Differential Diagnosis of SVT
& It's Mapping Techniques
Classification of SVT

• Atrial
  1. A Fib
  2. A Flu
  3. AT
    1) focal
    2) reentry
      – atrial
      – sinoatrial
  4. A Flu

• AV junction
  1. AVNRT
  2. AVRT
  3. PJRT
Carotid sinus massage

- Termination *(AV junction dependent)*
  - AVNRT
  - AVRT
- Slowing
  - A Flu
  - AT
그림6. Lewis 유도
ECG

1. Onset
2. Position of P wave in R–R interval during SVT
3. P wave morphology
4. Pseudo R’ in V1
5. QRS alternans
6. Cycle length variation
7. Effects of bundle branch block (BBB)
8. Ventricular preexcitation
Onset

- AVNRT
  - APB with marked $\uparrow P-R$
- Triggered/reentrant AT
  - APB without marked $\uparrow P-R$
- Automatic AT
  - gradual acceleration
- AVRT
  - by APB/VPB
Position of P wave in R–R

R–R interval

Irregular

P wave

(-)

AFib

F waves 250–350

AFlu

Ectopic

(+)

AT

Regular

P wave

(-)

AVNRT

AVNRT

AFlu

Rapid AFib

(+)

AVNRT

AT

RP<PR 1st half

AT

RP>PR 2nd half

AVNRT

Atypical AVNRT

PJRT
P wave Morphology

1. (+) in aVL, (−) in V1: right AT
   (−) in aVL, (+) in V1: left AT
2. (−) in inferior leads: inferior AT
   (+) in inferior leads: superior AT
3. (−) in aVR: along crista terminalis
4. MAT: varying
5. SART: similar to sinus P
Psedo R’ in V1

- more frequent in AVNRT than in AVRT/AT
QRS Alternans

- usually AVRT
- depends on *Abrupt onset* & more common in *Rapid tachycardia*
  - 27~38% in orthodromic AVRT
  - 13~23% in AVNRT
  - much less in AT
Rate & Cycle Length Alternans

- Rate
  - marked overlap
- Cycle length variation
  - relatively uncommon in Reentry
  - orthodromic AVRT+Dual AVN pathway
Effect of BBB

- BBB ipsilateral to accessory pathway
  - $\uparrow$ cycle length (circuit)
  - $\downarrow$ heart rate
Preexcited Tachycardias

- Antidromic AVRT
  - 1:1 VA conduction
- A Fib/AT conducting over AP
  - irregular rate
  - R–R shorter than 220~250 ms
- Tachycardia by Mahaim fiber
  - QRS ≤ 150 ms
  - LBBB+LAD (QRS axis 0°~−75°)
  - Transition in V4–6
Patterns of Ventricular Preexcitation (1)

- **Left**: $Rs$, $(+)$\(\delta\) wave in $V_1$

1. **Posterior**: $QS$, $(-)$\(\delta\) wave in inferior leads

2. **More anterior-laterally**:
   - $QS$, $(-)$\(\delta\) wave in $aVL$,
   - $(+)$\(\delta\) wave in inferior leads
Patterns of Ventricular Preexcitation (2)

- Posterior septum:
  - $(-)\delta$ wave in inferior leads
  - R/S abrupt transition in V1(rS), V2(Rs)
  - Subepicardial: $(-)\delta$ wave in II in the first 20 ms
- Middle to anterior septum
  - $(+)\delta$ wave in inferior leads, $(-)\delta$ wave in V1
  - Anteroseptal: Rs in III
  - Midseptal: R/S in III=1
Patterns of Ventricular Preexcitation

- Right: \( rS \) in \( V1 \), delayed \( \delta \) wave progression
  1. Posterior: \((-)\delta\) wave in inferior leads
  2. More anterior: \((+)\delta\) wave in inferior leads
Irregular R–R interval

