Mechanisms and Ablation of Accessory Pathways

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Consulting:
- Biosense Webster
- Boston Scientific
- Spectrum Dynamics
- VytronUS
- ACT

Lecture Honoraria:
- Biosense Webster
- Boston Scientific
- AtriCure
- Biotronik
- St Jude Medical
RF Ablation Electrode Above the Mitral Leaflet

Canine Heart

Transeptal Catheter
RF Ablation Electrode Above the Mitral Leaflet

Canine Heart

Transeptal Catheter

RF Lesion Includes the Epicardial Surface of LV
Ablation Lesions Are Effective

Key: Localize the Access Pathway

RF Ablation Electrode Above the Mitral Leaflet

RF Lesion Includes the Epicardial Surface of LV

Canine Heart

Transeptal Catheter

Ablation Lesions Are Effective

Key: Localize the Access Pathway
Traditional Ablation Targets for Accessory Pathways

Assumption:
APs Cross the AV Groove Perpendicular to the Annulus
Traditional Ablation Targets for Accessory Pathways
Traditional Ablation Targets for Accessory Pathways

Localization
Earliest Ventricular Activation
Traditional Ablation Targets for Accessory Pathways

- **Localization**
- Earliest Ventricular Activation
- Shortest Local A-V Interval

Diagram:
- A
- AP
- V

Earliest Ventricular Activation
Shortest Local A-V Interval
Traditional Ablation Targets for Accessory Pathways

Localization
Earliest Ventricular Activation
Shortest Local A-V Interval

Earliest Ventricular Activation
Shortest Local A-V Interval
Traditional Ablation Targets for Accessory Pathways

Localization

Earliest Ventricular Activation
Shortest Local A-V Interval

Earliest Atrial Activation
Traditional Ablation Targets for Accessory Pathways

**Localization**
- Earliest Ventricular Activation
- Shortest Local A-V Interval

**Earliest Atrial Activation**
- Shortest Local V-A Interval
Traditional Ablation Targets for Accessory Pathways

Localization
Earliest Ventricular Activation
Shortest Local A-V Interval

Earliest Atrial Activation
Shortest Local V-A Interval
Earliest Ventricular Activation
Shortest Local A-V Interval

Localization
Earliest Ventricular Activation
Shortest Local A-V Interval

Earliest Atrial Activation
Shortest Local V-A Interval

Early Studies (1990’s)
Earliest Vent Activ or Earliest Retro Atrial Activ: Only 50% Success
Traditional Ablation Targets for Accessory Pathways

Earliest Ventricular Activation

- Shortest Local A-V Interval
  - Not at Location of AP

Earliest Atrial Activation

- Shortest Local V-A Interval
  - Not at Location of AP

Early Studies (1990’s)
Earliest Vent Activ or Earliest Retro Atrial Activ: Only 50% Success
Traditional Ablation Targets for Accessory Pathways

Assumption:
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Traditional Ablation Targets for Accessory Pathways

Assumption:
APs Cross the AV Groove Perpendicular to the Annulus

Oblique Course
Left Posterior Accessory AV Pathway

Section Through the Mitral Annulus

Trichrome Stain

Courtesy Prof Anton Becker
Orientation of Left Atrial Myocardial Fibers

Tricuspid Annulus

HB

Mitral Annulus

CS

Great Cardiac Vein

LAO Projection
Orientation of Left Free-Wall Accessory Pathways

- Tricuspid Annulus
- Mitral Annulus
- Great Cardiac Vein
- HB
- LAO Projection
- CS
- Orientation of Left Free-Wall Accessory Pathways
- A
- V
Oblique Course of Accessory Pathways

Left Free Wall Accessory Pathway
(Epicardial View)
Oblique Course of Accessory Pathways

- Left Free Wall Accessory Pathway
  (Epicardial View)
- Atrial Insertion
- Ventricular Insertion
- Septal
- AP
- Lateral
- Atrium
- Ventricle
Oblique Course of Accessory Pathways

