

# Entrainment and Resetting of VT

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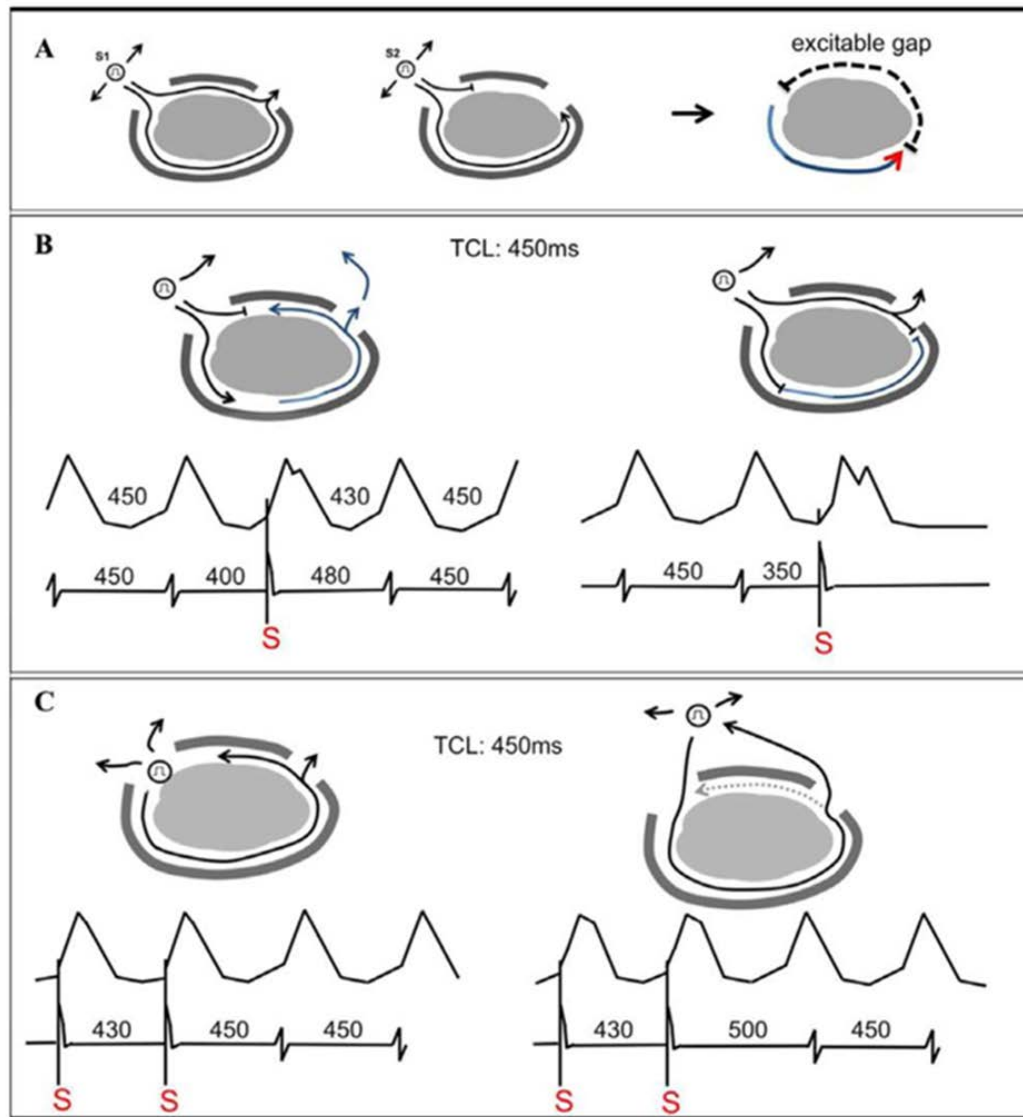
# Definition

- Resetting and entrainment are specific responses to the introduction of 1 or more stimuli during re-entrant tachycardia.
- In 1977, Waldo et al, observed that a critical rate of pacing was required to terminate atrial flutter.
- At lower rates of pacing, continuation of the arrhythmia occurred immediately after cessation of pacing.