• A Fib
• A Flu
• AT
Right Atrial Flutter

<table>
<thead>
<tr>
<th>ECG Lead</th>
<th>Clockwise</th>
<th>Counterclockwise</th>
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<tbody>
<tr>
<td>II, III, aVF</td>
<td>(+/-)</td>
<td>(-)</td>
</tr>
<tr>
<td>I</td>
<td>(+)</td>
<td>Biphasic/isoelectric</td>
</tr>
<tr>
<td>aVL</td>
<td>biphasic/isoelectric</td>
<td>(+)</td>
</tr>
<tr>
<td>V1</td>
<td>(-/biphasic)</td>
<td>(+)</td>
</tr>
<tr>
<td>V6</td>
<td>(+)</td>
<td>(-)</td>
</tr>
</tbody>
</table>
Atrial Tachycardia

- 130~240 bpm
  1. Enhanced automaticity
     - warming up & cooling down, incessant
  2. Triggered activity
  3. Intra-atrial microreentry
  4. Macroleentry: after surgery
     - 130~170/m, longer P–R
Regular R–R interval

- P wave: presence, morphology, position
  1. Site of origin
  2. Mechanism
No P wave

- Typical AVNRT: RSR’ in V1
- D/D
1. A Flu with 2:1 AV conduction (150/min)
2. Rapid A Fib
P wave in 1\textsuperscript{st} half of R–R

- Orthodromic AVRT
  - P(–) in I,(+) in V1: left–sided AP
  - Ipsilateral BBB: longer cycle length
  - QRS alternans
- D/D
  1. AVNRT
  2. AT
  3. A Fib/A Flu with 1:1 AV conduction
P wave in 2\textsuperscript{nd} half of R–R interval

- Permanent Junctional Reciprocating Tachycardia (PJRT)
  - Incessant, often irregular R–R
  - Antegrade AV nodal conduction
  - Retrograde decremental AP conduction
P wave in 2\textsuperscript{nd} half of R–R interval

- D/D
  1. Atypical AVNRT
  2. AT: different P
     - Ectopic: inferior atrium near CS ostium
     - IART
  3. SART: similar to sinus P
  4. Sinus tachycardia: same P
     - Appropriate
     - Inappropriate: exaggerated acceleration of rate
Regular wide QRS tachycardia

- Aberrant conduction
- Fixed BBB
- Accessory pathway (AP)
Preexcited QRS tachycardia

- A Fib with AP
- A Flu with AP: 250~300/min
- Tachycardia with Mahaim fiber
  - LBBB+LAD
- Antidromic AVRT
- Tachycardia using 2 APs
- AVNRT with bystander AP
Conventional Contact Catheter Mapping

- Preprocedural ECG
- Diagnostic procedure
- Operator experience
- Coordination with imaging
Diagnostic procedure

- Quadripolar electrode catheters
  1. high RA (HRA)
  2. His bundle
  3. RV apex (RVA)
  4. coronary sinus
- Basic intervals in sinus rhythm
- Programmed stimulation at RVA & HRA
  1. Eight-beat drive train at two cycle lengths
  2. Extrastimulus decremented by 10~20 ms
- Decremental pacing
Fluoroscopic Views

- Frontal
  1. Advancing to heart
  2. RVOT
- RAO
  1. Valves: mitral, tricuspid, aortic
  2. His bundle
- LAO
  1. Valve annuli: mitral, tricuspid
  2. Septum
  3. LV: septal, lateral, basal
  4. Coronary sinus
Catheter Mapping

- Recording
- Analysis
1. Determine activation timing
2. Create a mental map of activation sequence
- Electrophysiological & Anatomic targets
Conventional Mapping Methods

- Main methods
  1. Activation sequence mapping
  2. Pace mapping
  3. Entrainment mapping
Activation Sequence Mapping

• During tachycardia
  1. Electrogram from roving catheter
  2. Comparing with reference signal
• Earliest signal/progression of activation around macroreentrant circuit
Activation Sequence Mapping

- Focal tachycardias in normal structure
  1. Focal AT
  2. Focally initiated A Fib
- For reentrant circuits
  - complemented by pace mapping
Pace Mapping

- Focal tachycardia
- Pace match: cardiac activation sequence/surface ECG of arrhythmia
  - reproduced by pacing at its focal origin, at similar cycle length
Entrainment Mapping