Tricuspid Annulus
Mitral Annulus
Atrial Insertion
Lateral or Anterior

Septal
Ventricular Insertion
Septal or Posterior

Atrium

AP

Ventricle

Lateral

V

A

Mitral Annulus

HB

Atrium

AP

Lateral

Oblique Course of Accessory Pathways

Ventricular Insertion
Septal or Posterior

Atrial Insertion
Lateral or Anterior
Oblique Course of Accessory Pathways

Demonstrate Oblique Course by Differential Atrial or Ventricular Pacing
Oblique Course of Accessory Pathways

Atrium

Basal Inf RV Septal Pacing

Septal AP Lateral

Ventricle
Oblique Course of Accessory Pathways

Atrium

Septal

AP

Ventricle

Lateral

Basal Inf
RV Septal Pacing
Oblique Course of Accessory Pathways

- Atrium
- Ventricle
- Septal

Basal Inf
RV Septal Pacing

Ventricular Potential
Overlaps AP Potential

AP

Heart tissue diagram showing the oblique course of accessory pathways with annotations.
Oblique Course of Accessory Pathways

Atrium

Ventricle

AP
Oblique Course of Accessory Pathways

Atrium

AP

Ventricle

Short Local V-A Interval
Oblique Course of Accessory Pathways

Atrium

Septal

AP

Ventricle

Lateral

Basal Sup LV Pacing
Oblique Course of Accessory Pathways

Atrium

Septal

AP

Lateral

Ventricle

Basal Sup LV Pacing
Oblique Course of Accessory Pathways

Ventricular Wavefront is Moving Away as it Activates the Ventricular Insertion of the Accessory Pathway
Oblique Course of Accessory Pathways

Ventricular Potential is Far from AP
Oblique Course of Accessory Pathways

AP Potential is Unmasked

Ventricular Potential is Far from AP
Oblique Course of Accessory Pathways
Oblique Course of Accessory Pathways

Artificially Long Local V-A at Site of Earliest Atrial Activation
Oblique Course of Accessory Pathways

Oblique Course is Responsible for the Isolated AP Potential
Case #1

- 28 y/o man

- Concealed left lateral accessory pathway
Pacing Basal Inferior RV Septum

RAO Projection

RAA
HB
CS
RV

LAO Projection

RAA
HB
CS
RV
Pacing Basal Inferior RV Septum
Concealed Left Free-Wall Accessory Pathway

Effect of Ventricular Pacing Site on Local V-A Interval
Effect of Ventricular Pacing Site on Local V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Basal RV Septum

Ventricular Potentials Overlapping Atrial Potentials
Effect of Ventricular Pacing Site on Local V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Basal RV Septum

Where is Target for Ablation?

Effect of Ventricular Pacing Site on Local V-A Interval
Reversing Ventricular Wavefront

Pacing Basal RV Septum

Pacing Floor of PA

LAO

Pacing Basal RV Septum

RAA
Concealed
Left Free-Wall
Accessory Pathway

Pacing Floor
of PA

Tricuspid
Annulus
Mitral
Annulus

HBp
HBd
CSp
CS7
CS6
CS5
CS4
CS3
CS2
CSd
RV

Effect of Vent Pacing Site on Local V-A
Effect of Vent Pacing Site on Local V-A

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Effect of Vent Pacing Site on Local V-A

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval
Effect of Vent Pacing Site on Local V-A

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Mitral Annulus

Tricuspid Annulus

HB

CS

Pacing Floor of PA

RAA

HBp

Hbd

CSp

CS7

CS6

CS5

CS4

CS3

CS2

Csd

RV

Earliest A

Striking Increase in V-A Interval

Ventricular Activation
Effect of Vent Pacing Site on Local V-A

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Striking Increase in V-A Interval

Earliest A

Effect of Vent Pacing Site on Local V-A
Effect of Vent Pacing Site on Local V-A

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Tricuspid Annulus
Mitral Annulus
HB
CS