# Definition

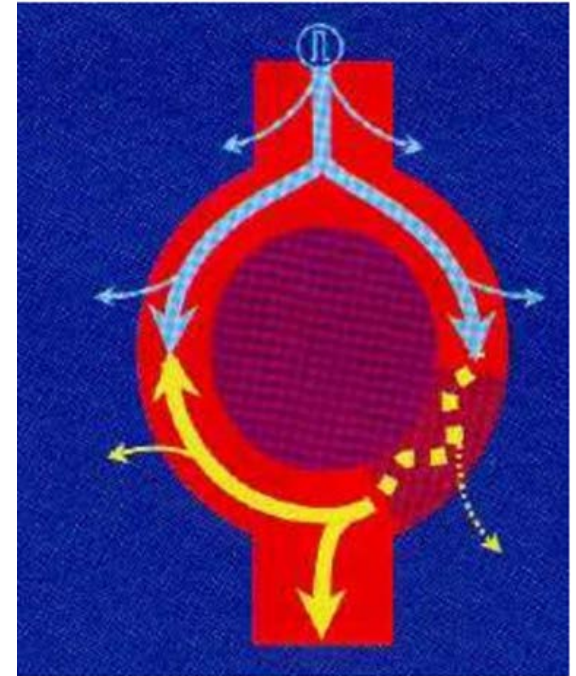
- Resetting
  - advancement in timing of a tachycardia cycles as a result of a premature stimulus
- Entrainment
  - Continuous resetting of a tachycardia by overdrive pacing, typically in the presence of fusion

# Re-entry, reset and entrainment

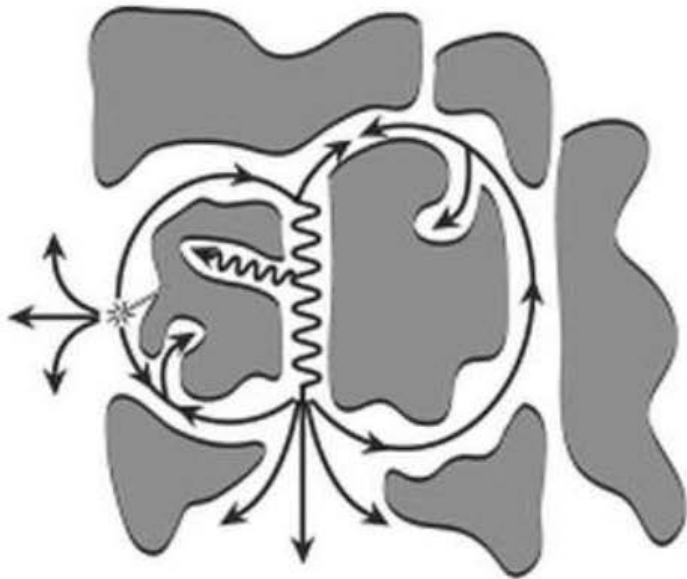


# Prerequisites for Entrainment

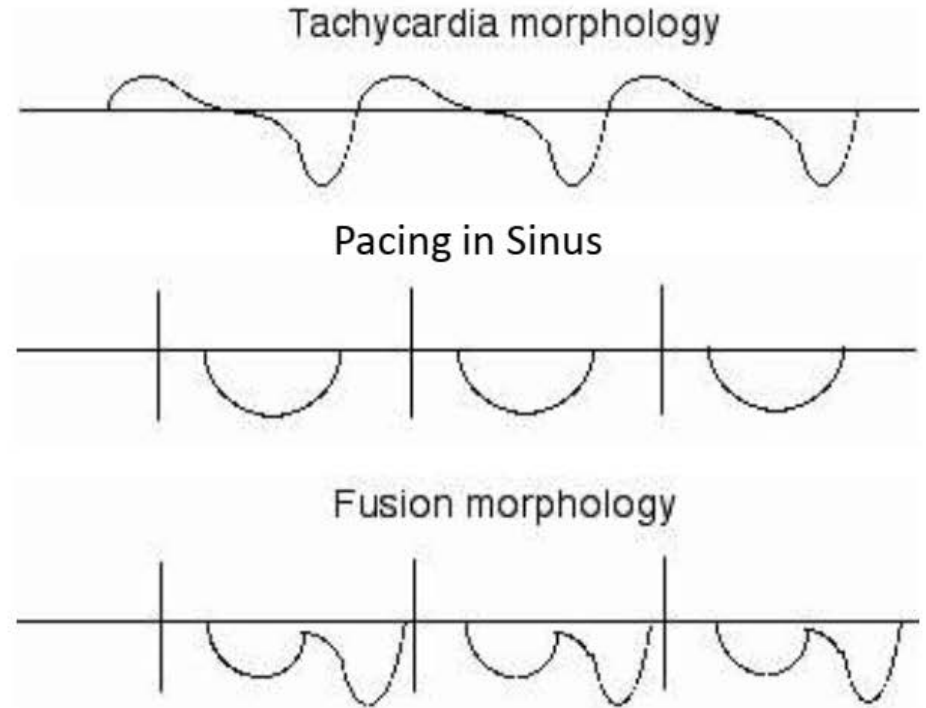
- Gap of excitability is present during tachycardia
  - Time interval between the tail of refractoriness of the last tachycardia impulse and the time of arrival of the next tachycardia impulse during which stim could be delivered.
- The site of origin of tachycardia must not be protected by entrance block.
- The paced impulses entering the site of origin must be able to accelerate the tachycardia rate to the pacing rate.
- The paced impulses should not result in termination of tachycardia.



