EP, RFA & Cryoablation: The Basics for the Clinical Cardiologists

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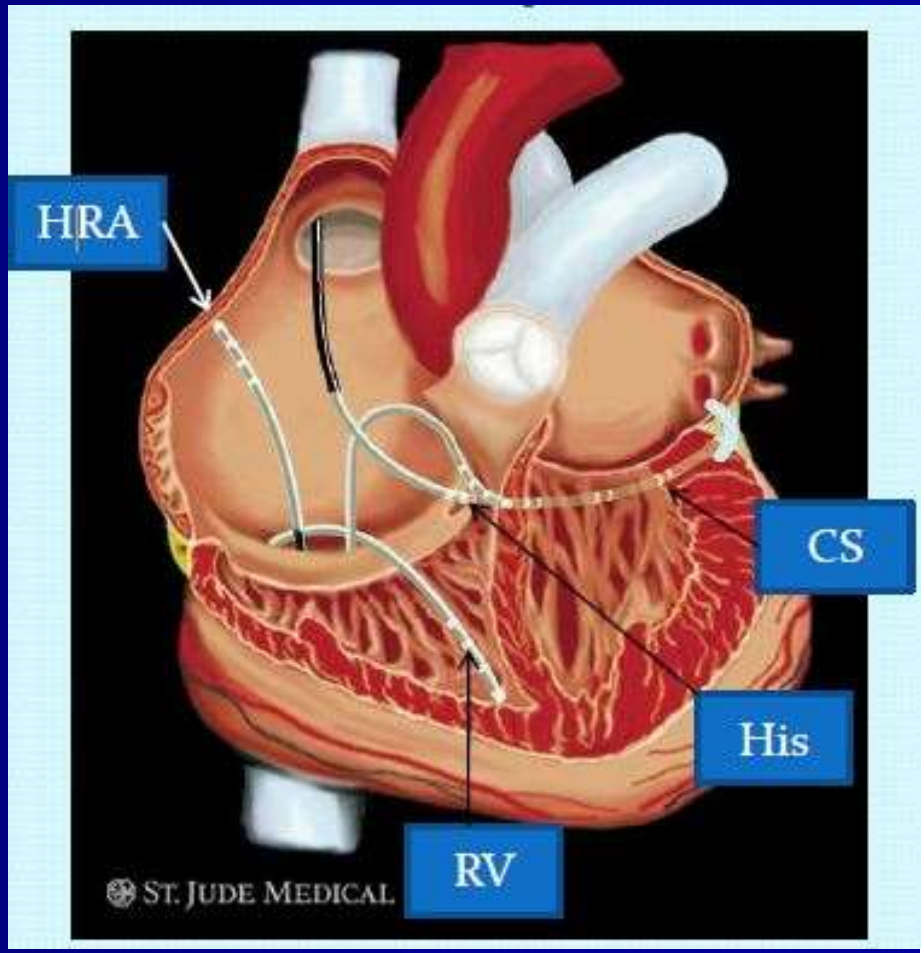
Equipment

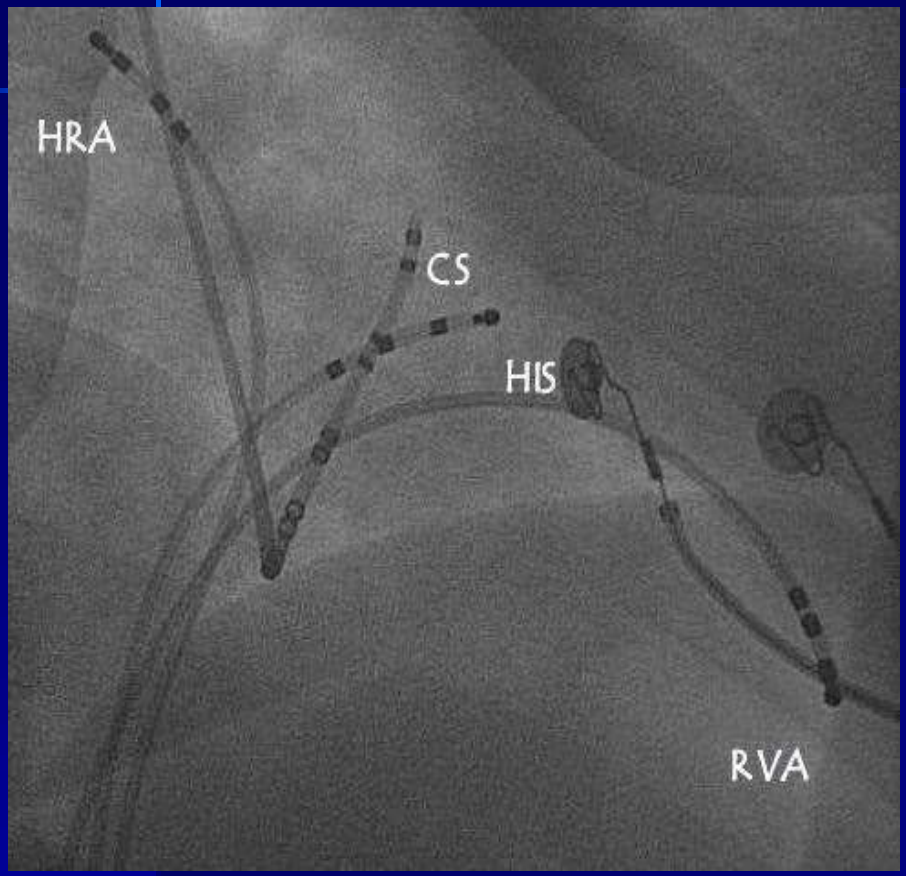
- Fluoroscopy
- EP recording system and stimulator
- Diagnostic and ablation catheters
- Power generator for RFA; CryoConsole for cryoablation
- Resuscitation equipment

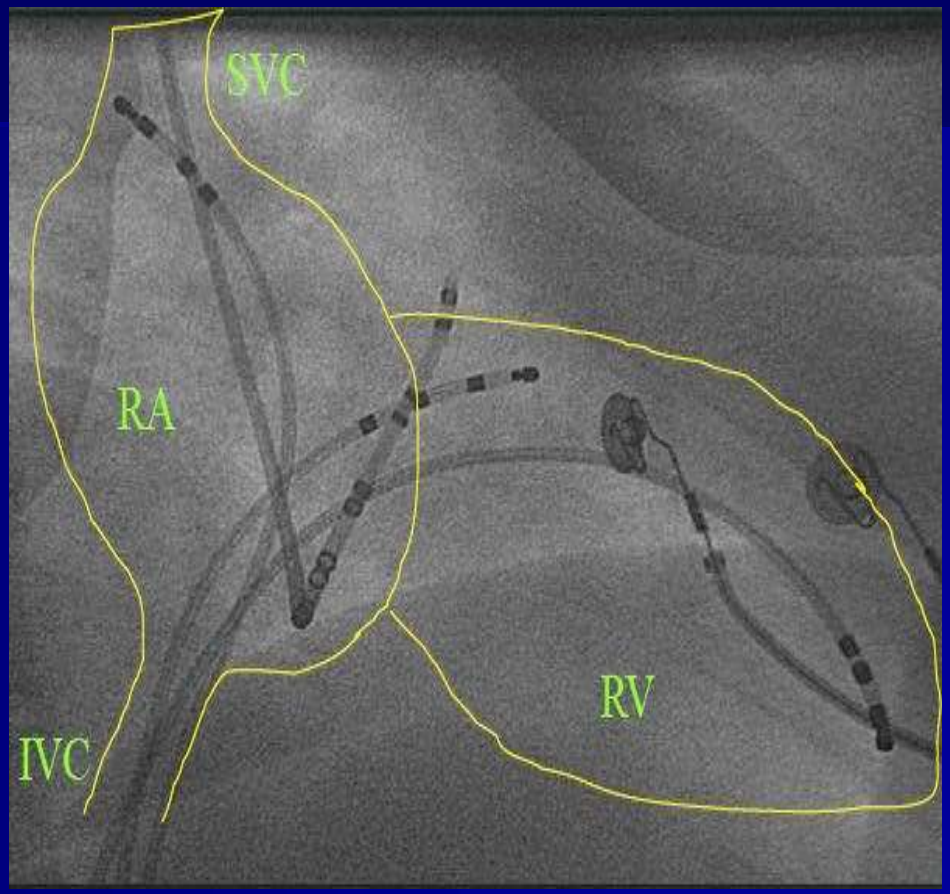
Routine Catheter Positions

- High Right Atrium (HRA)
- His Bundle (HIS)
- Right Ventricular Apex (RVA)
- Coronary Sinus (CS)

