Mahaim Fiber
Recognition and Management

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Mahaim Fibers

- 1940 Mahaim; fibers connected His or AV node to the ventricle
- 1975 Lev
  fibers passed from AV node to left and to the right posterior ventricular septum
- 1975 Anderson
  classified two anatomical types; Nodoventricular fibers and fasciculoven tricular fibers
- 1988 Tchou
  proposed accessory pathways behave a typical nodal fiber
  actually arose directly from RA and inserted into the RBB
  named as atriofascicular accessory pathway
Most accessory pathway with antegrade decremental conduction properties referred to as as Mahaim fibers
Classification of Mahaim Fibers
Variants of Preexcitation
Three types of schematic representation of Antidromic reciprocating Tacycardia containing Mahaim fibers.

A. nodofascicular fibers. B. nodoventricular fibers. C. atriofascicular fibers
<table>
<thead>
<tr>
<th>Atriofascicular Pathways</th>
<th>Nodofascicular (NF) Pathways</th>
<th>Fasciculoventricular pathways</th>
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<tbody>
<tr>
<td>- Minimal or no preexcitation during SR</td>
<td>- Characteristics of atriofascicular fibers except;</td>
<td>- Normal PR interval during SR</td>
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<td>Normal PR interval during SR</td>
<td>- Failure of late atrial extrastimulus to reset the tachycardia without anterograde penetration into the AV node</td>
<td>- Discrete slurring of the QRS complex indicating preexcitation</td>
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<td>- Preexcitation with LBBB morphology during IAP or atrial extrastimulation</td>
<td>- mechanical block at the location of the normal AV node</td>
<td>- Fixed preexcitation during IAP or atrial extrastimulation</td>
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<td>- Anitidromic AVRT with LBBB morphology identical to maximal preexcitation</td>
<td>- VA dissociation during tachycardia</td>
<td>- Proximal insertion at the His bundle or bundle branches</td>
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<td>- Long conduction times</td>
<td>- Failure of recording accessory pathway activation potentials at the parietal tricuspid annulus</td>
<td>- Distal insertion into the ventricular summit</td>
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<td>- Decremental conduction properties</td>
<td>- NF fibers as bystander in AVNRT</td>
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<td>- Conduction only in antegrade direction</td>
<td>- Fusion of the QRS complex during tachycardia spontaneously or in response to programmed electrical stimulation</td>
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<td>- Vulnerable to adenosine</td>
<td>- VA dissociation during preexcited tachycardia standard criteria for AVNRT</td>
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<tr>
<td>- Reset of AVRT with late atrial extrastimuli without antegrade penetration into the normal AV node and without change in QRS morphology and ventricular activation sequence</td>
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<tr>
<td>- Recording of accessory pathway activation potentials at the parietal tricuspid annulus</td>
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- VA dissociation during preexcited tachycardia standard criteria for AVNRT
Differentiation of Atriofascicular and manifest NF/NV mediated Antidromic Tachycardia

- **Common** (short V-H$_{SVT}$ ; VH<HV)
  \[ VH_{SVT} < VH_{RVP} ; AF, NF \]
  - due to time for stim to reach RB)
  - exclude NV or slowly conducting AV bypass tract
  RB before H ; AF, NF
  \[ H - A_{SVT} = H A_{RVP} ; AF, NF \]

- **Uncommon** (Long V-H SVT)
  \[ VH_{SVT} > VH_{RVP} ; AF, NF \]
  H before RB ; AF, NF
  \[ H A_{SVT} = H A_{RVP} ; AF, NF \]
Electrocardiographic Features During Sinus Rhythm

- Overt pre-excitation is usually absent
- Only subtle ECG abnormalities, such as an rS pattern in lead III, absence of septal Q waves in leads I and V6, and terminal QRS slurring or notching, suggest the presence of Mahaim conduction.
- However, patients with short, rapidly conducting fibers may have typical pre-excitation
Features of Mahaim Accessory Pathways

• Baseline normal QRS or different degrees of manifest preexcitation with left bundle branch block morphology;

• Programmed atrial pacing leading to obvious manifest preexcitation following an increase in A-V interval along with shortening of H-V interval at shorter pacing cycle lengths; and right bundle electrogram preceding His bundle activation during anterograde pre-excitation and supraventricular tachycardia (SVT).
Figure 1: A: Atriofascicular pathway: baseline ECG discloses minimal preexcitation with a 0.12 s PR interval. During atrial pacing LBBB with aQRS = -20°, QRS 130 msec wide. B: Atrioventricular pathway in Ebstein's disease: baseline ECG without preexcitation and disclosing RBBB with normal PR interval. During atrial pacing manifest preexcitation with LBBB (aQRS = -30°), QRS 160 msec wide with a slurred initial r wave in V1
Figure 3: Atrioventricular pathway: high right atrial (HRA) pacing at 450 msec causes Wenckebach block on the accessory pathway. Progressive prolongation of AV interval (80-120-150-block) is due to prolongation of A-AP potential (40-80-115-block). Preexcitation degree increases from the first to the second QRS complex and remains constant in the third QRS despite further prolongation of A-APP interval.

Mahaim Fibre Tachycardia: Recognition and Management. EB Sternick, MD, Indian PACE 2003; 3(2): 47-59
P-delta increase during AES

A

B

C

P-delta = 198 msec
AH = 191 msec
HV = 40 msec

P-delta = 310 msec
AH = 258 msec
HV = 40 msec

Echo
ECG during tachycardia
atriofascicular bypass tract

KN Lee, MD; YHKim, MD, PhD. International Journal of Arrhythmia 2017;18(3):151-154
ECG during tachycardia
nodofascicular bypass tract
A: During short V-A AVRT (tachycardia cycle length 300 ms), there is also anterograde activation over the left anterior fascicle to produce a fused QRS complex with a normal axis. B: With retrograde right bundle branch block, anterograde conduction over the left anterior fascicle is no longer possible and conduction to the left ventricle proceeds only via the right free wall. Therefore, the long V-A AVRT (tachycardia cycle length 350ms) has a leftward axis. During the change from short V-A AVRT to long V-A AVRT, the QRS width also increases from 120 to 150 ms.