# Manifest Fusion Morphology



Outer Loop

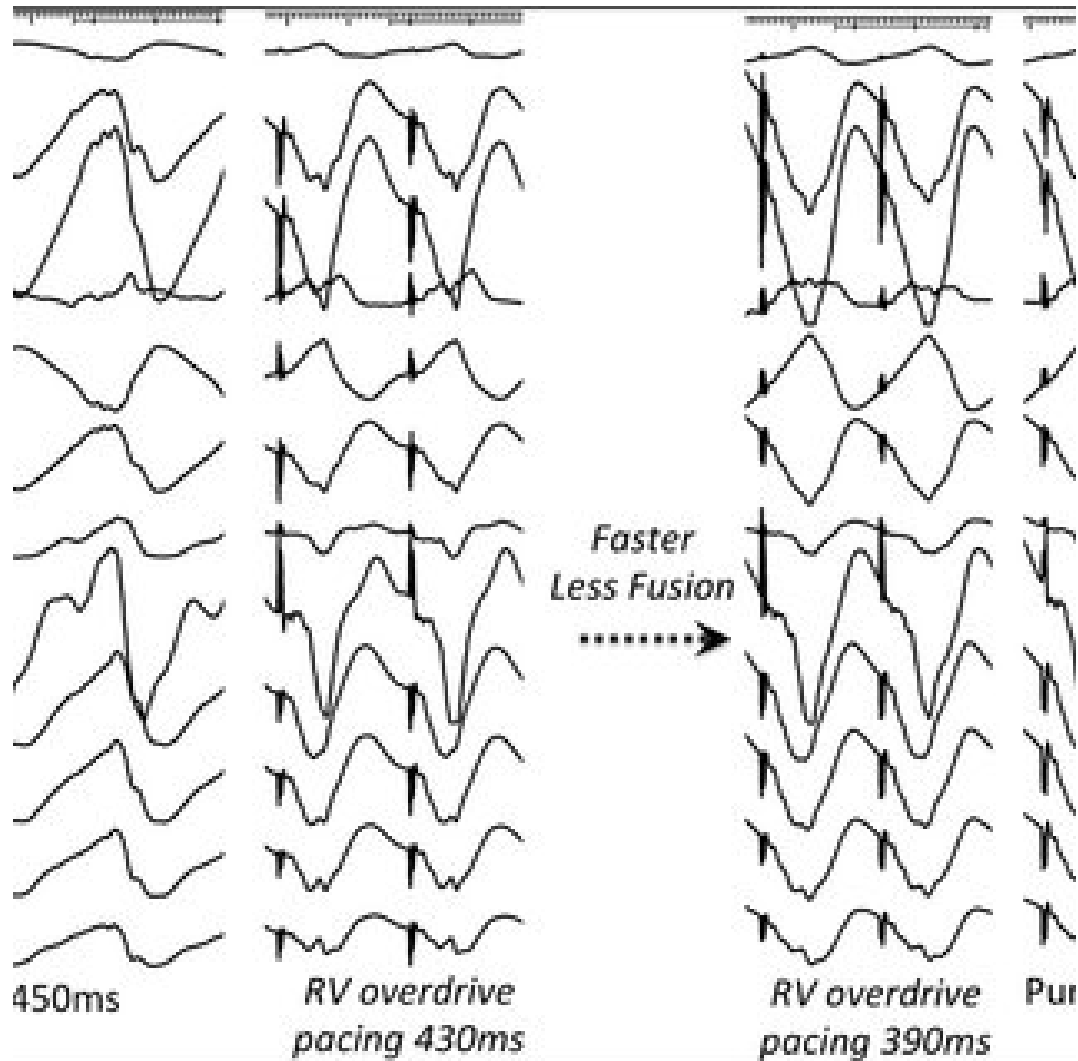


***Pacing stimuli captures myocardium outside the reentrant circuit resulting in different paced and Tachy complexes***

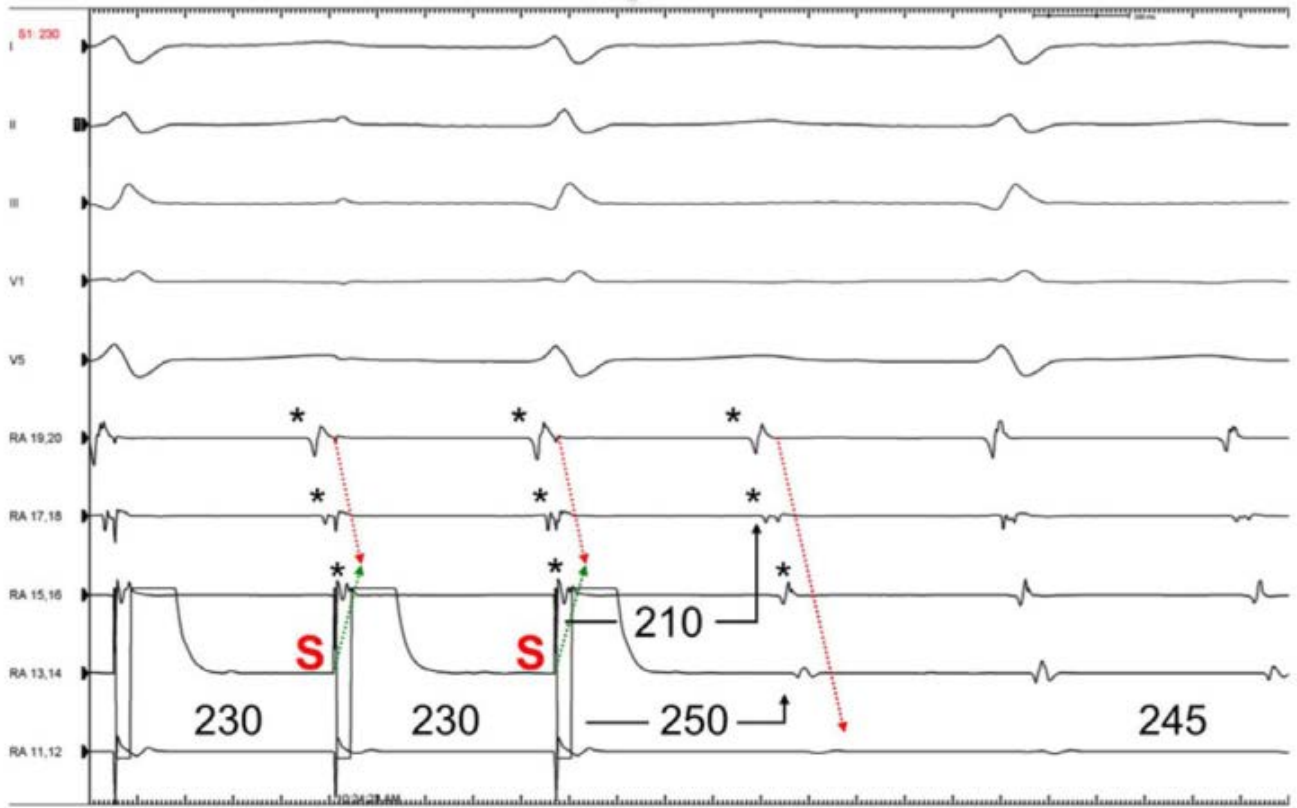
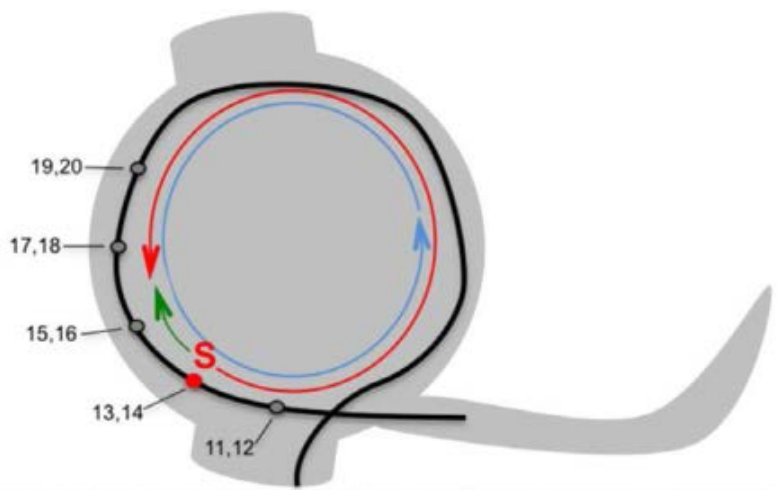
# Criteria establishing Entrainment

- I. During pacing at constant rates faster than the tachycardia, any of the following indicate entrainment
  1. Constant QRS fusion except for the last captured beat, which is entrained but not fused
    - Fused QRS complexes in the case of VT
    - Fused P waves in atrial tachycardia/flutter
  2. Progressive fusion
    - (A) The degree of constant fusion in the ECG is different for different pacing rates.
    - (B) The electrogram recorded at a site separate from the pacing site has a different stimulus to electrogram interval and electrogram morphology at two different pacing rates.
  3. Interruption of re-entry occurs with localized conduction block to one electrogram recording site followed by activation of the site after a shorter conduction time from the stimulus site.