AP Potential is Unmasked

Striking Increase in V-A Interval

Earliest A

Effect of Vent Pacing Site on Local V-A

Concealed Left Free-Wall Accessory Pathway

Pacing Floor of PA

Tricuspid Annulus
Mitral Annulus
HB
CS

AP Potential is Unmasked

Striking Increase in V-A Interval

Earliest A
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

II
V₁
RAA
HBₚ
HBₐ
CSₚ
CS₇
CS₆
CS₄
CS₃
CS₂
CS₁
RV

V and A Overlap
No AP Potentials

V and A Overlap
Vent Activ

V and A Overlap
Vent Activ
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

Marked Increase in Local V-A at Site of Earliest Atrial Activation

V and A Overlap
No AP Potentials

V and A Overlap
No AP Potentials
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

II
V₁
RAA
HBₚ
HBₐ
CSₚ
CS₇
CS₆

V and A Overlap
No AP Potentials

Marked Increase in Local V-A at Site of Earliest Atrial Activation

Unmasks AP Potentials

V and A Overlap
No AP Potentials

Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

II
V₁
RAA
HBₚ
HBₐ
CSₚ
CS₇
CS₆

V and A Overlap
No AP Potentials

Marked Increase in Local V-A at Site of Earliest Atrial Activation

Unmasks AP Potentials

V and A Overlap
No AP Potentials
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

Where to Ablate?

Unmasks AP Potentials

Marked Increase in Local V-A at Site of Earliest Atrial Activation
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

Where to Ablate?

Near CS₅
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

Where to Ablate?

Near CS<sub>5</sub>
Where to Ablate?

*Near CS₅*
Pacing Basal Inferior Septum

Reversing Ventricular Wavefront

Pacing Outflow Tract

Where to Ablate? *Near CS₅*

Late Atrial Activation at Mid-Body of AP (20 ms)
Where to Ablate? 

Near CS$_5$

Why is “A” Late at Middle of AP?

Late Atrial Activation at Mid-Body of AP (20 ms)
Late Atrial Activation at Mid-Body of AP

Very Rapid Conduction
Late Atrial Activation at Mid-Body of AP

Very Rapid Conduction
Late Atrial Activation at Mid-Body of AP

Turning Delays Conduction

Very Rapid Conduction
Late Atrial Activation at Mid-Body of AP

Mid-Body of Accessory Pathway

Turning Delays Conduction

Very Rapid Conduction

Atrium

AP

Ventricle
Left Lateral Accessory Pathway

RAA Pacing

LV Pacing
Left Lateral Accessory Pathway

RAA Pacing

LV Pacing

100 ms
Left Lateral Accessory Pathway

RAA Pacing

LV Pacing

Earliest A
Left Lateral Accessory Pathway

RAA Pacing

LV Pacing

Late A at Mid-Body of AP (25 ms)
HB

Ablation

CS

LAO Projection
Sharp Potential on Bipolar EGM may be Recorded from Electrode 2
HB

RAO Projection

Ablation Lesion Does Not Reach Electrode 2

Ablation

CS

RAO Projection

Sharp Potential on Bipolar EGM may be Recorded from Electrode 2
Ablation lesion does not reach electrode 2. Sharp potential on bipolar EGM may be recorded from electrode 2. Position to ablation electrode to record AP potential on unipolar 1 (tip) electrogram.
Ablation Lesion Does Not Reach Electrode 2

Position the Ablation Electrode to Record AP Potential on Unipolar 1 (Tip) electrogram

Sharp Potential on Bipolar EGM may be Recorded from Electrode 2
Concealed Left Lateral Accessory Pathway

Pacing RV/LV from Floor PA
Concealed Left Lateral Accessory Pathway

Ventricular and Atrial Potentials

Pacing RV/LV from Floor PA
Concealed Left Lateral Accessory Pathway
Concealed Left Lateral Accessory Pathway