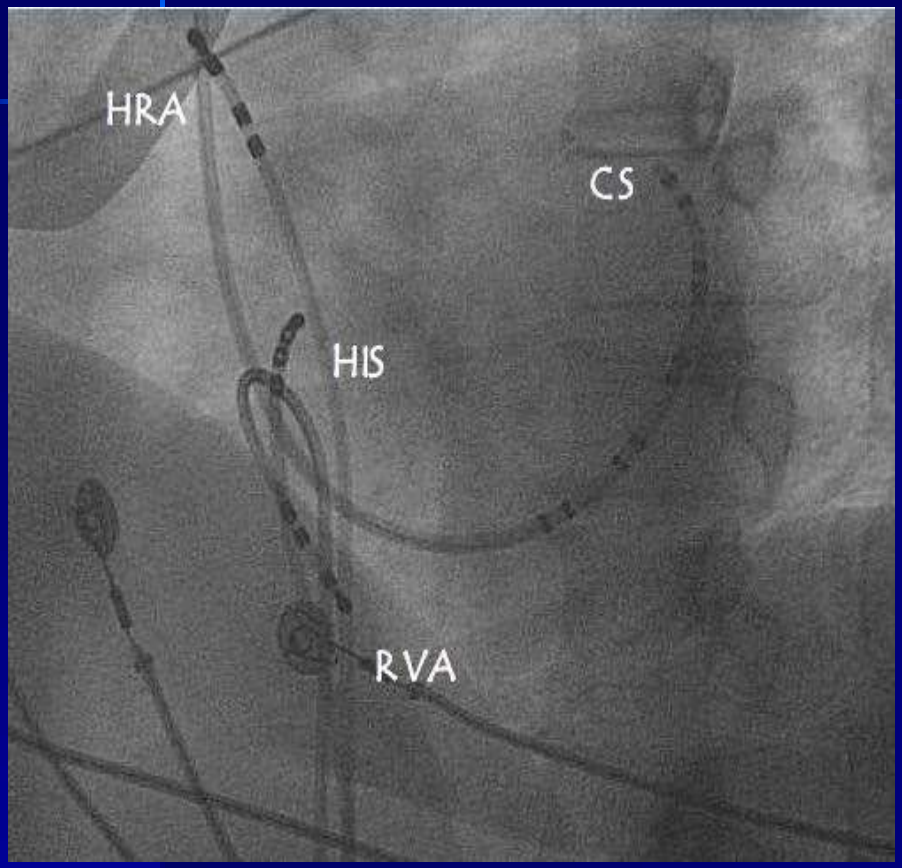


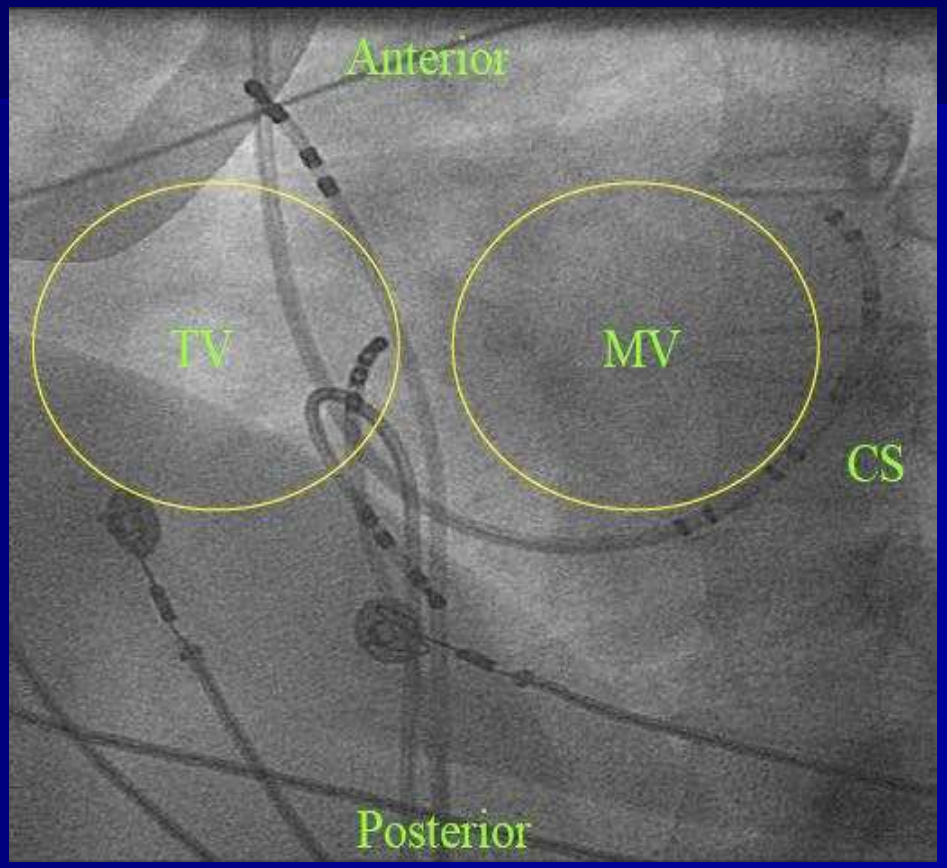
RAO



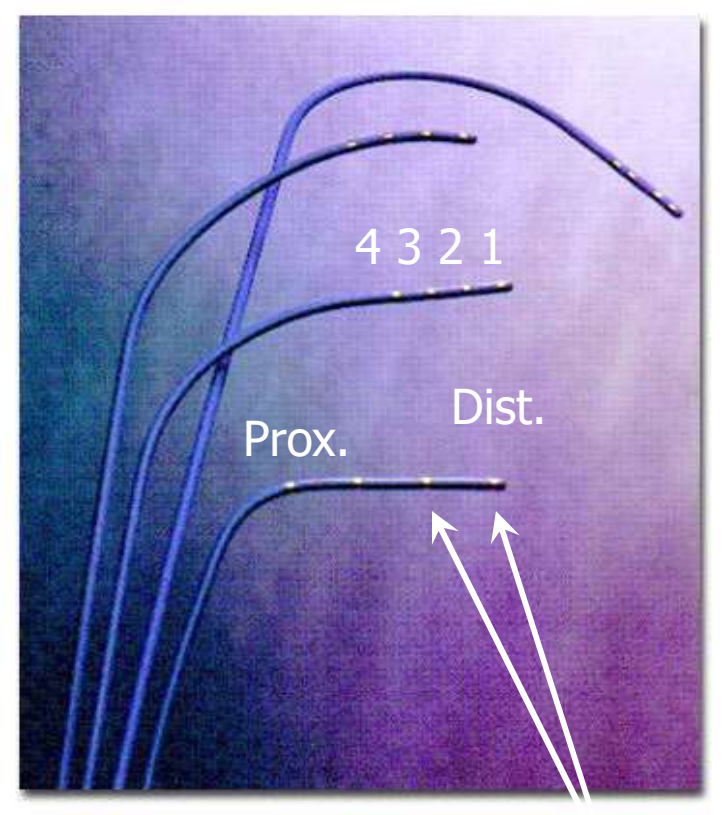


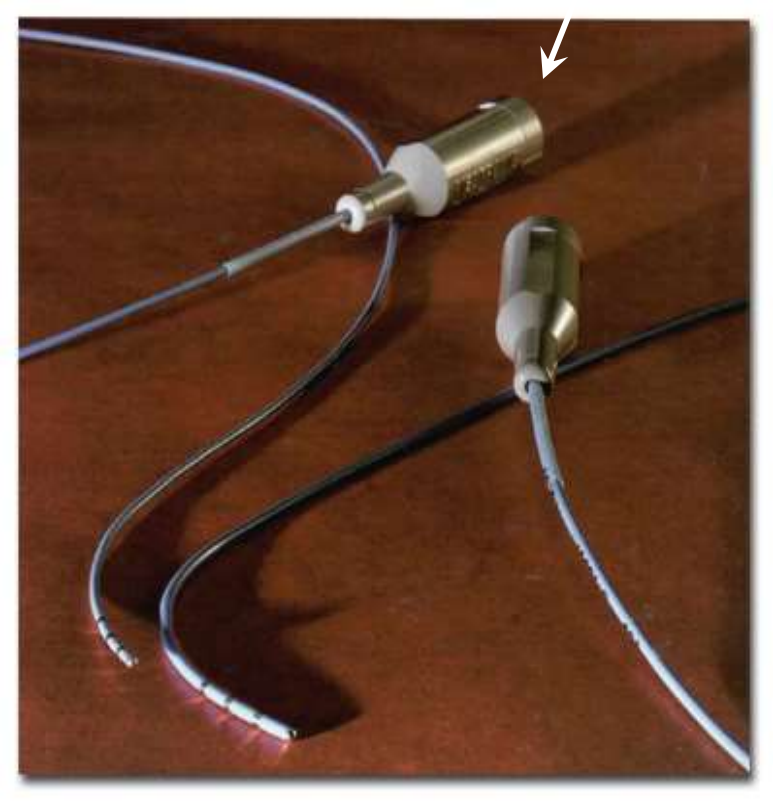
LAO





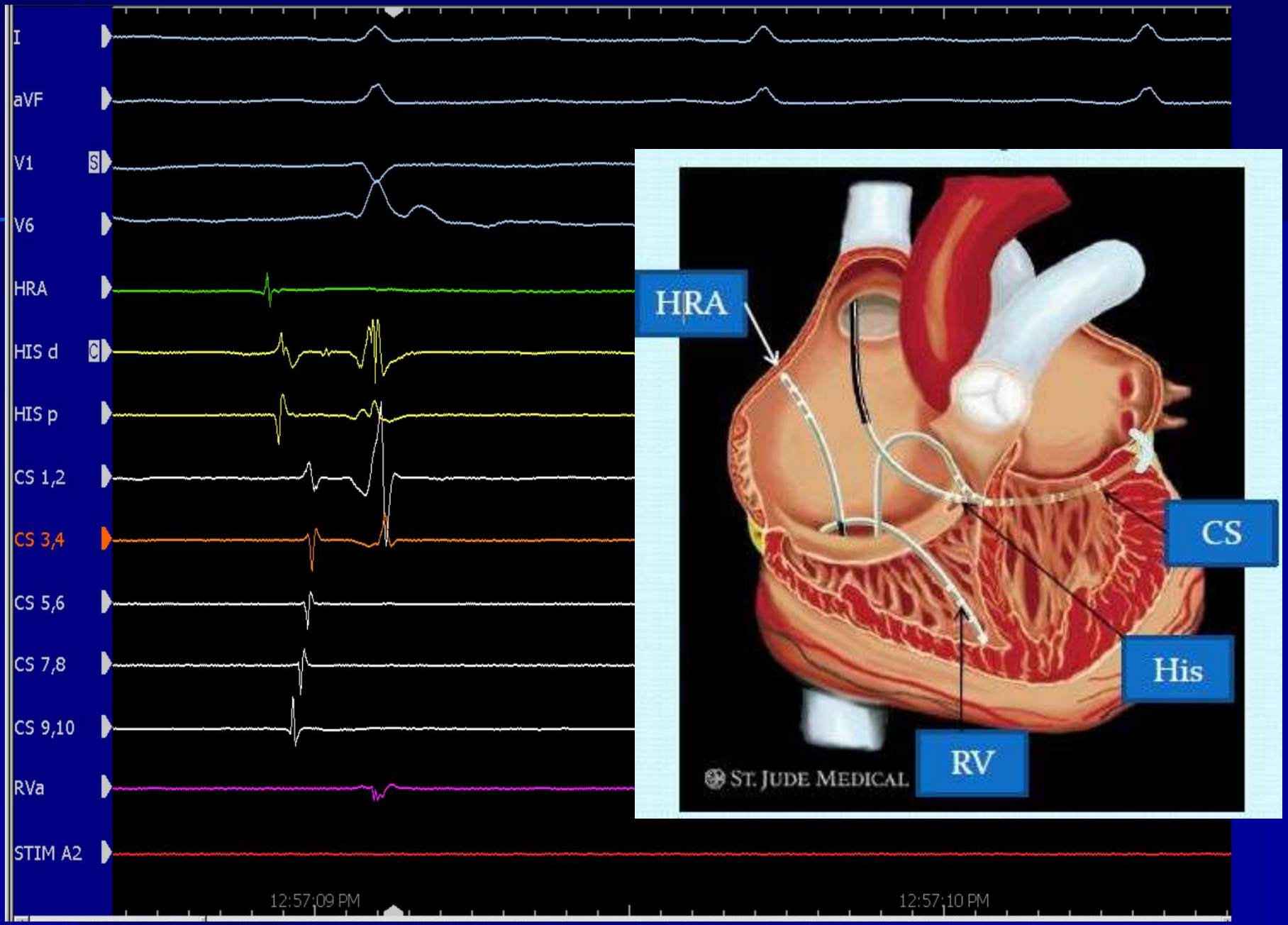
Electrode Catheter





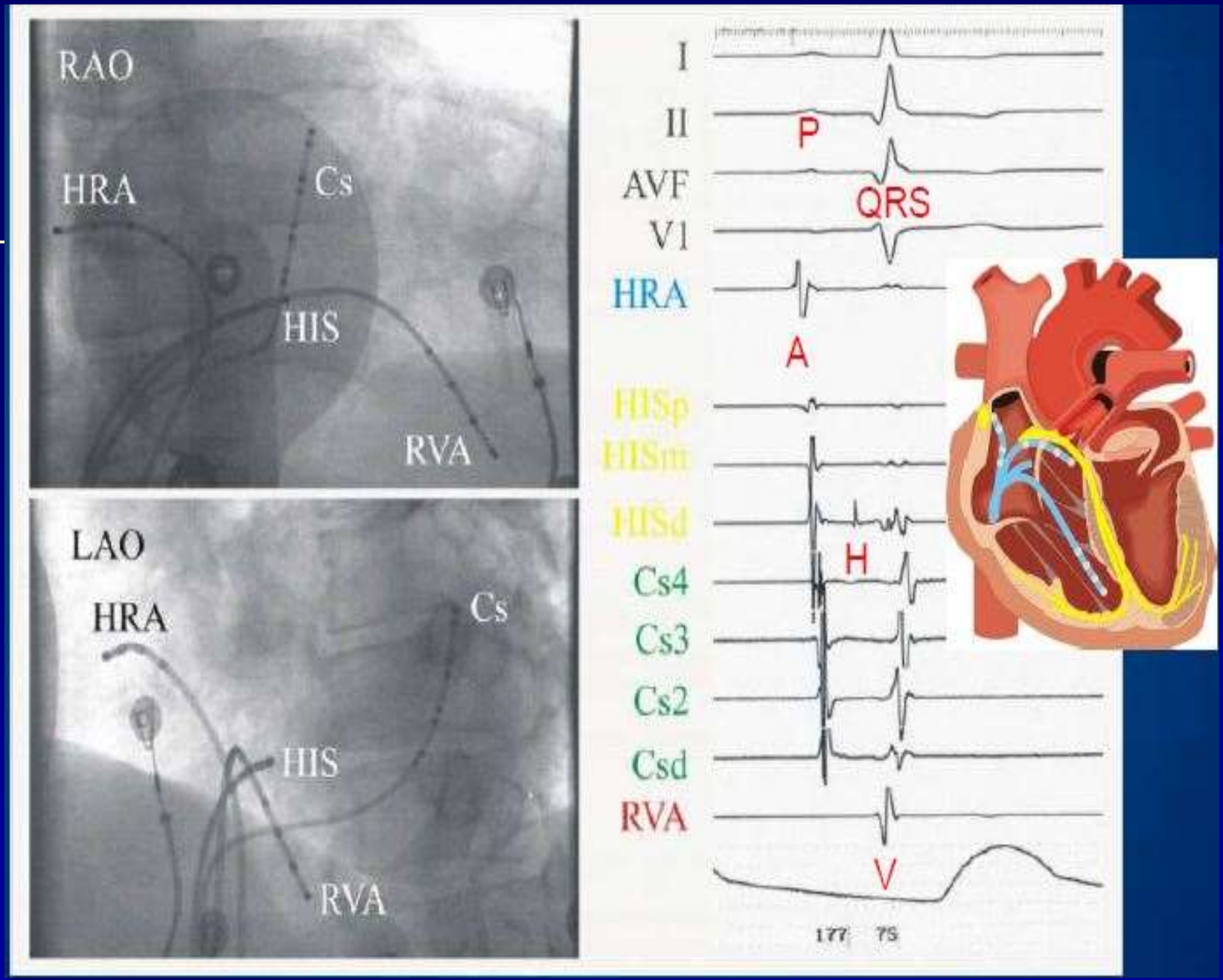
Bipolar intracardiac recording (localized electrical activity-depolarization of tissue)

EP Recording System and Stimulator


I
aVF
V1
S
V6
HRA
HIS d
C
HIS p
CS 1,2
CS 3,4
CS 5,6
CS 7,8
CS 9,10
RVa
STIM A2
12:57:09 PM
12:57:10 PM
HRA
CS
His
RV
ST. JUDE MEDICAL