# Progressive fusion



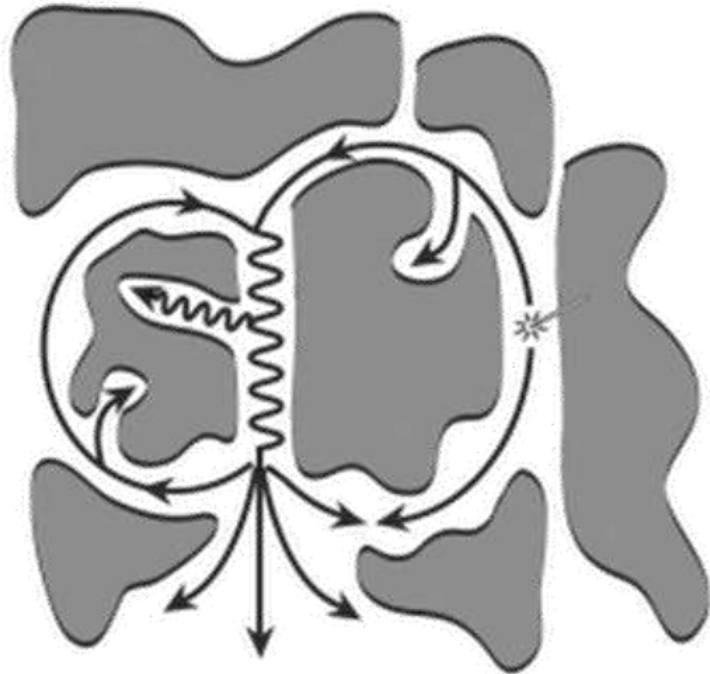




# Types of Entrainment

- Entrainment with Fusion:
  - QRS fusion is seen on the EKG
- Entrainment with Concealed Fusion:
  - Paced QRS is identical to that of the tachycardia during entrainment
- Concealed Entrainment:
  - QRS is identical to the paced morphology in the absence of tachycardia

