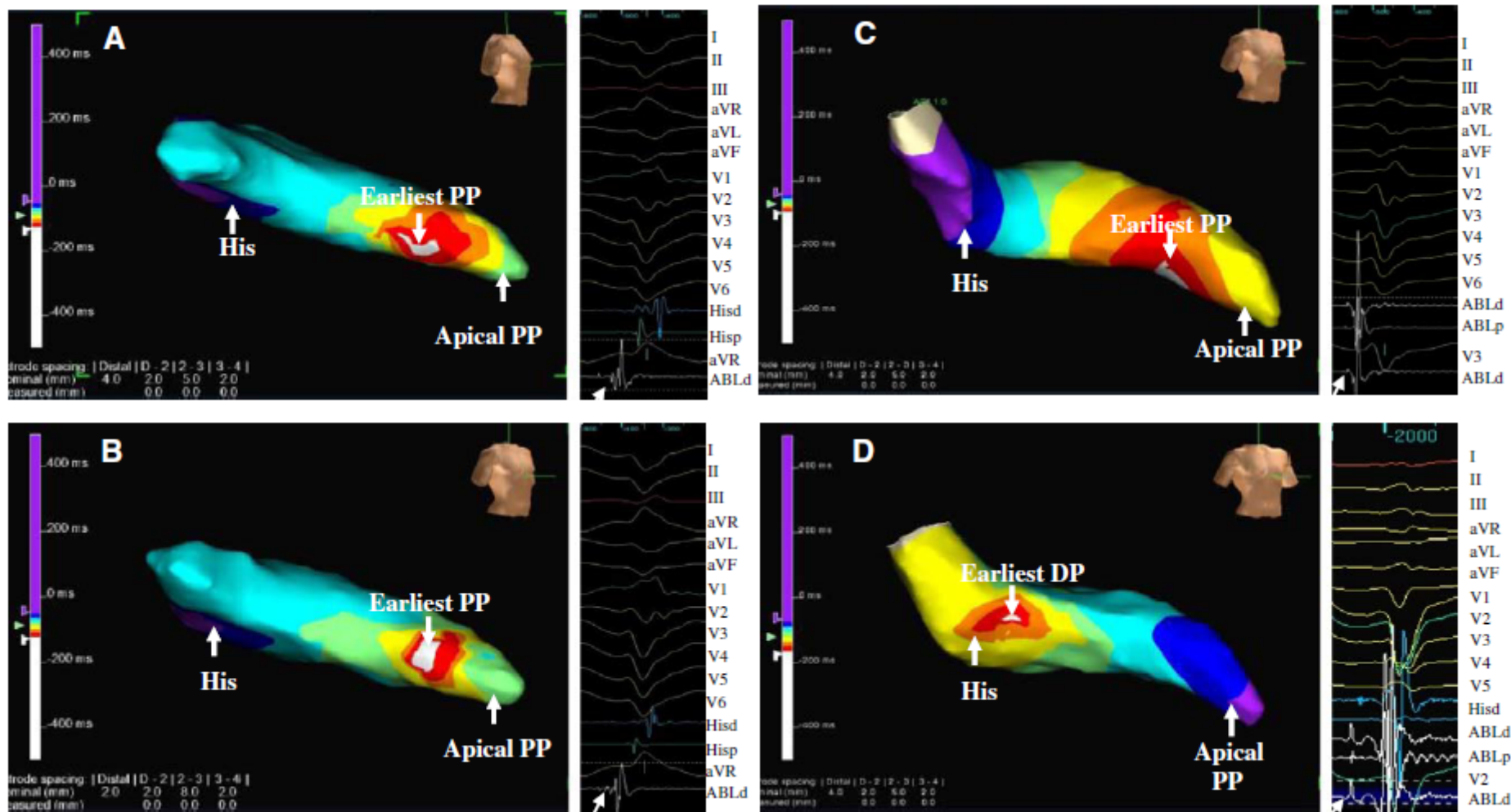
Activation map using the NavX system of Fascicular VT

The earliest presystolic Purkinje potential (earliest PP) during FVT was targeted.