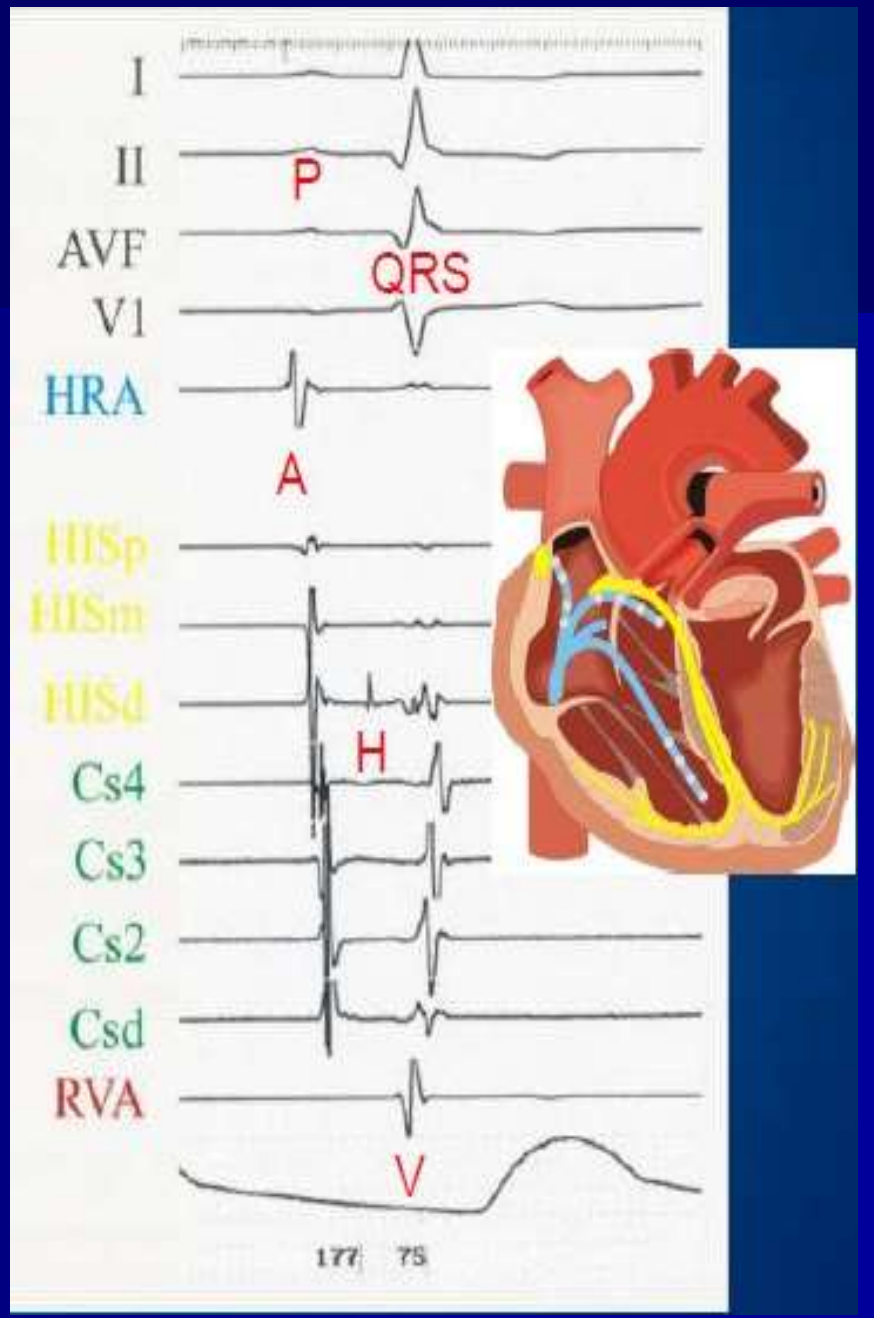
EPS

- Baseline assessment of SAN, AVN, His-Purkinje function
- Detection of accessory pathway (either concealed or WPW)
- Induce clinic arrhythmia by programmed stimulation +/- pharmacological challenge (isoprenaline, atropine)
- Mapping (locate the target for ablation)
- Ablation
- Post-ablation assessment


RAO
HRA
Cs
HIS
RVA
LAO
HRA
Cs
HIS
RVA
I
II
AVF
V1
HRA
HISp
HISm
HISd
Cs4
Cs3
Cs2
Csd
RVA
P
QRS
A
H
V
177 75

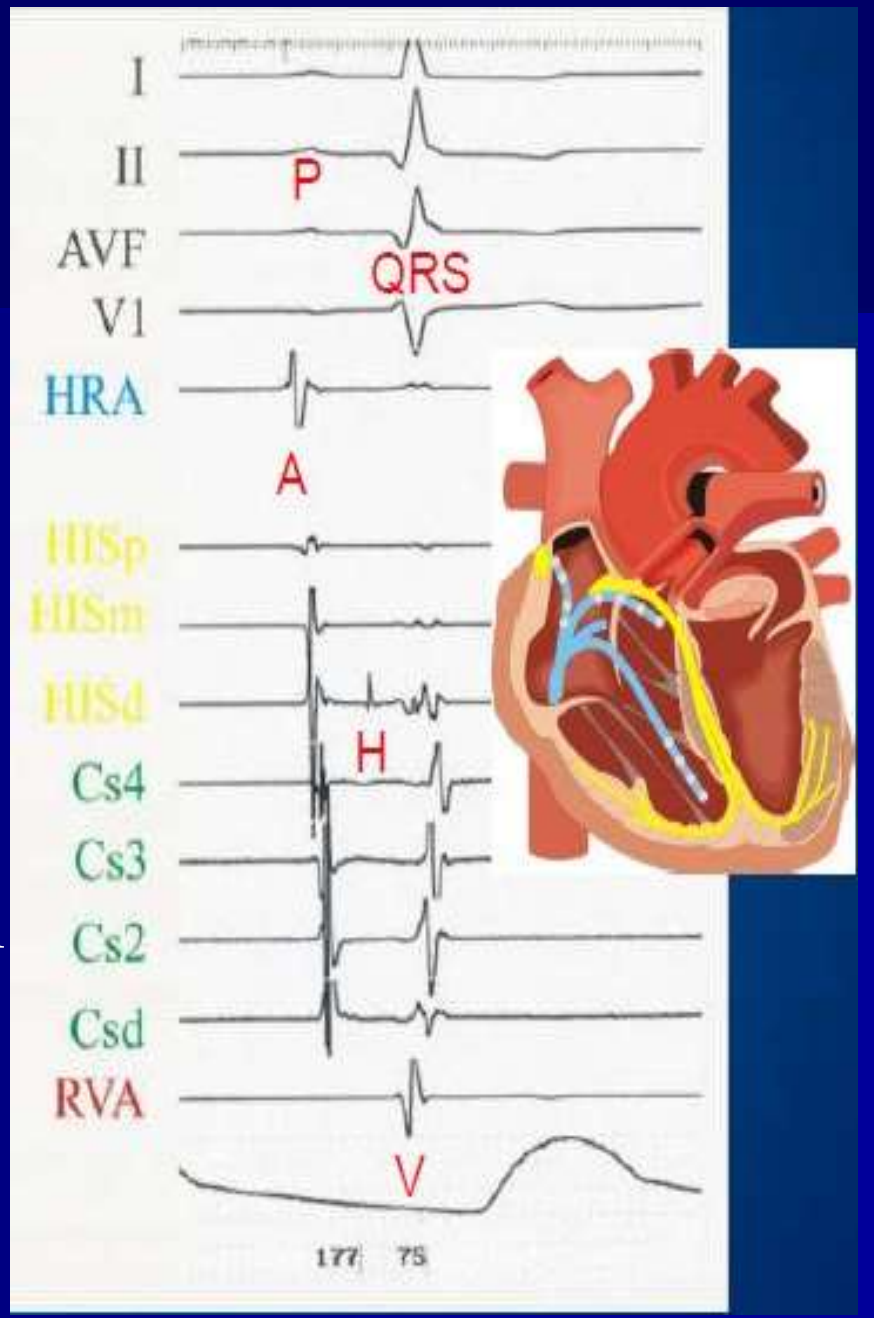
AH Interval

- Time taken to travel over AVN
- Measured from atrial EGM at His bundle to His EGM
- Normal: 55-125ms



HV Interval

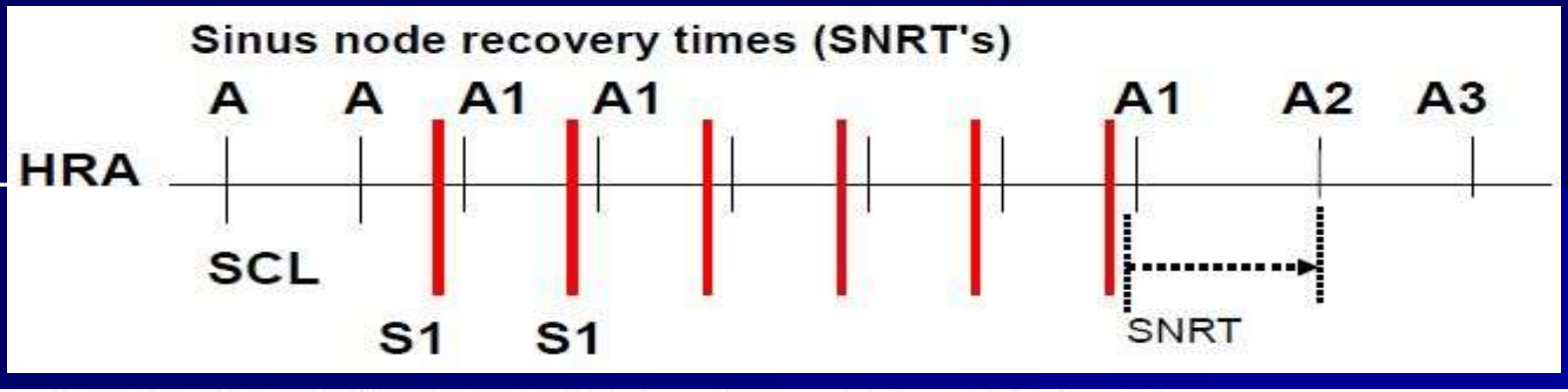
- Time taken to travel through His-Purkinje system
- Measured from His EGM to earliest ventricular activation in any leads including surface
- Normal: 35-55ms

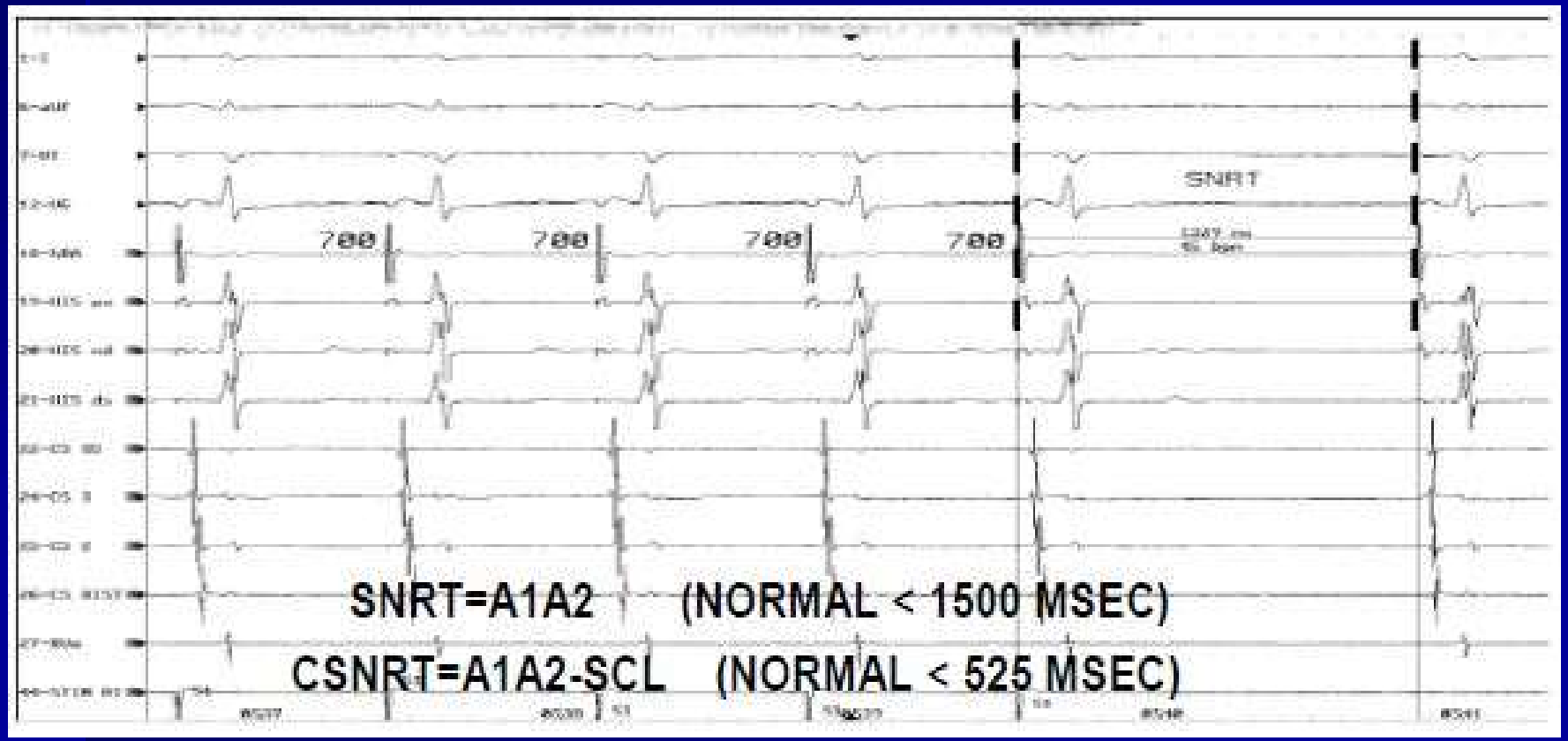


Standard Conduction System Study

- Evaluate sinus node function
  - SNRT
- Evaluate antegrade AV node conduction (Incremental pacing and S1S2)
  - AV decremental properties
  - AVNERP
  - AV Wenckebach CL
- Evaluate retrograde AV node conduction (Incremental pacing and S1S2)
  - VA conduction properties
  - VAERP
  - VA Wenckebach CL