- $V_1$
- RAA
- $H_{B_p}$
- $H_{B_d}$
- $C_{S_p}$
- $C_{S_5}$
- $C_{S_d}$
- $R_{V_p}$

Earliest A

100 ms
Concealed Left Lateral Accessory Pathway

- $V_1$
- RAA
- $HB_p$
- $HB_d$
- $CS_p$
- $CS_5$
- $CS_d$
- $LV_d$
- $RV_p$

Earliest A

100 ms
Concealed Left Lateral Accessory Pathway

- $V_1$
- RAA
- $HB_p$
- $HB_d$
- $CS_p$
- $CS_5$
- $CS_d$
- $LV_d$
- $RV_p$

Early A wave is depicted, indicating the concealed accessory pathway's activation in this ECG tracing.
Concealed Left Lateral Accessory Pathway

- V₁
- RAA
- HBₚ
- HB₆
- CSₚ
- CS₅
- CS₆
- LV₆
- RV₆

Earliest A

Ablate Here?
Addition of Unipolar Electrograms

Bip 1-2
LV
Uni 2
Uni 1
RV

RAA
HB_p
HB_d
CS_p
CS_d

V_A
A

100 ms
Addition of Unipolar Electrograms

- $V_1$
- RAA
- $HB_p$
- $HB_d$
- $CS_p$
- $CS_d$

- Bip 1-2
- LV
- Uni 2
- Uni 1
- RV

- AP

100 ms
Addition of Unipolar Electrograms

V1
RAA
HBp
HBd
CSp

CSD

Bip 1-2
LV
Uni 2
Uni 1

RV

S

100 ms

AP
A

A

V
Retrograde Transaortic Approach

RAO Projection

LAO Projection

Pulling LV Catheter Back Towards LV
Study Population

RFCA of Accessory Pathway

114 Patients

Left Free-Wall 65 (57%)
Right Free-Wall 22 (19%)
Posteroseptal 21 (19%)
Anteroseptal 6 (5%)
Change in Local V-A Interval (Site of Earliest Atrial Activation)

- Local V-A (ms) values for different locations:
  - All Locations (n = 104)
  - Left Free-Wall (n = 64)
  - Right Free-Wall (n = 18)
  - Postero-Septal (n = 19)
  - Antero-Septal (n = 5)

- Reversing Ventricular Wavefront

- Points indicate change in Local V-A interval:
  - Long Local V-A
  - Short Local V-A

- Values: 0, 20, 40, 60, 80, 100, 110, 120, 170, 190
Change in Local V-A Interval with Reversal of Ventricular Wavefront
Change in Local V-A Interval with Reversal of Ventricular Wavefront

Oblique Course

\[ \geq 15 \text{ ms} \]
Change in Local V-A Interval with Reversal of Ventricular Wavefront

Oblique Course

91 of 106 (86%) APs have an Oblique Course

Δ Local V-A Interval (ms)

Number of Access Pathways

≥15 ms
Recording AP Potential

- AP Potential Recorded: 99 (89%)
- AP Potential Not Recorded: 12 (11%)
Value of Recording AP Potential for Ablation

Otomo et al, Circulation 2001

# RFs Required to Eliminate AP Conduction

Median 1.0

111 patients

99 (89%)

12 (11%)
Value of Recording AP Potential for Ablation

# RFs Required to Eliminate AP Conduction

Otomo et al, Circulation 2001
Conclusions

- 86% of accessory pathways (all locations) have an oblique course
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- Direction of the oblique course can be identified and (and AP potential recorded) by pacing the atrium or ventricle from opposite sides
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- Ideal target for ablation – AP potential
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Conclusions

- 86% of accessory pathways (all locations) have an oblique course

- Direction of the oblique course can be identified and (and AP potential recorded) by pacing the atrium or ventricle from opposite sides

- Ideal target for ablation – AP potential (Uni 1 electrogram)

- In absence of an AP potential – target earliest antegrade ventricular activation or earliest retrograde atrial activation
Thank You!