- Macro–reentrant tachycardia
- Merely confirms reentrant mechanism
  1. Stimuli from sites within/outside circuit
     - reset tachycardia
  2. A train of stimuli fall within excitable gap
     - continuously reset(entrain) tachycardia
Entrainment Mapping

- Criteria for confirming pacing within circuit
  1. Concealed entrainment
  2. Identical interval between pacing site & fixed reference point during pacing & tachycardia
  3. Post-pacing interval after entrainment
     - return cycle generated by last pacing stimulus is equal within 30 ms to TCL
AVNRT

• Concept of Dual AVN Pathway
  – Discontinuity in AVN function curve
• Unusual Physiology of Dual AVN pathways
  – Multiple antegrade & retrograde AVN pathway
    1. Slow–slow
    2. Slow–intermediate
    3. Fast–intermediate
Mapping of AVNRT

- Dual AVN physiology
  - >50 ms ↑ in A–H after 10~20 ms shortening in A1–A2
- Typical: long A–H & short H–A'
- Atypical: short A–H & long H–A'(long RP)
Mapping of AVNRT

• Anatomic approach
  1. AP: floor of coronary sinus os
  2. LAO: inferior tricuspid annulus (6–o’clock) to 4–o’clock
Mapping of AVNRT

• Based on electrogram
  1. RAO: inferior tricuspid annulus near coronary sinus os
  2. Slow pathway potential
     1) single or multiple
     2) usually high frequency
     3) follow or fuse with local atrial electrogram
     4) Usually posterior or midseptum, usually anterior to coronary sinus os
• Combined approach
WPW Syndrome & Concealed Accessory Pathways

- ECG algorithms
- Pre-excitation maximized by rapid atrial pacing

1. Planning for procedure
2. Guide mapping
3. Identify target area for ablation
Anatomy & Electrophysiology of AP

- Anatomic & functional dissociation of AP
  - Atrial & ventricular insertion
  - Antegrade & retrograde component
- Conduction properties
  1) Fast (90%)
  2) Decremental (10%)
    - Right free wall, posteroseptal
    - Mahaim: atriofascicular/nodoventricular, close to RBB
    - Sensitive to verapamil, adenosine
AVRT

- Antidromic AVRT
- Multiple AP: 5~20%
- Mahaim tachycardia (LBBB+LAD)
  - VA dissociation: nodofascicular
- AVNRT with innocent bystander AP
AT

- Dx criteria
  1. Atrial activation sequence different from that during sinus rhythm or ventricular pacing
  2. Changing P–R & R–P interval related to changing of tachycardia rate
  3. AV block without affecting tachycardia
Mapping of Focal AT

- Atrium
  1. Crista terminalis
  2. Atrial septum
  3. Koch’s triangle
  4. Atrial appendage
  5. AV annulus
- Thoracic veins with atrial connection
  1. SVC
  2. IVC
  3. CS
  4. PV
Mapping of focal AT

- Sequential point-by-point during stable tachycardia: earliest activation relative to P wave or reference atrial electrogram
- Simultaneous mapping: electrogram timing & color maps
- Global activation using a single beat of tachycardia
- Noncontact system: nonsustained & hemodynamically unstable
Mapping of macroreentrant AT

- Myopathy/scar after surgery
- on 3-D mapping
- Single/figure-of-eight reentrant circuit
  1. Normal tissue
  2. Scar tissue
     - low voltage
     - slow conduction zone (SCZ)
- Pacing at/close to exit site of SCZ
  - concealed entrainment with identical sequence
  - short post-pacing interval
A Flutter

- Typical: isthmus–dependent
  - Clockwise & counterclockwise
- Anatomic approach: low RA, double potentials, with confirmatory entrainment
  - Simultaneous mapping: atrium(crista terminalis) & cavotricuspid isthmus
A Flutter

- Atypical: isthmus–independent
  1. Low RA free wall
  2. High RA: SVC–setum
  3. Two or four PV orifices, mitral annulus isthmus, fossa ovalis
- Method
  1. Simultaneous recording from multiple electrode catheters, entrainment
  2. 3–D mapping