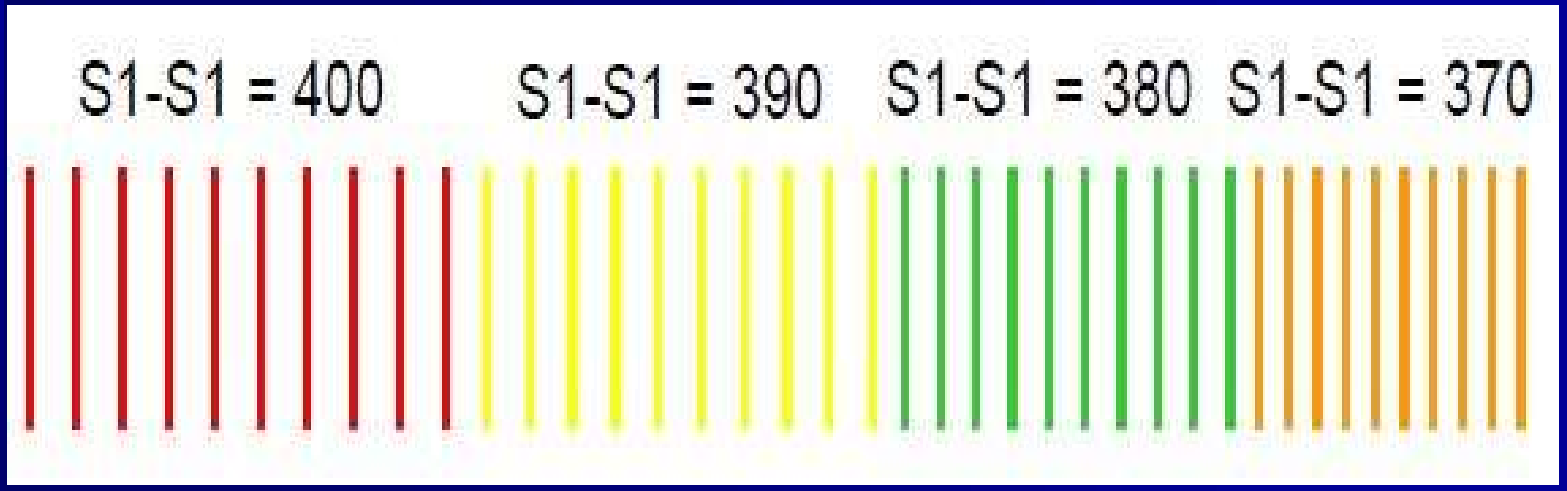
Sinus Node Function



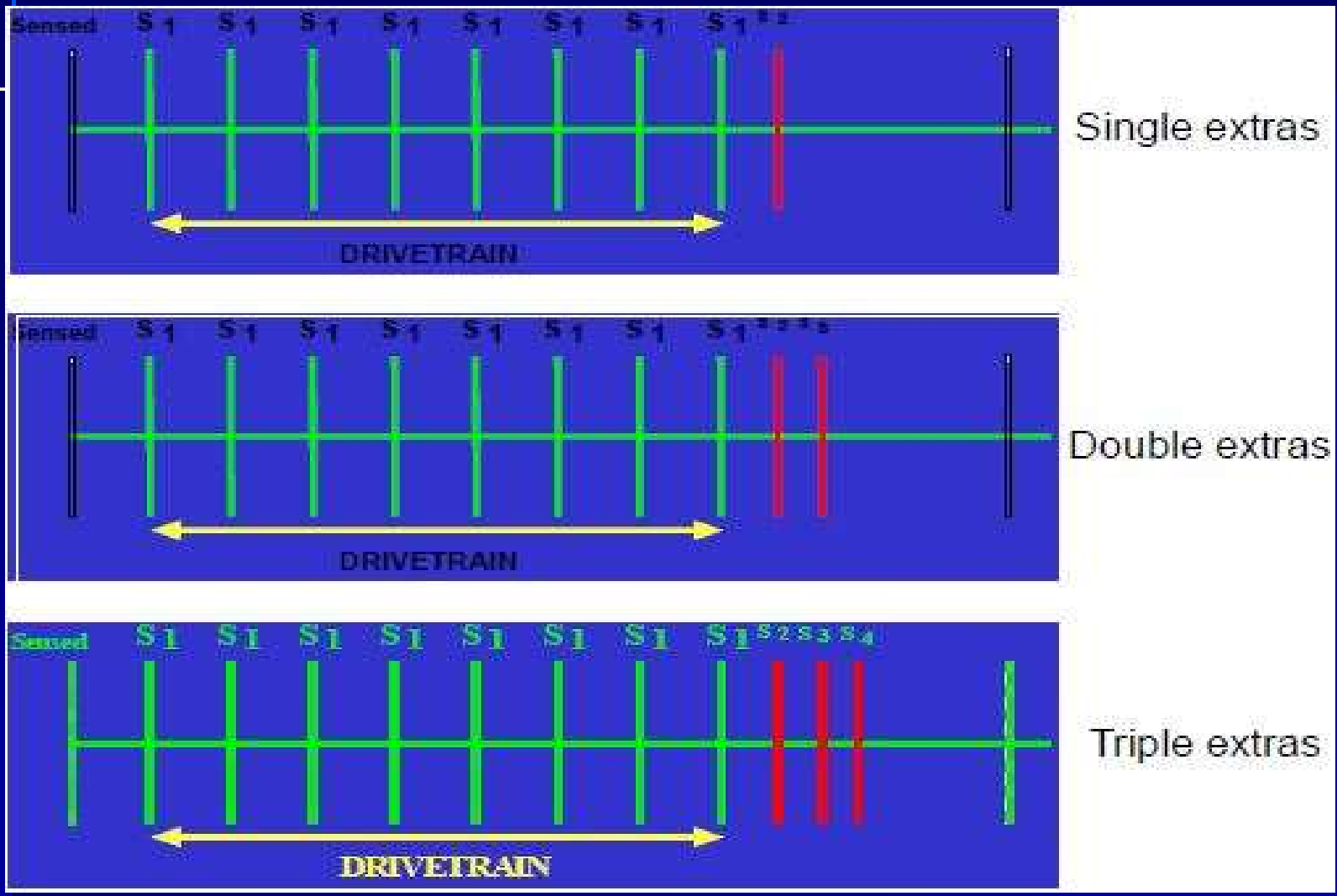


Incremental Pacing

- Pacing the heart at a fixed rate. The rate is increased (pacing interval decreased) with each set of beats.



Extrastimulus Pacing

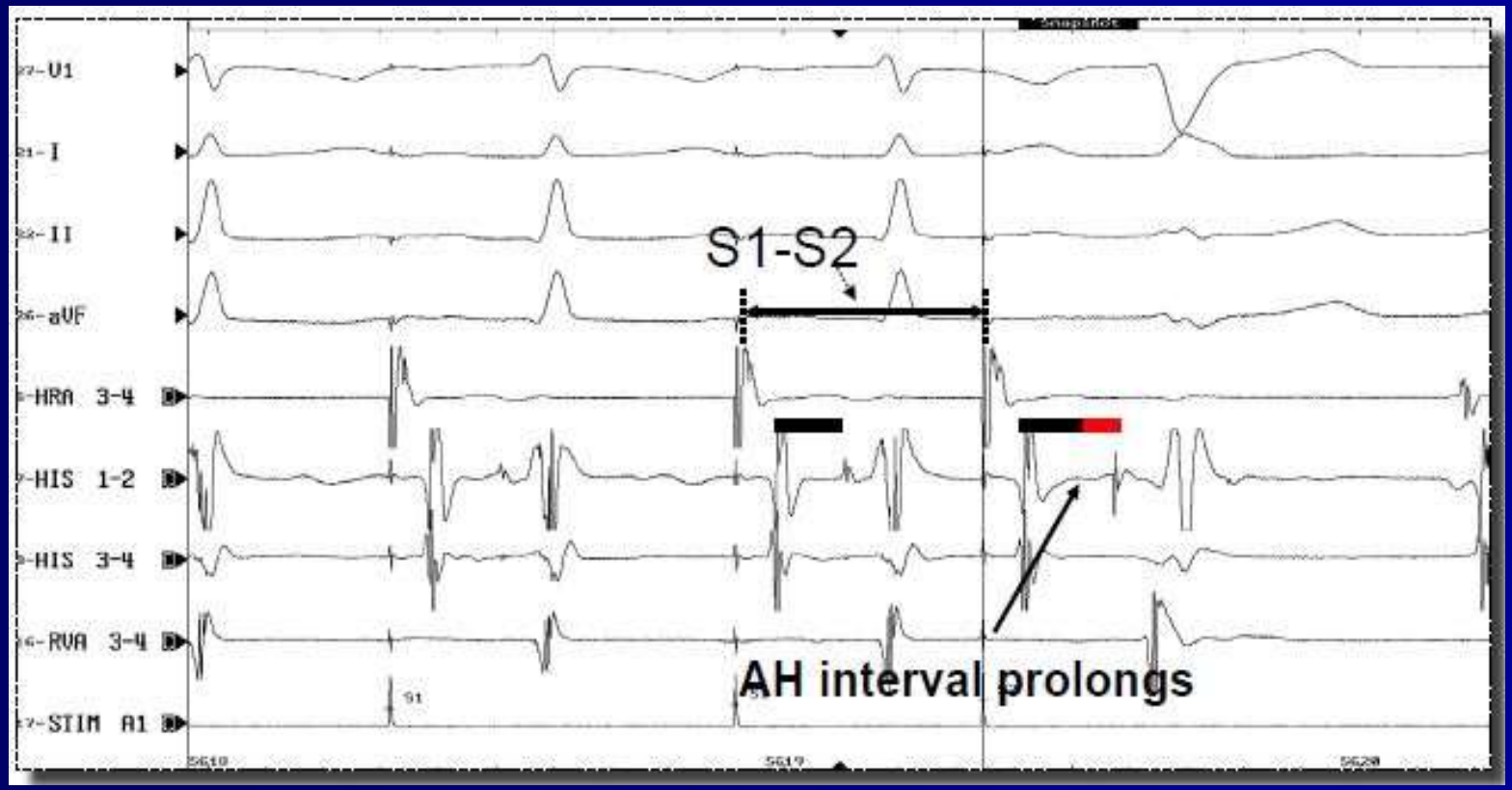


Types of Conduction

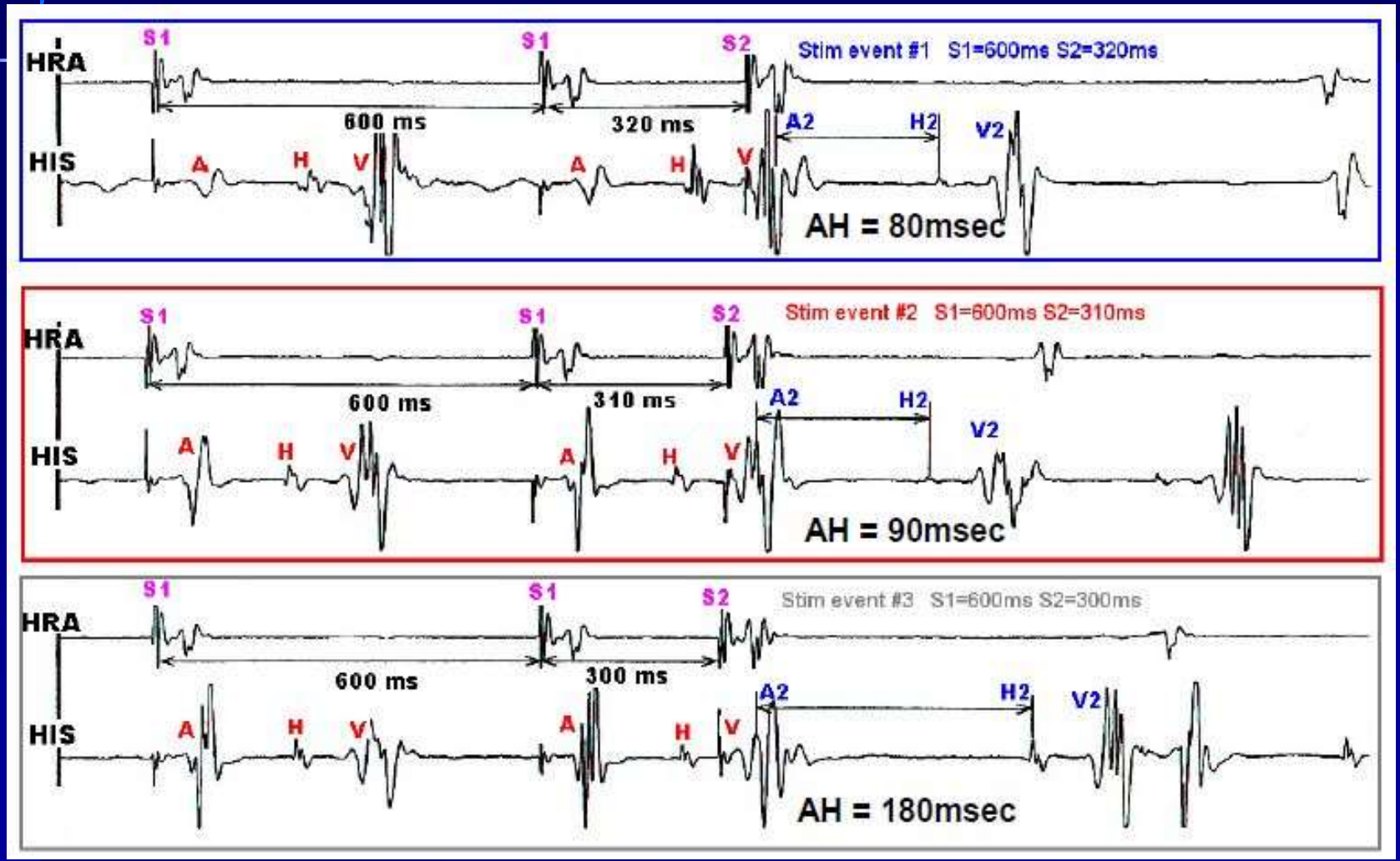
- Decremental Conduction
  - Normal nodal tissue exhibits decremental conduction
  - A propagated impulse at a progressively decreasing interval causes a progressive increase in the impulse conduction delay
- Non-decremental Conduction
  - Atrial and ventricular myocardium and most accessory pathways exhibit non-decremental conduction
  - There is no delay in the propagation of an impulse through the tissue despite an increasing prematurity of an impulse