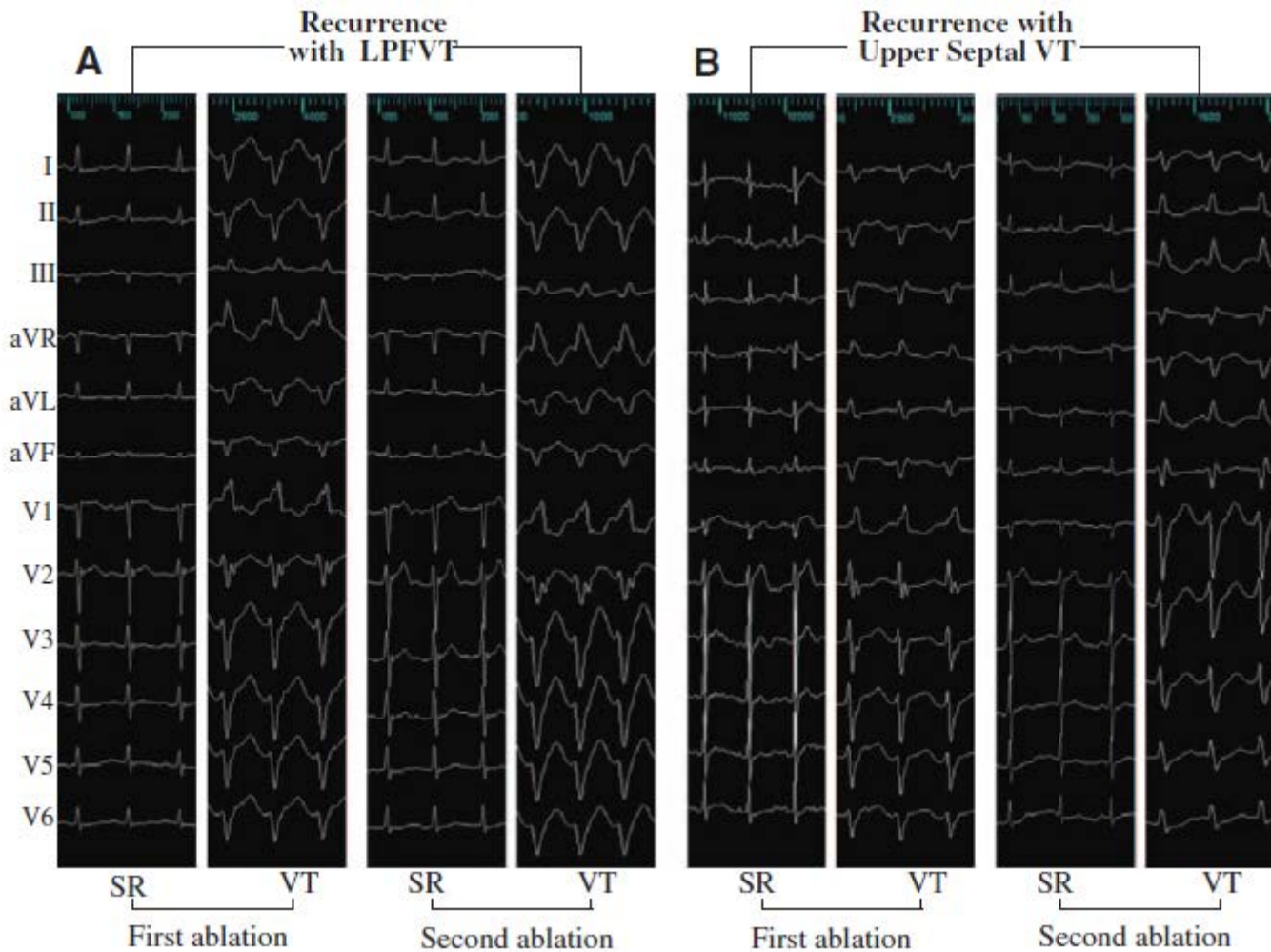


$$\frac{\text{His-RF}}{\text{His-Apical PP}} = \frac{\text{A}}{\text{B}}$$

His potential Earliest PP Apical PP



A, Activation map in patient 1 recorded during the first ablation procedure for LPF VT
B, Activation map in patient 1 recorded during the second ablation procedure after recurrent LPFVT.
C, Activation map in patient 2 recorded during the first ablation procedure with LPFVT.
D, Activation map in patient 2 recorded during the second ablation procedure after upper septal VT.