A: atrial electrogram; AF: anterior fascicle; AVN: atrioventricular node; AVRT: atrioventricular reentrant tachycardia; CSp: proximal coronary sinus catheter; HBE: His bundle catheter; HRA: high right atrium catheter; LBB: left bundle branch catheter; M: Mahaim potential; PF: posterior fascicle; RB: right bundle potential; RBB: right bundle branch catheter; RVA: right ventricular apex catheter; V-H: ventriculo-His interval. Reproduced from Gandhavadi et al, 2013, with kind permission.
Intracardiac EGM during Tachycardia

- QRS wide LBBB
- recordings of both right bundle branch and His electrogram
- confirm the relationship between the activation sequence of His and right bundle potential
- HV interval shortened or reversed
- RB potential preceeding His potential

Mahaim Fibre Tachycardia: Recognition and Management. EB Sternick, MD, Indian PACE 2003; 3(2): 47-59
Recognition of Atriofascicular pathway involvement of tachycardia

Figure 4: Antidromic tachycardia. Late (S) atrial extrastimuli delivered from the lateral high right atrium without disturbing AA timing at the His bundle recording advances QRS complex by 20 msec and His deflection by 30 msec, proving that the pathway is extra nodal and participates on the circuit.

Mahaim Fibre Tachycardia: Recognition and Management. EB Sternick, MD, Indian PACE 2003; 3(2): 47-59
Recognition of Atriofascicular pathway involvement of tachycardia

Short VH tachycardia; Late coupled PAC delayed next ventricular activation which suggests antegrade conduction via atriofascicular mahaim fiber.
Techniques for Mapping and Ablation
- Atriofascicular fibers -

• Targeting atrial insertion/Tricuspid annulus
  1. site of recording the local AP potential
  2. site to show the mechanical block of the AP
  3. site showing “reset phenomenon”
  4. site showing shortest Stim-to-delta wave along the TA

• Targeting the site of ventricular insertion
  1. The earliest ventricular activation site of maximally preexcited beats
  2. The presence of a local AP activation potential
  3. A paced QRS matching the tachycardia QRS
The annulus was classified into regions: posterior and postero-septal sites (P), posterolateral sites (PL), lateral sites (L), anterolateral sites (AL) and anteroseptal sites (AS). The QRS frontal plane axis was classified as superior (< -30°), horizontal (≤ +15° and ≥ -30°) and normal (> ±15°). Regardless of the frontal plane axis, most of the cases were ablated at the L and PL regions. There was not a single case with normal frontal plane axis located at the AS region. 

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DG Katritsis, HJ Wellens, ME Josephson Mahaim Accessory Pathways Diagnostic Electrophysiology & Ablation RADCLIFFE CARDIOLOGY 2017 29
Figure 6: Three examples of "M" potentials (TA- tricuspid annulus electrograms): from left to right: first two cases with His-like potentials and the third with narrow and low amplitude potential. Ablation was successful in each of those sites.
Catheter Ablation of ventricular Insertion of Atriofascicular Pathway
Mahaim potential mapping during antidromic reciprocating tachycardia. Electroanatomical mapping system (CARTO)
### Differential diagnosis of Tachycardia with a Typical LBBB QRS morphology

<table>
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<th>Condition</th>
<th>Description</th>
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<tr>
<td><strong>SVT with fixed LBBB</strong></td>
<td>LBBB present on baseline ECG Identical QRS match during tachycardia Most often due to orthodromic AVRT At rapid rates, QRS alternans may be present</td>
</tr>
<tr>
<td><strong>SVT with functional LBBB aberrancy</strong></td>
<td>Preexcitation minimal or absent during SR Late QRS transition, leftward axis common Frequently coexists with other accessory pathways or AV nodal reentry</td>
</tr>
<tr>
<td><strong>Atriofascicular antidromic tachycardia</strong></td>
<td>Accessory pathway does not participate in reentrant circuit of orthodromic AVRT, AVNRT, or atrial tachycardias (including atrial fibrillation and flutter)</td>
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<tr>
<td><strong>SVT with bystander atriofascicular accessory pathway</strong></td>
<td>Associated with acquired structural heart disease (cardiomyopathy, valvular disease) Prolonged PR interval and nonspecific IVCD often present during sinus rhythm</td>
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<tr>
<td><strong>Bundle branch reentrant ventricular tachycardia</strong></td>
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</table>
Figure 3. Surface ECG leads I, II, aVF, and V1 and intracardiac recordings during Mahaim tachycardia. A critically timed extrastimulus (S1) delivered at the low right atrium terminates the tachycardia without affecting the timing of the atrial electrogram in the HB region as demonstrated by the identical A-A intervals during tachycardia and following S1 on His p and His d. The HB potential is marked with asterisks and RB potential with arrowheads. LRA = low-right atrium. The other abbreviations are the same as in Figure 1. All intervals are in milliseconds. Paper speed 150 mm/s.
Conclusion

• Mahaim pathways are decrementally conducting connections between the right atrium or the AV node and the right ventricle in or close to the right bundle branch.
• They can be atriofascicular, atrioventricular, nodofascicular and nodoventricular, depending on their variable proximal and distal insertions.
• Catheter ablation is accomplished by identifying the proximal and distal insertions and, ideally, the recording of a proximal pathway potential at the tricuspid annulus or a distal one on the right ventricular free wall.