AV Decremental Conduction

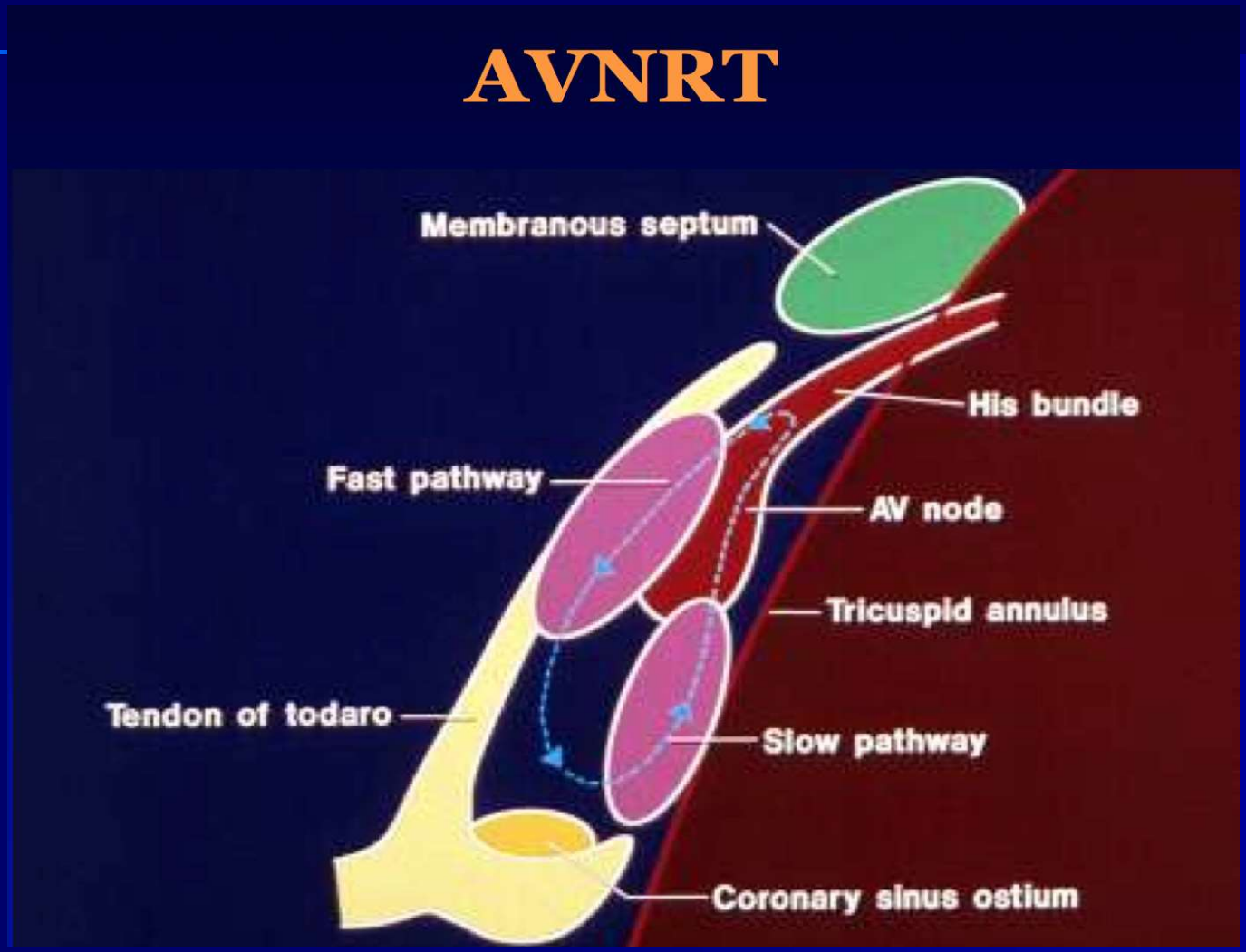
With the AV decremental property, as the pacing rate is increased, eventually the rate of conduction will progressively slow, as seen by progressively longer and longer AH intervals as the S1-S2 pacing interval is decreasaed.



AH Jump

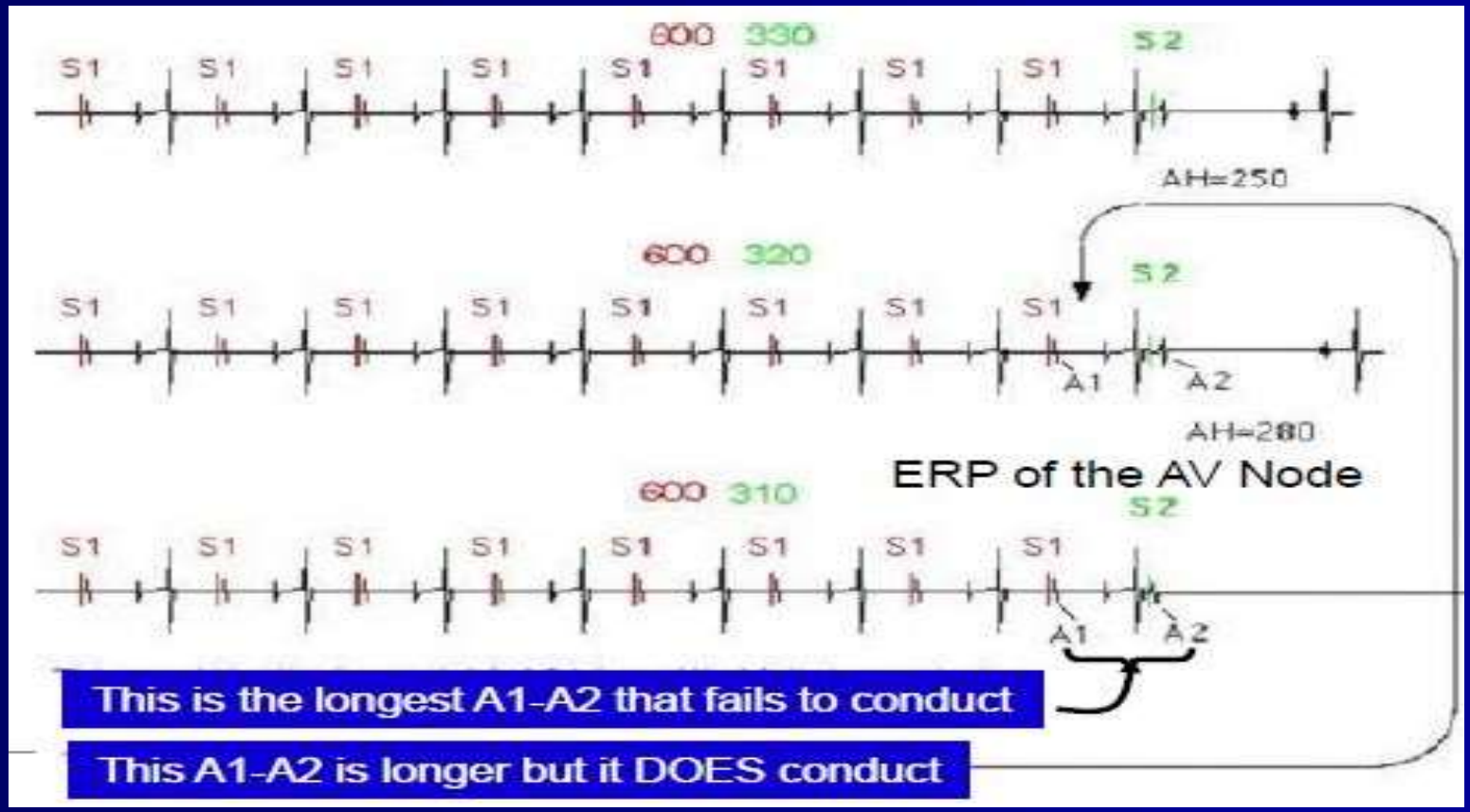

HRA
HIS
S1
S1
S2
Stim event #1 S1=600ms S2=320ms
600 ms
320 ms
A
H
V
A
H
V
A2
H2
V2
AH = 80msec
S1
S1
S2
Stim event #2 S1=600ms S2=310ms
600 ms
310 ms
A2
H2
V2
AH = 90msec
S1
S1
S2
Stim event #3 S1=600ms S2=300ms
600 ms
300 ms
A2
H2
V2
AH = 180msec

Dual AV Nodal Physiology



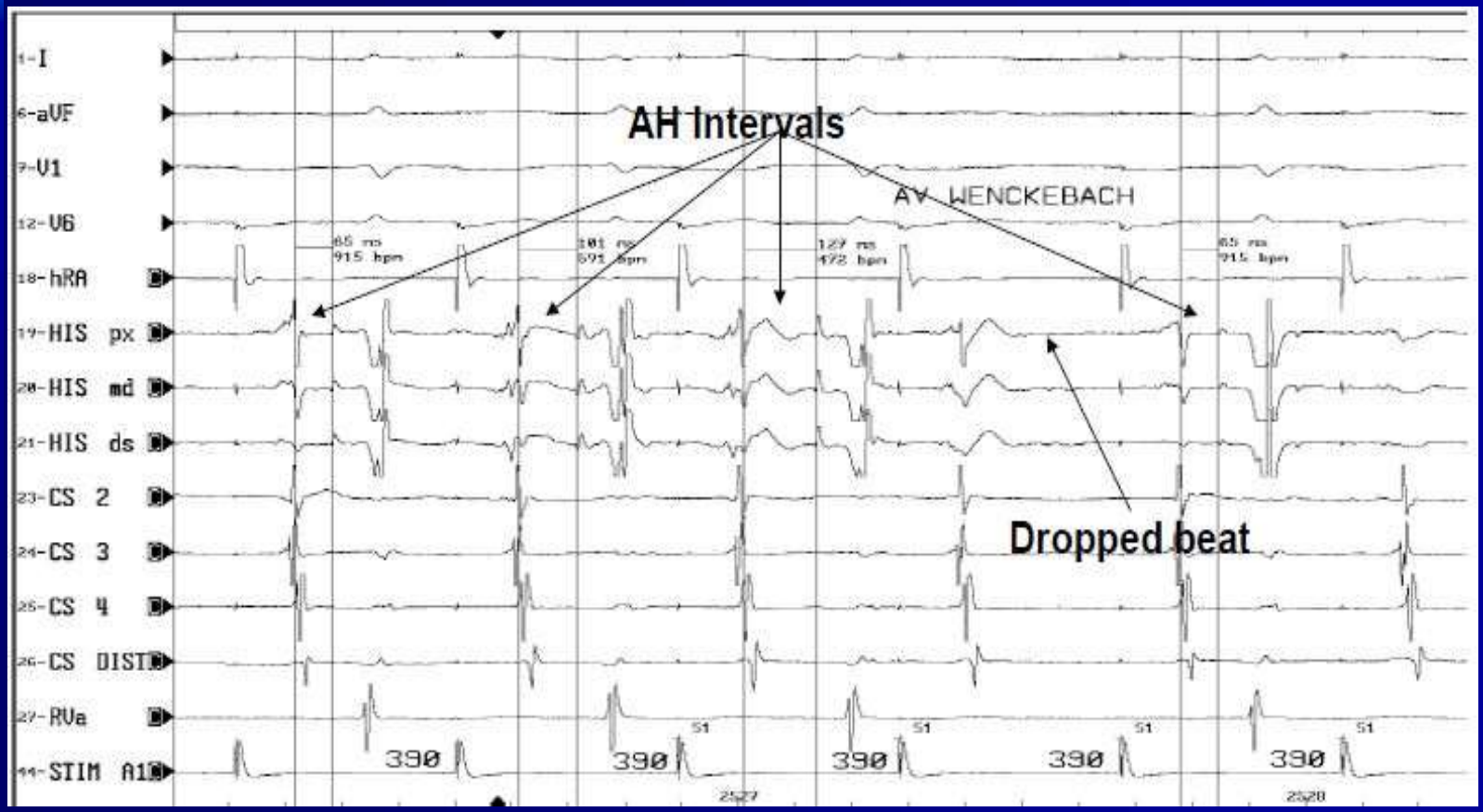
AVNERP

The ERP of the AV node is reached when conduction from the atrium to the ventricle is blocked due to reaching the refractory period of the AV nodal tissue. To identify the ERP of the AV Node a series of programmed stimulation trains are conducted to find the longest A1-A2 interval that fails to conduct to the His.