# Concealed Entrainment Morphology

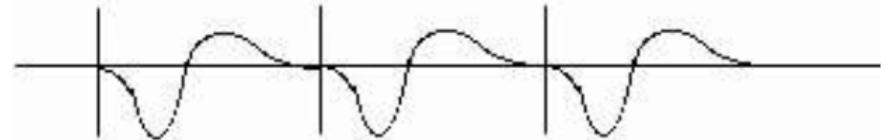


Inner Loop

Tachycardia morphology



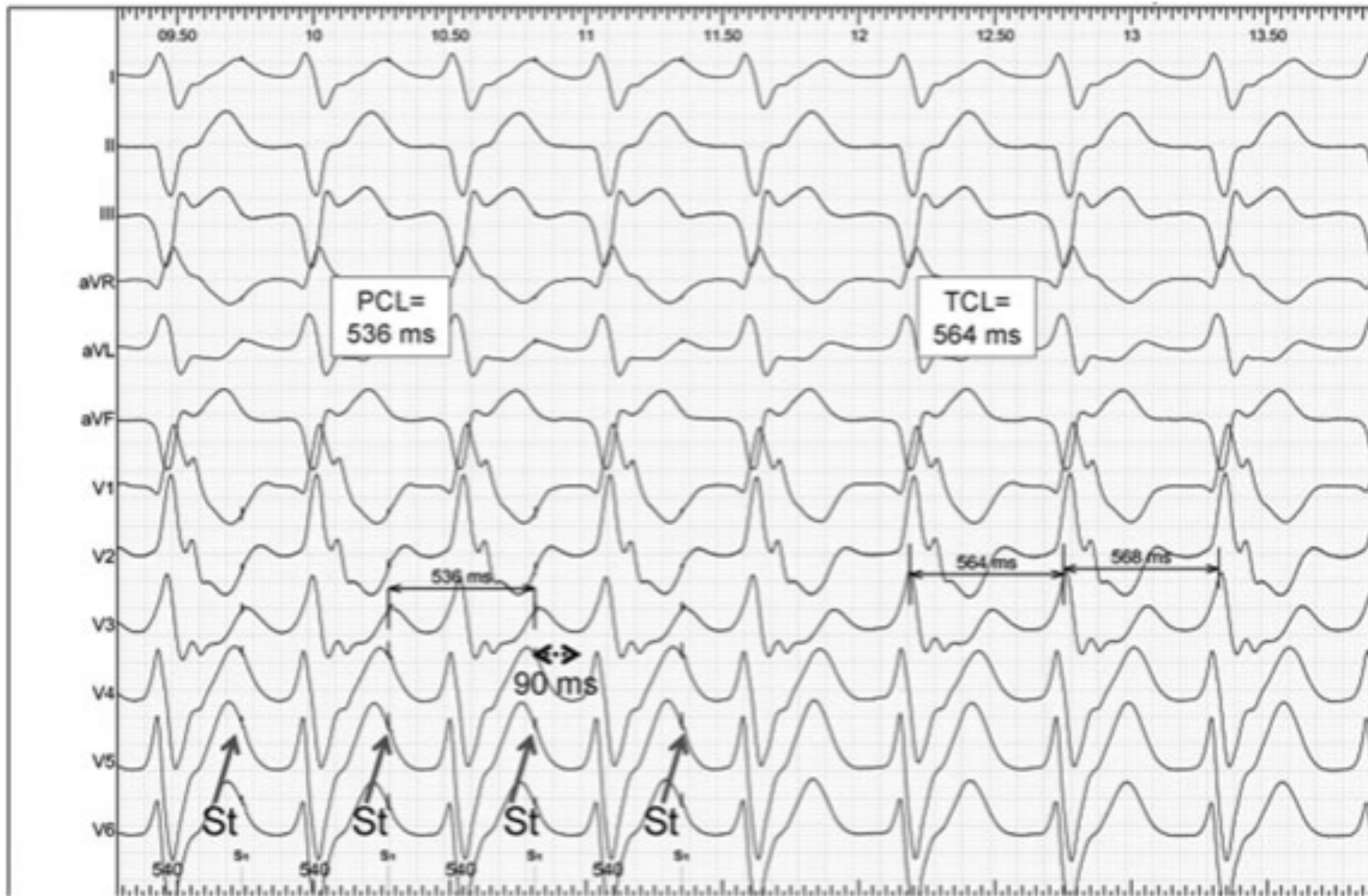
Concealed Entrainment morphology



## *Entrainment from a Inner Loop site*

1. Orthodromic Wavefront and Antidromic Stimulated wave front collide upstream.
2. Orthodromic activation of the isthmus and exit site produces identical paced and e.g. VT morphology (concealed Fusion)
3. PPI = TCL