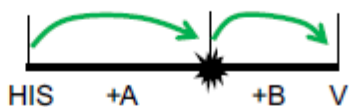
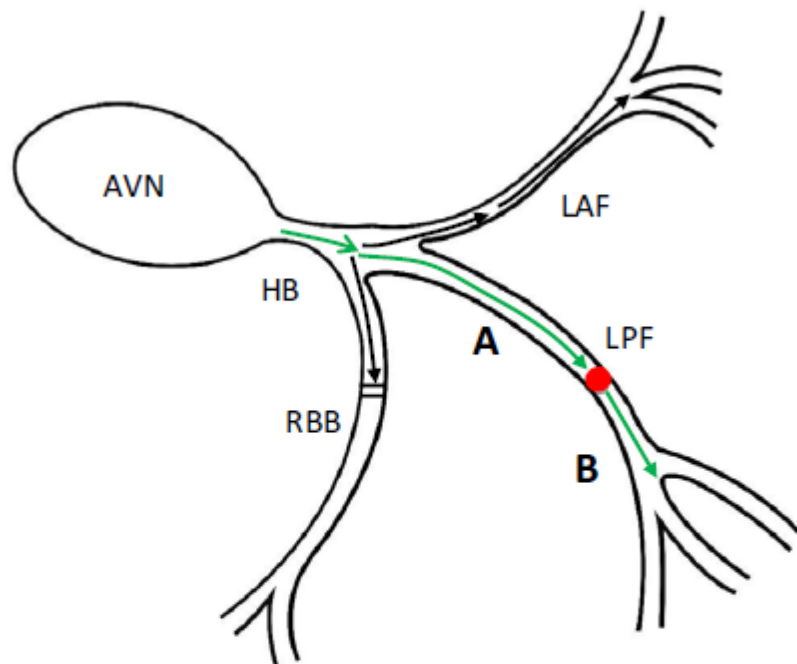


Non-Reentrant Fascicular Tachycardia

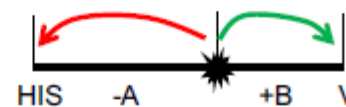
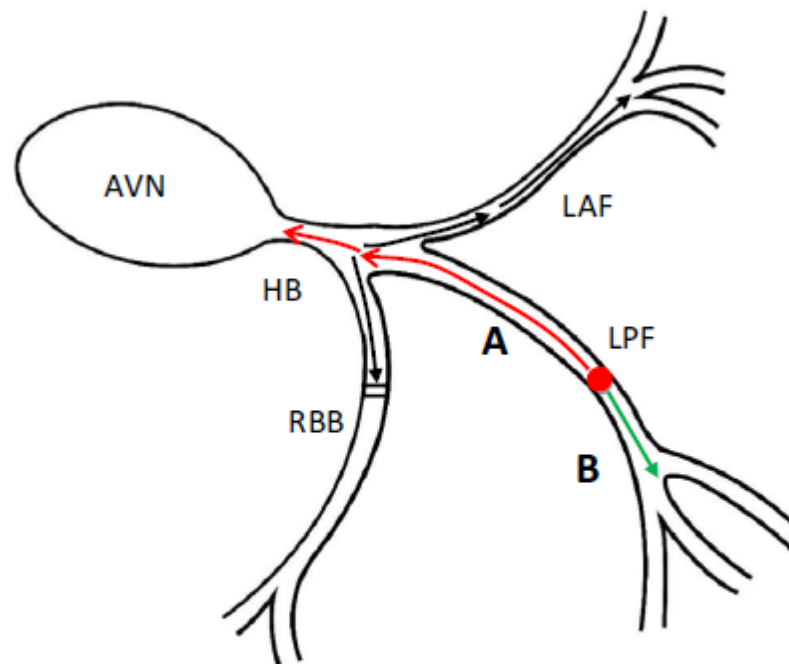
- Among 530 **idiopathic VT** patients referred for ablation, 15 (**2.8%**) identified with focal non-reentrant fascicular tachycardia (11 men, 45 ± 21 years).
- Monomorphic VT (cycle length: 337 ± 88 ms) with a relatively narrow QRS (123 ± 12 ms) did **not respond to verapamil**.
- VT : RBBB/superior axis configuration in 11 patients (73%)
inferior axis in 3 (20%).
LBBB/superior axis configuration in 1 patient (7%)
- A high-frequency presystolic Purkinje potential was recorded during VT/premature ventricular complex, preceding the QRS by 25 ± 16 ms.