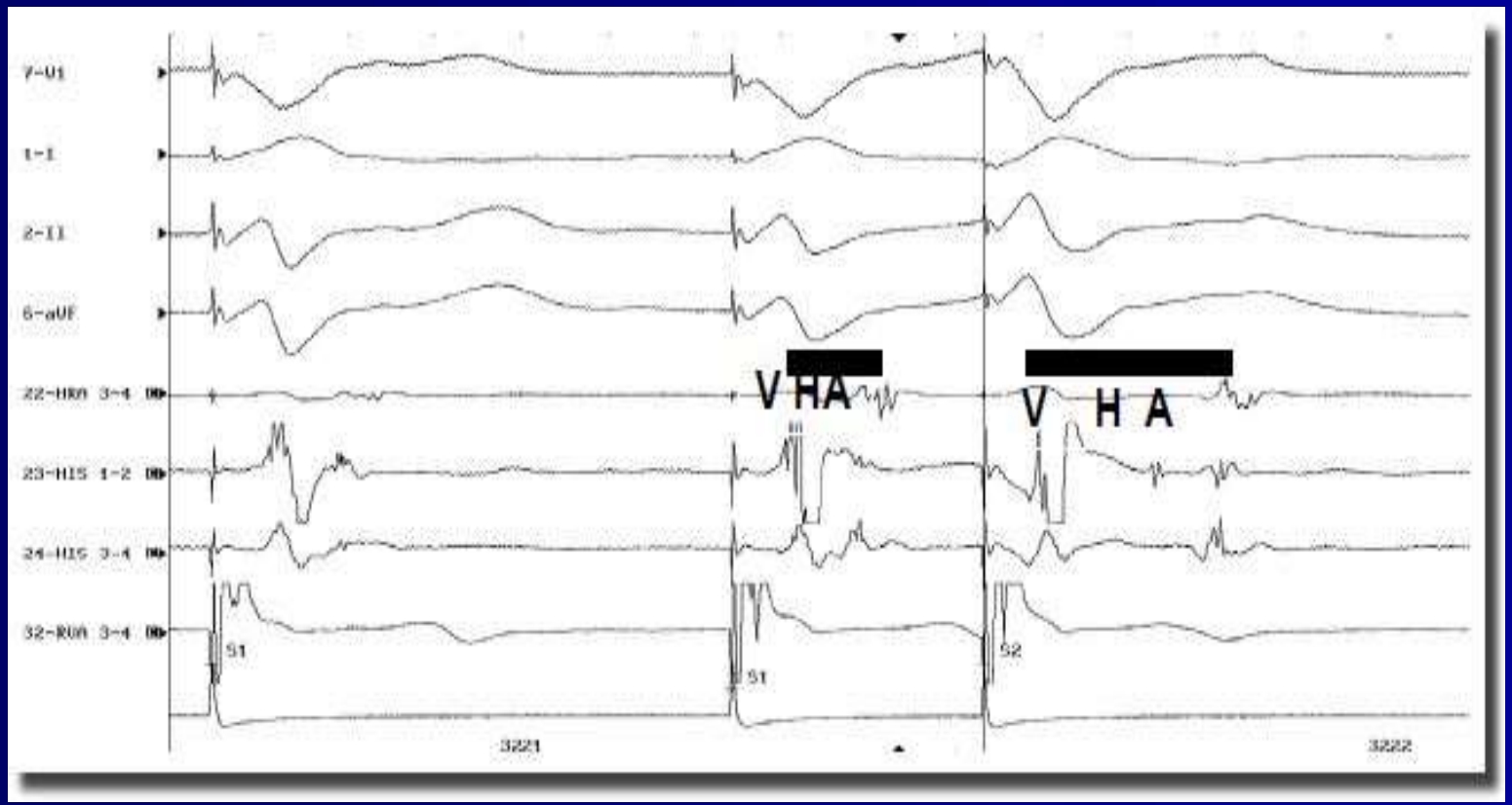
AV Wenckebach

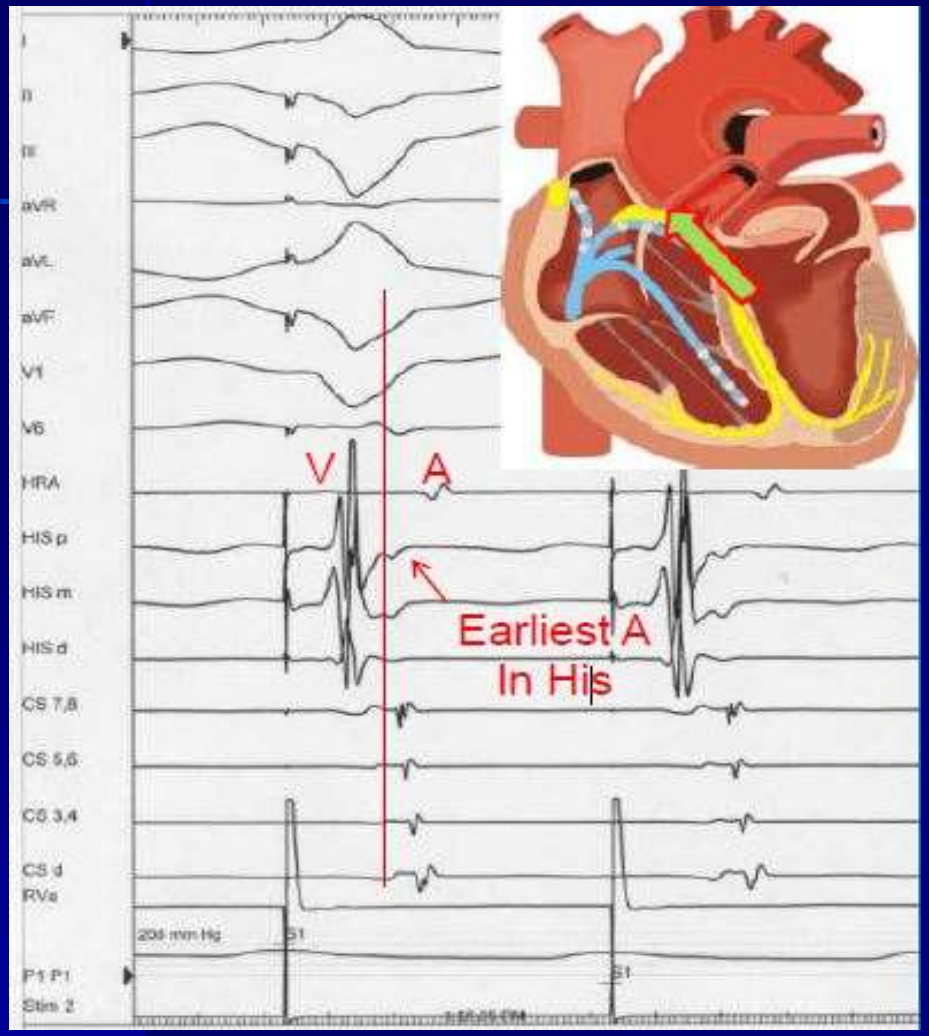
With Wenckebach there are grouped beats with gradual prolongation of the AH interval until conduction to the ventricle eventually drops. Therefore only an occasional “A” wave will not conduct to produce a “V” (see the dropped “V” above).

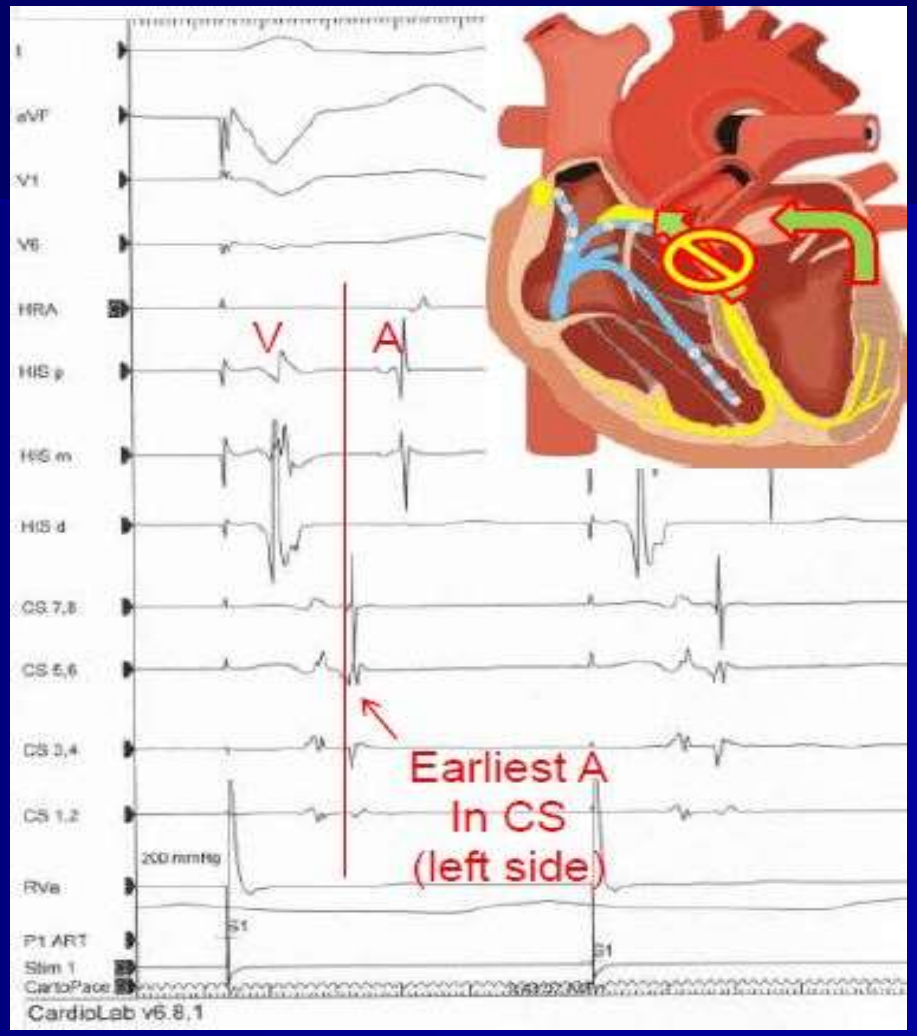


VA Decremental Conduction

Just as when you pace faster and faster from the atrium, when you pace at faster and faster rates in the ventricle, you will have decremental conduction. That is, as you pace faster and faster, the VA or HA interval will progressively prolong the faster you go.