# Examples of concealed entrainment

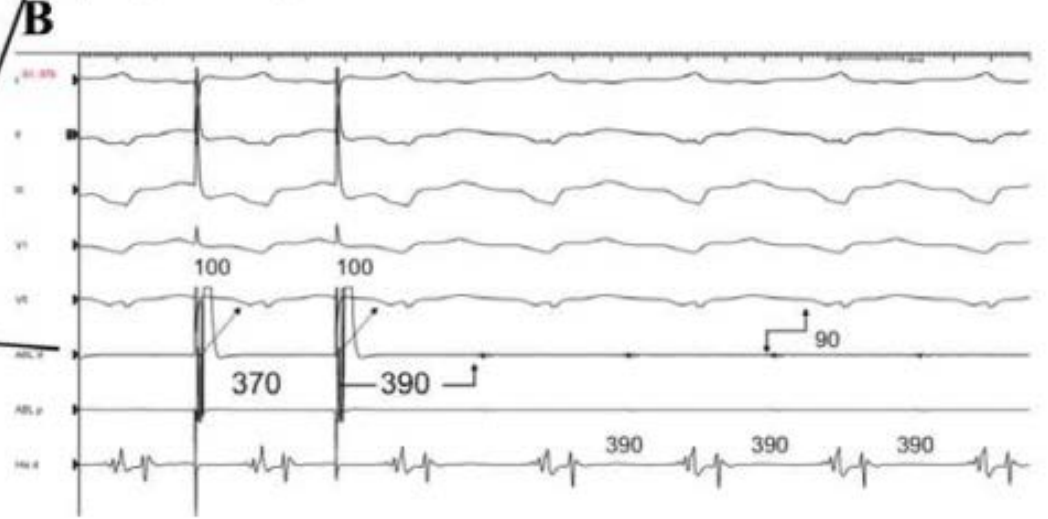
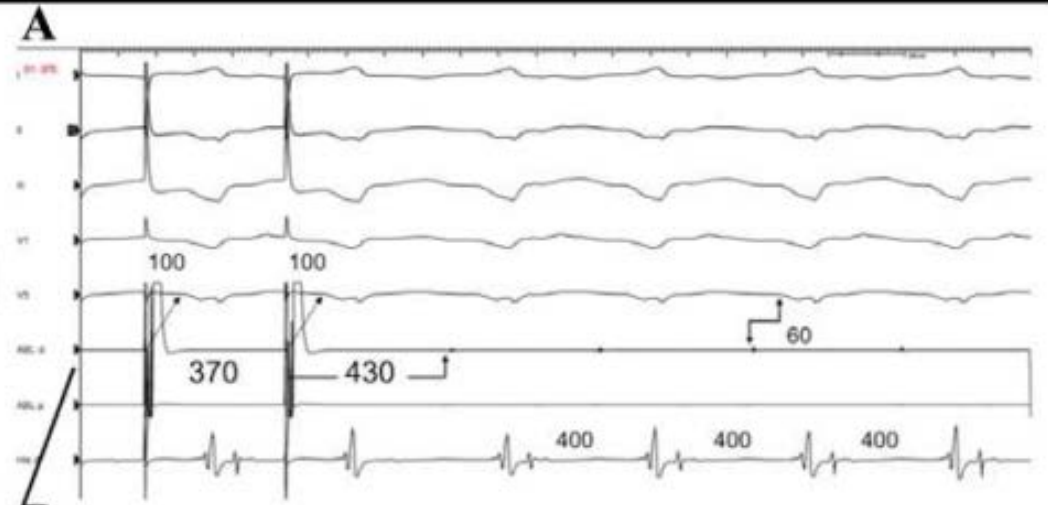
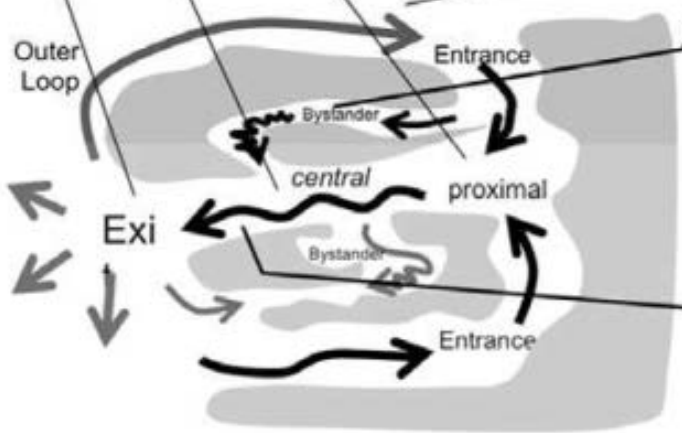
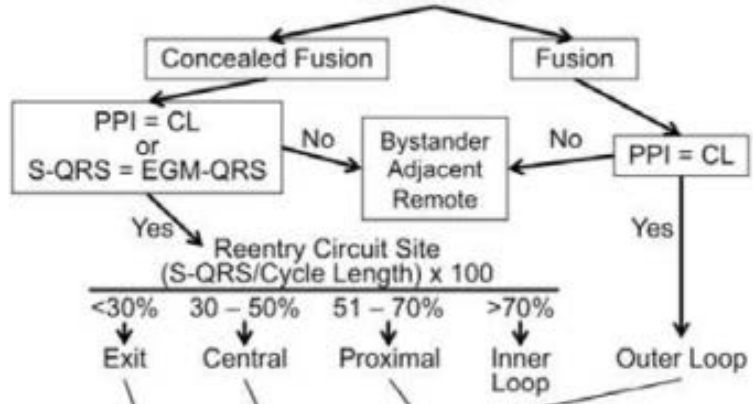