Origin Prediction of Left Fascicular VAs

Chen H, et al. Heart Rhythm 2016;13:686



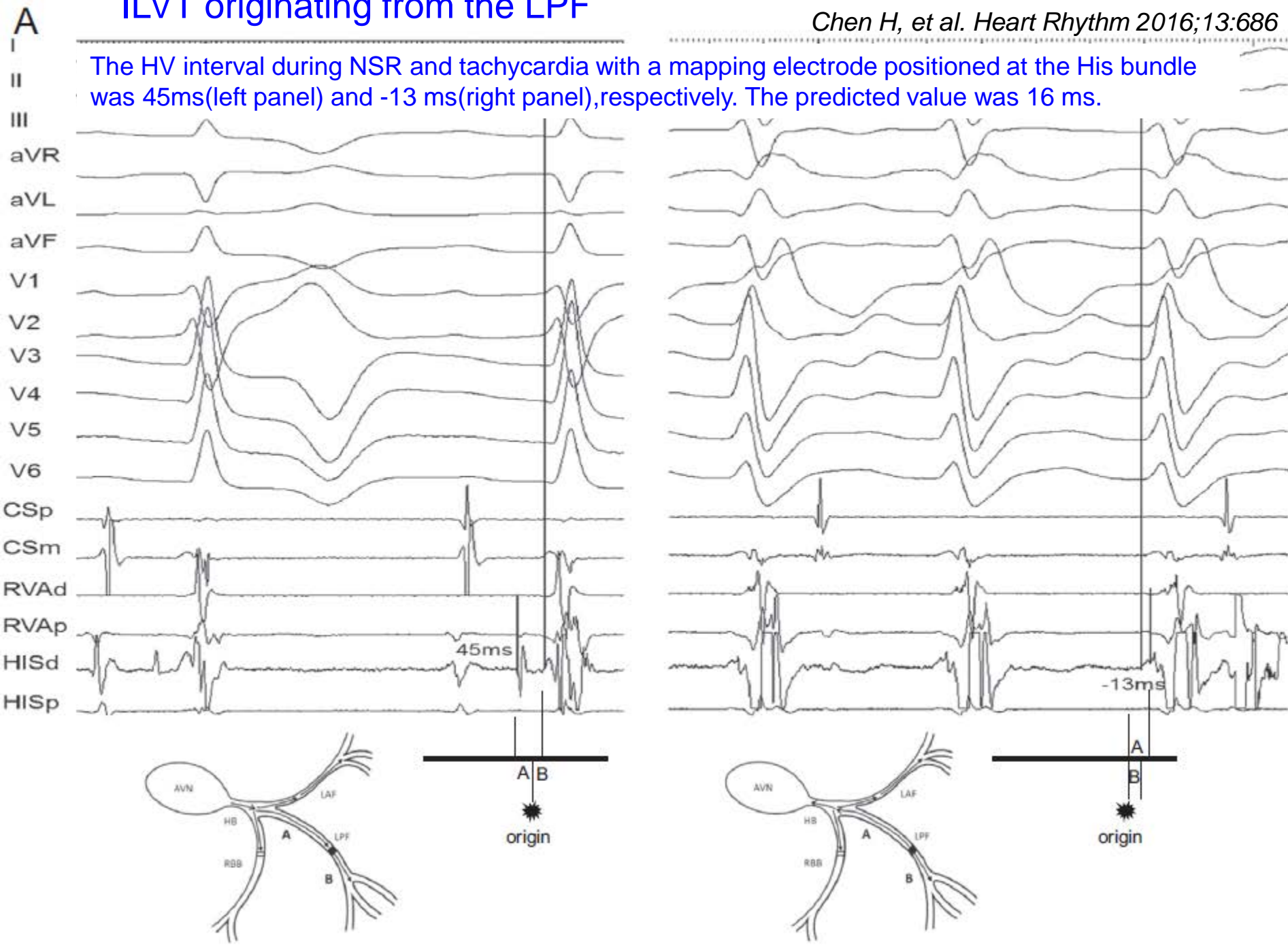
Sinus HV=A+B



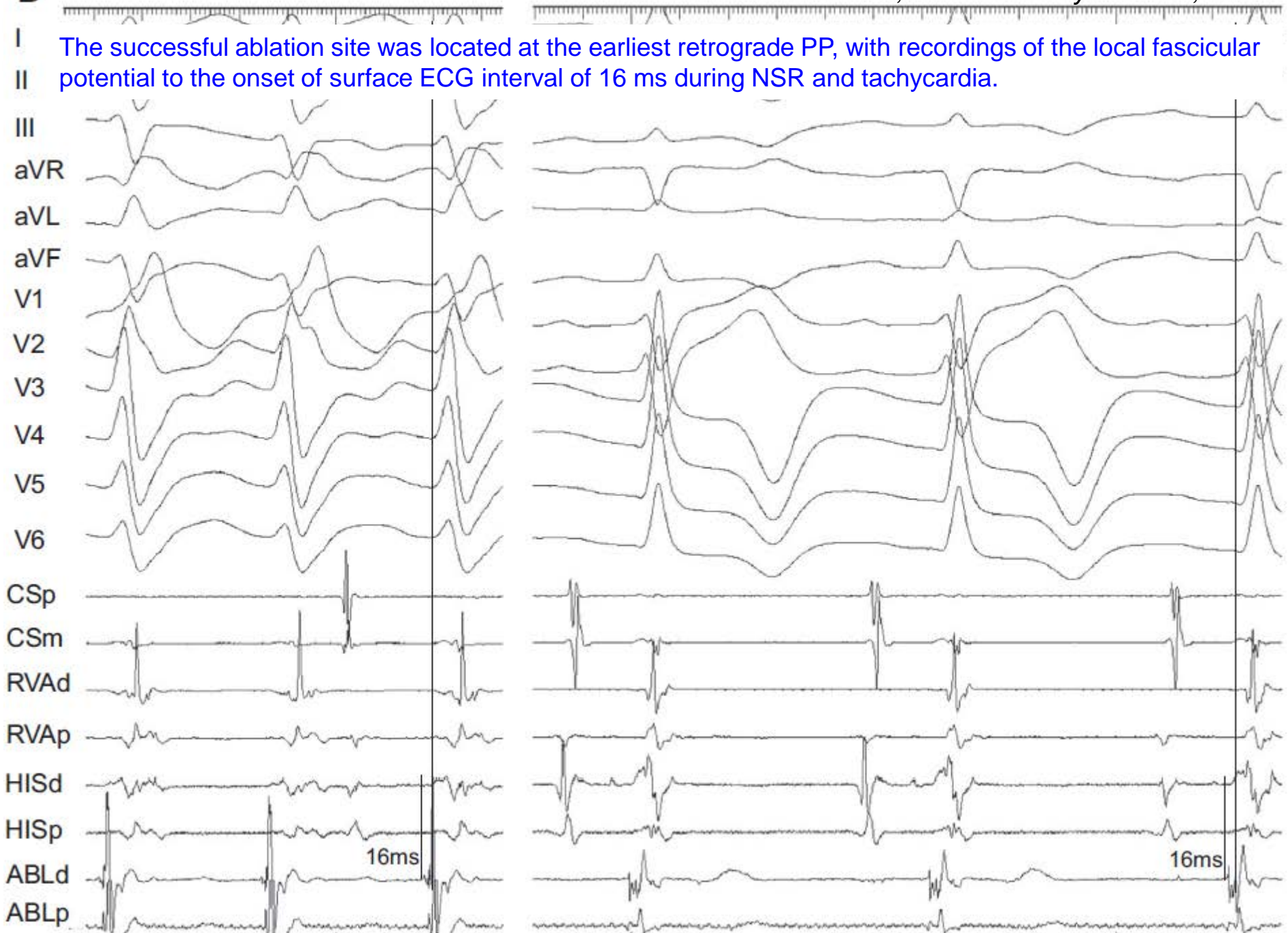
Tachy HV=B-A

The conduction interval from the earliest retrograde PP to the His bundle : time A,
 The conduction interval between the earliest retrograde PP and the onset of the surface ECG: time B
 The HV interval during NSR = A + B (left panel), the HV interval during LFTAs = B – A (right panel).
 The **predicted earliest retrograde PP time** (time B) = $(HV_{NSR} + HV_{LFTA})/2$

ILVT originating from the LPF

Chen H, et al. *Heart Rhythm* 2016;13:686

B



Summary

- LV Fascicular Tachycardia
 - RBBB with LAD/RAD
 - Fascicular reentry (in distal His-Purkinje system)
 - abnormal Purkinje fiber located in the distal third of the LPF Purkinje network
 - Mapping
 - Pace map
 - Purkinje potential
 - Diastolic potential
 - The earliest P-Potential