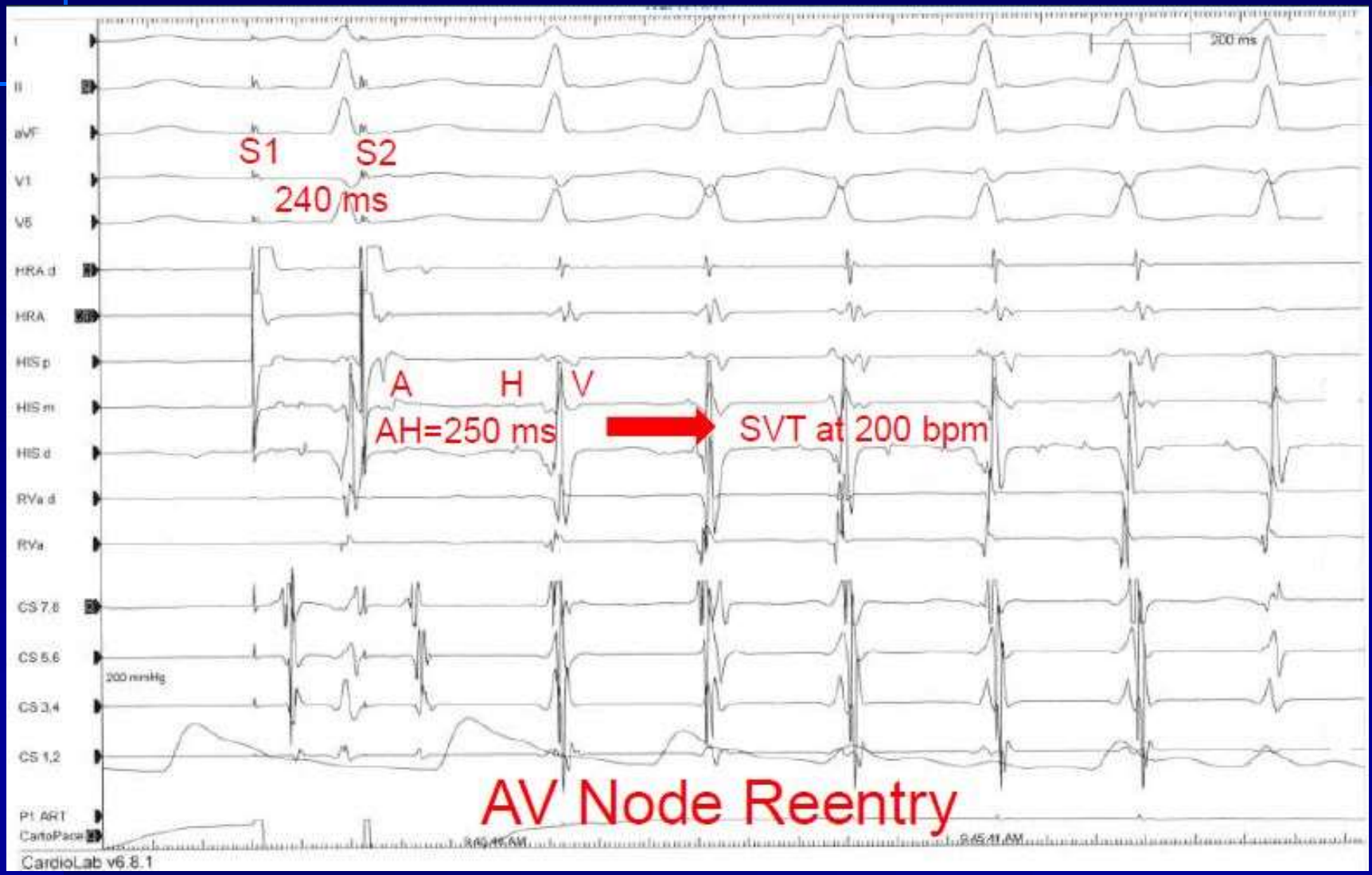




Concentric VA conduction

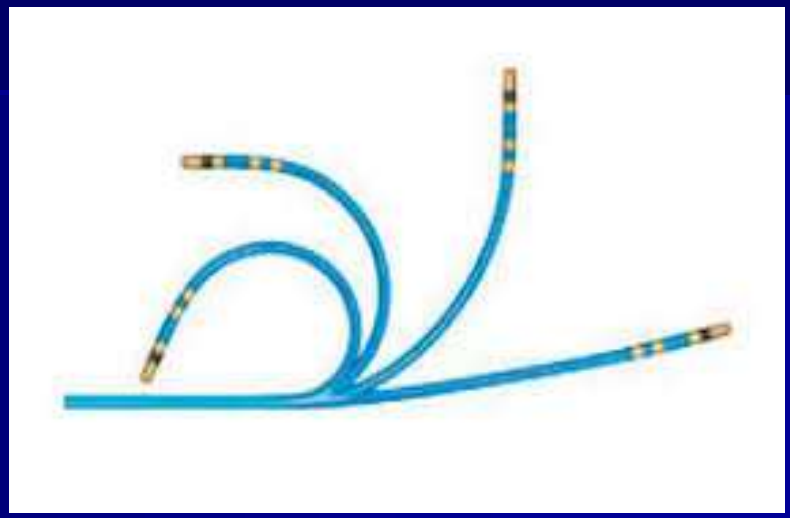
Eccentric VA conduction

Arrhythmia Induction



RF Ablation

- Standard RF
- Irrigated RF



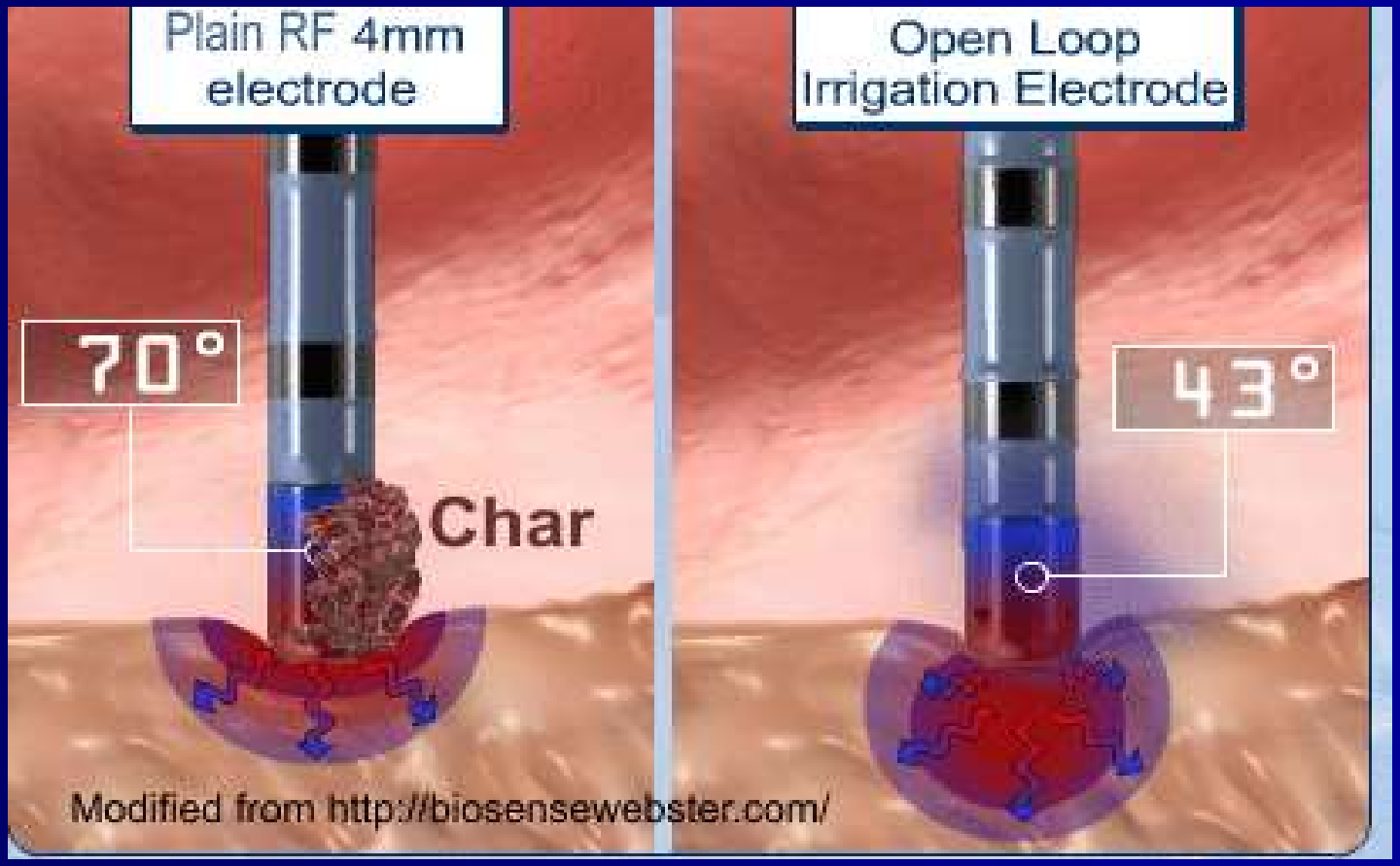
RF Temp Control

- Target around 60 degree celsius
- Each lesion 30-60s
- Power titrated to achieve target temp
- Char formation at high power (>60W)

Irrigated RF

- Power control
- Reduces surface temp
- Allows for longer duration of power delivery
- Heat generation occurs deeper within the tissue
- Creates a larger volume lesion
- AF and RV/LV ablation

Lesion Development between RF vs Irrigated RF



CryoAblation

1. Pressurized liquid N_2O is delivered from the CryoConsole through an ultrafine, robust injection tube, to the ablation segment

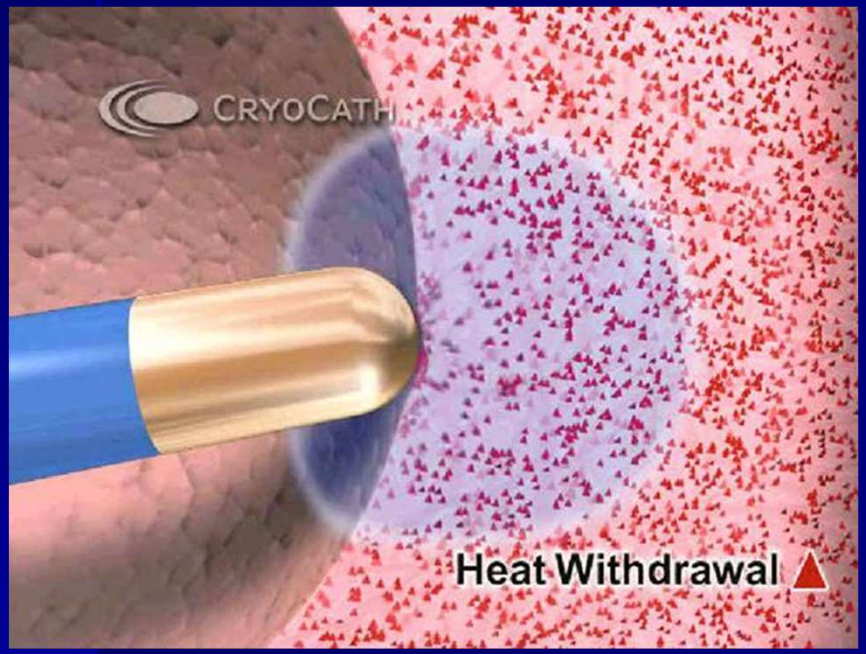
2. Inside the ablation segment, the liquid N_2O vaporizes it absorbs heat from the surrounding tissue

3. The warmed vapor is returned to the console through a lumen maintained under vacuum

4. The CryoConsole controls safe delivery of N_2O to the catheter and return of the warmed vapor. There are numerous safety systems to prevent any potential hazards

Basic Cryo and RF Biophysics

Cryo removes heat from the tissue



Coldest temperature is at tip/tissue interface

RF add heat to the tissue

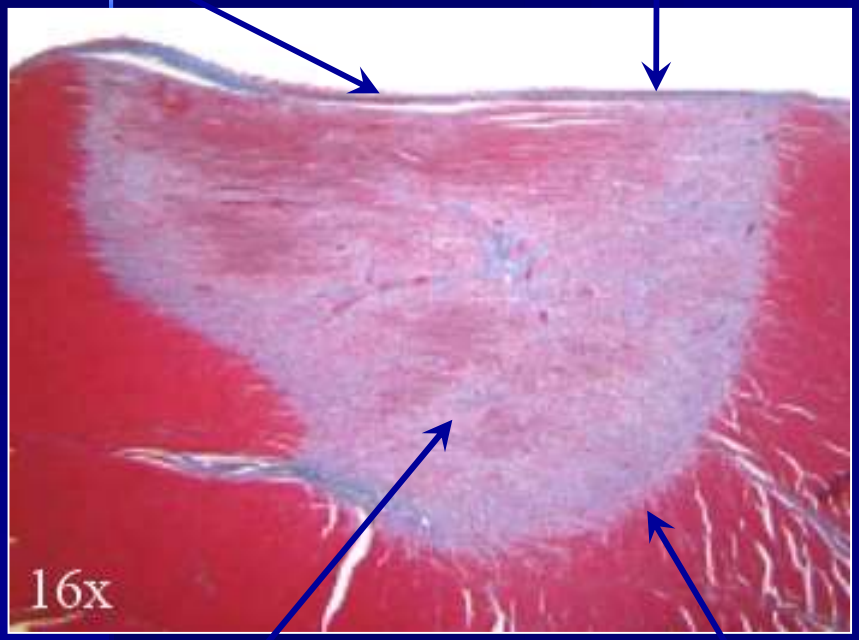
Hottest temperature is a few mm below the tip/tissue interface