# Determining Pacing Site

How to Determine if the Pacing Site is Within the Circuit

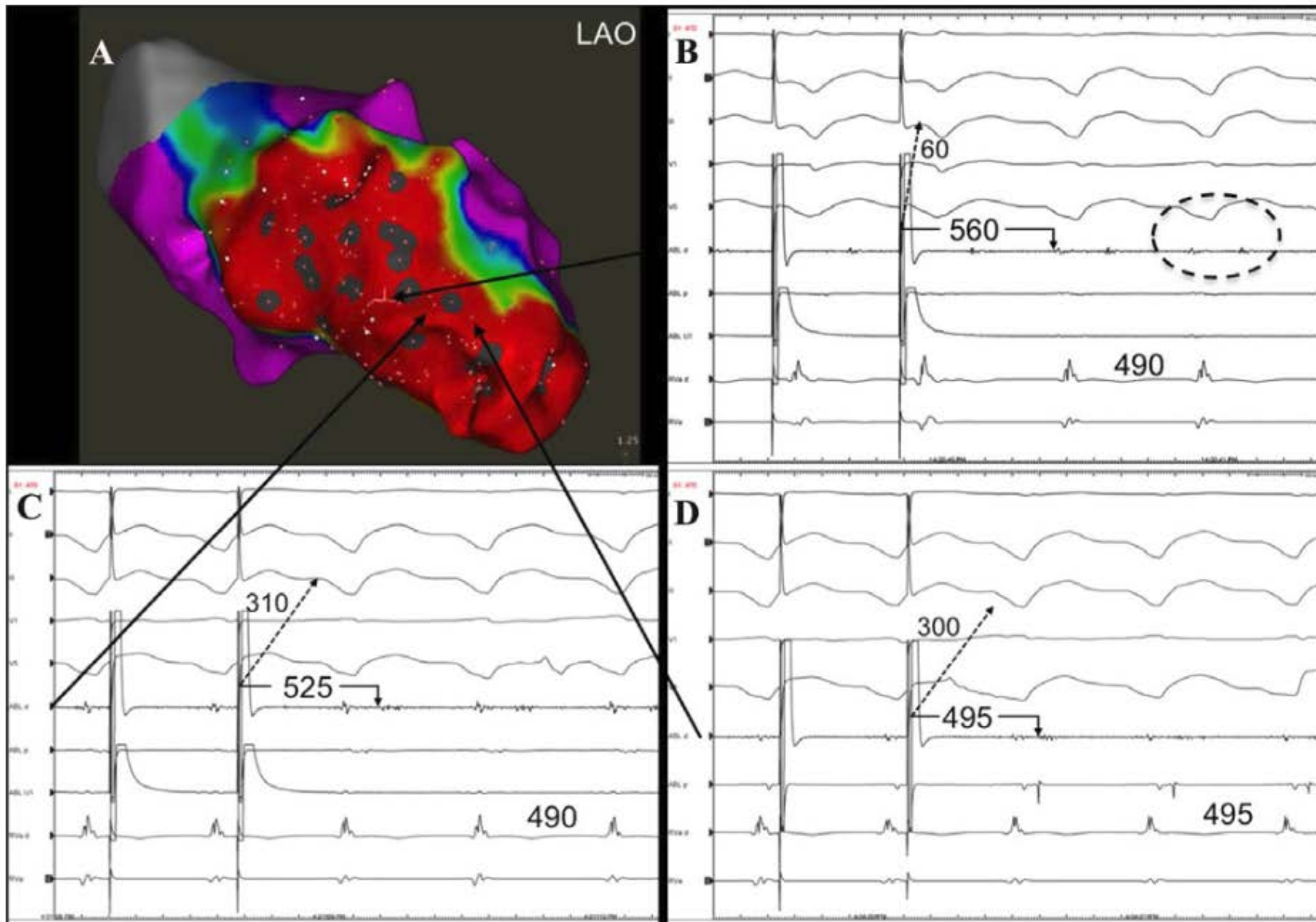
- Post Pacing Interval (PPI)
- QRS Configuration during Entrainment
- S-QRS Interval During Entrainment with Concealed Fusion

## Map Site Classification



# How to perform VT entrainment mapping

- QRS morphology of VT - exit site from isthmus
- Combination of substrate, activation and entrainment mapping for VT
  - Voltage map of scar
  - Pace-mapping during 3D geometry to find QRS morphology resemble VT
  - Usually, exit site is near the low voltage border, the S-QRS is typically <40 milliseconds.
  - place the catheter at a potential isthmus site proximal to the exit region and then initiate VT with programmed stimulation -> immediately pace for entrainment -> assessment of concealed fusion, PPI and S-QRS for exit site





# Limitation and Pitfall of entrainment mapping

- Easily inducible and hemodynamically stable during VT
- Unable to reliably capture with a fixed relationship of stimulus to EGMs.
- Non-local recording and non-local stimulation – particularly with large interelectrode distance and/or large tip electrode.
- Contact with tissue generating signal.
- Obscuring EGM by pacing artifact.
- Termination/change during pacing.
- High current produces non-local stimulation (enlarged virtual electrode).

# Summary

- Entrainment mapping and activation mapping is complimentary for VT ablation.
- systematic approach to the interpretation of pacing maneuvers and to be aware of the limitations and potential factors that can lead to erroneous inferences when these methods are applied for mapping.