Lesion Histology

Cryo

Minimal Thrombus

Endocardium Intact



Fibrosis Complete

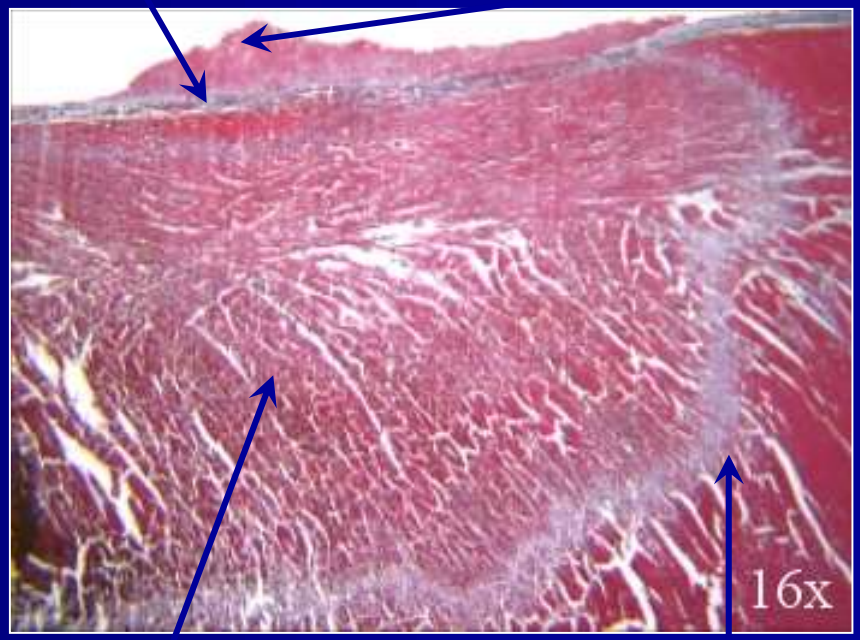
Well Demarcated

Cryolesion at 1 Week (canine model)
-75°C • 1 x 4 minutes

RF

Disrupted Endocardium

Thrombus Present



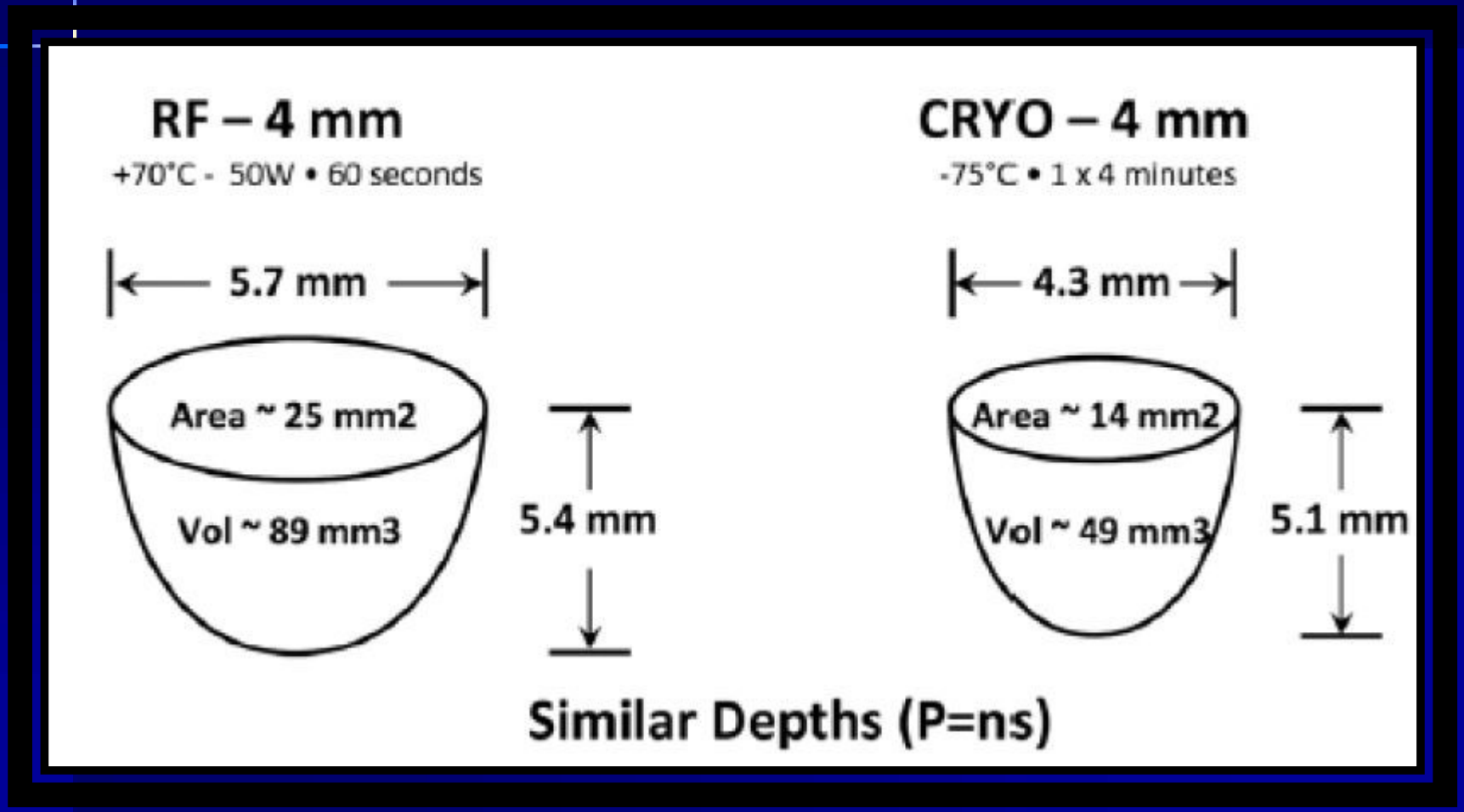
Hemorrhage Still Present

Fibrosis Started

RF Lesion at 1 Week (canine model)
+70°C • 50 W • 60 seconds

Khairy, Paul, et al. Circulation 2003

Cryoablation: A More Accurate Lesion Placement

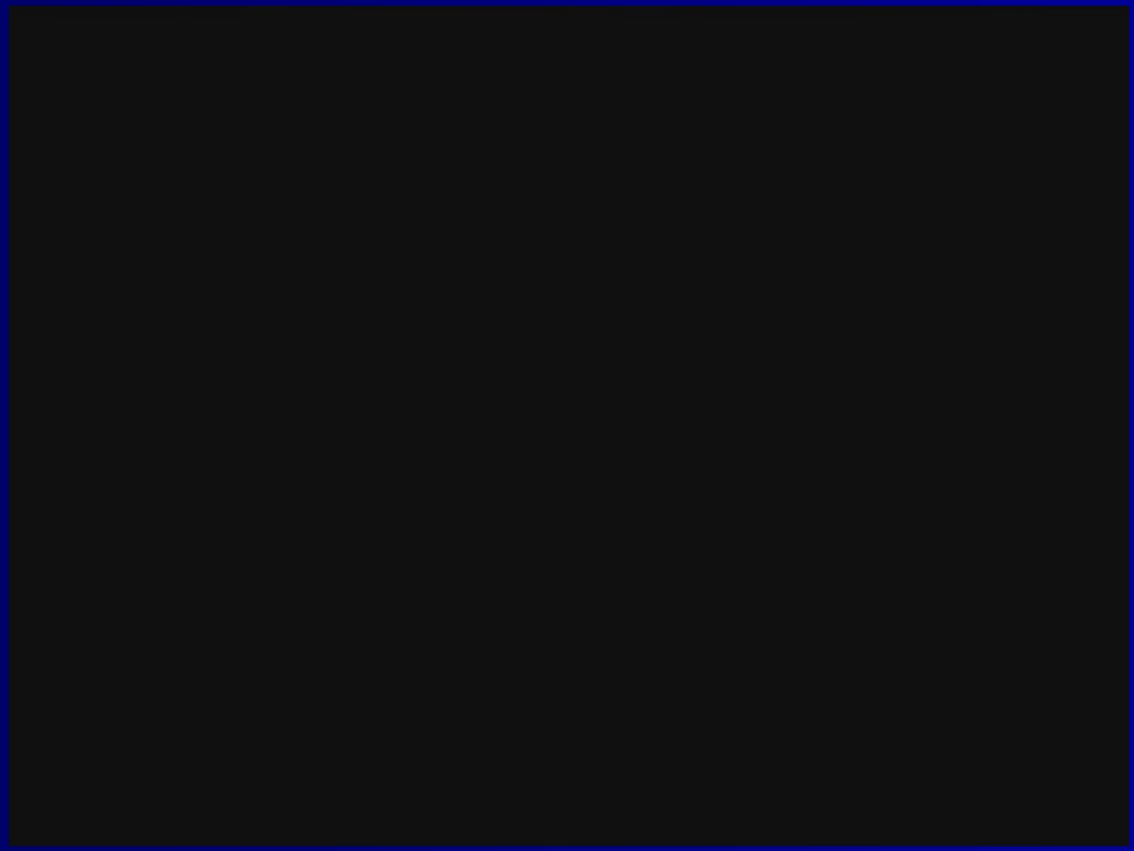


Andrade, et al. Circ Arrhythm Electrophysiol 2013

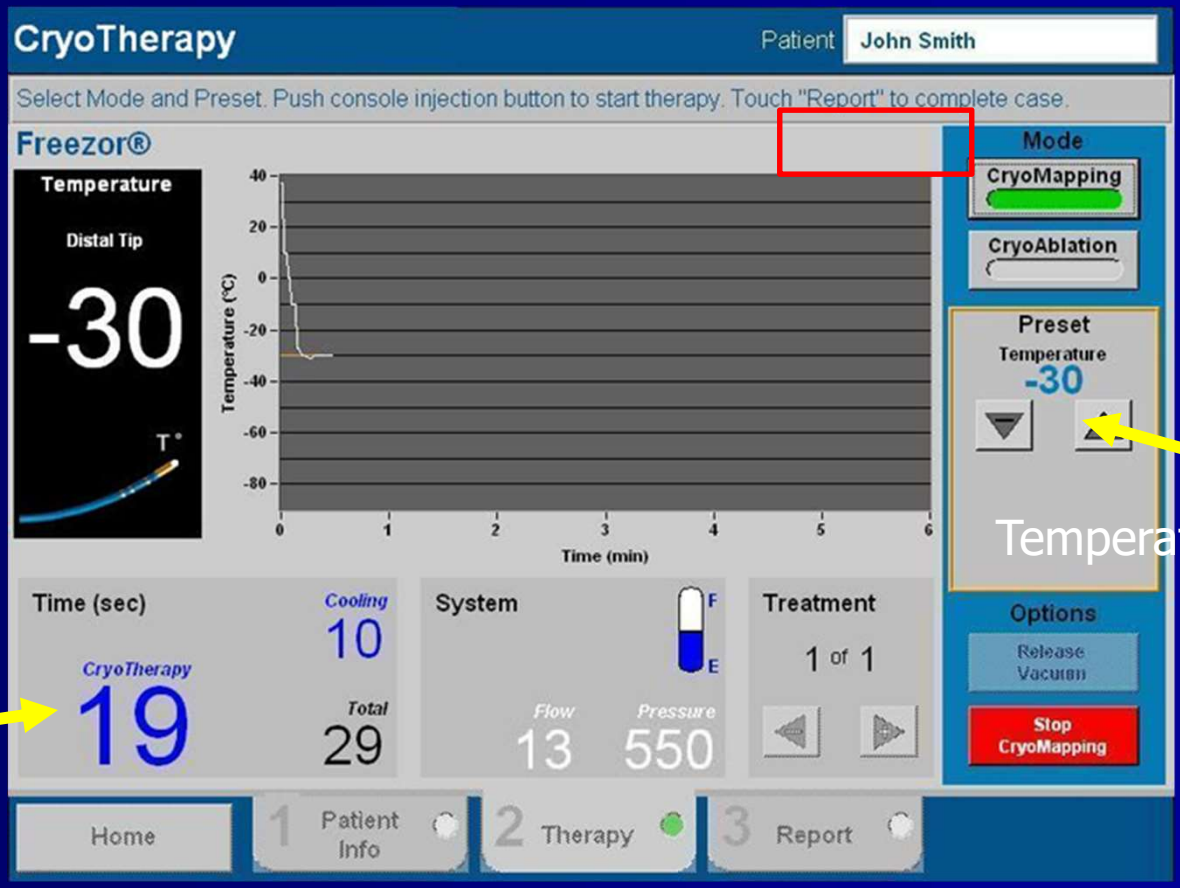
Advantages of Cryoablation

- Cryoadhesion: catheter tip firmly attaches to the endocardium upon freezing → catheter stability
- Cryomapping: -30°C, reversible damage → for precise site testing and avoid complication

CryoAdhesion



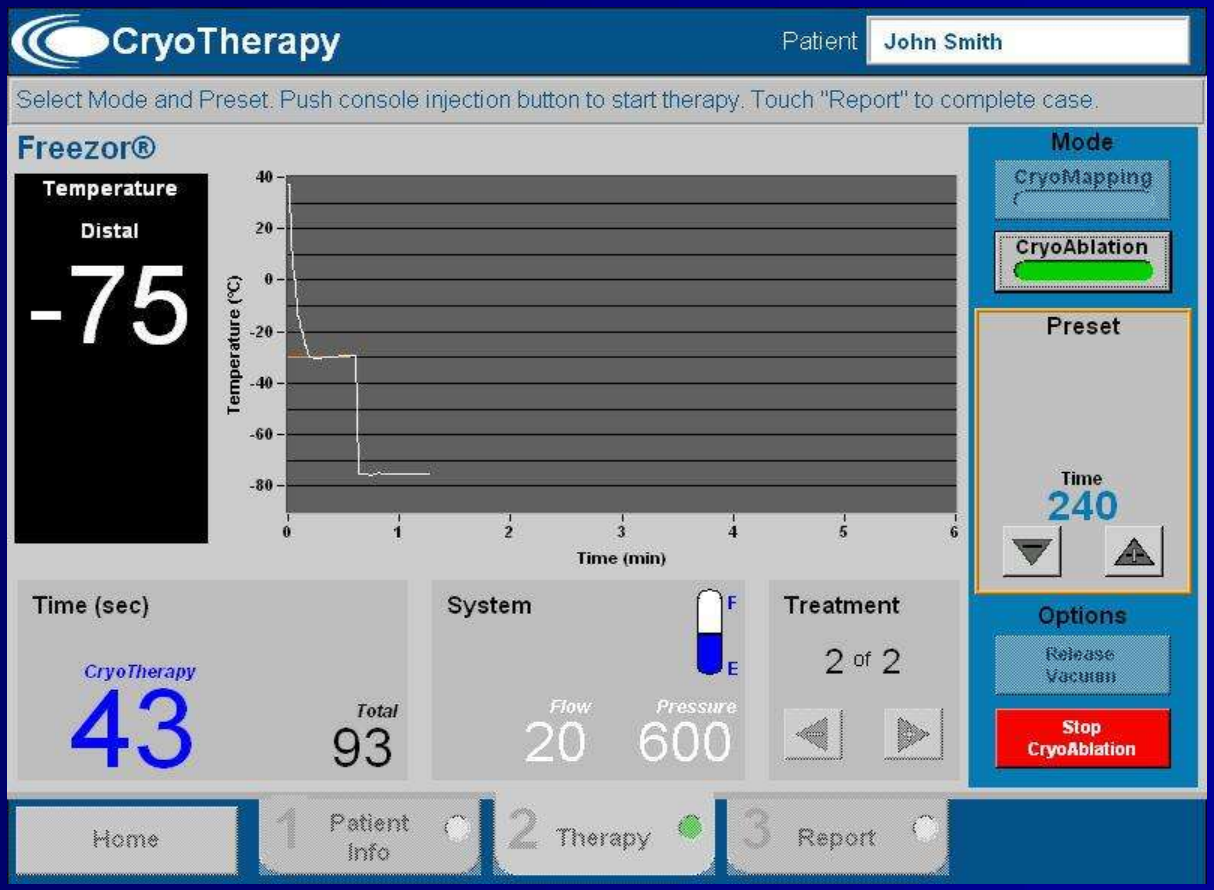
CryoMapping Operation



60s Timer

Temperature Control

CryoAblation Operation



Thank you!