AVN independent SVT: substrates, mechanisms and recognition

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Classification

AVN independent SVT includes:

• Inappropriate sinus tachycardia
• Sinus nodal reentrant tachycardia

• Atrial tachycardia (AT):
  • focal AT
  • macroreentrant AT (MRAT):
  ➢ typical atrial flutter
  ➢ reverse typical atrial flutter
  ➢ atypical atrial flutter
• Atrial fibrillation
Inappropriate sinus tachycardia

• The sinus node activates at rates above the physiological range, but without an appropriated relationship to metabolic or physiological demands.

ECG for resting HR - >100bpm;
24h Holter - the mean heart rate > 95bpm

It is actually a focal tachycardia originating in the sinus node.
Inappropriate sinus tachycardia

- Uncommon,
- Young women,
- Autonomic dysfunction,
- Pharmacologic therapy: usually ineffective.
- Ablation: high (70%) recurrence rate.
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**Sinus nodal reentrant tachycardia:**

- only accounts for 1% of the SVT patients.
- **Mechanism:** like AV nodal reentry, sinus node has the same slow conduction electrophysiology.
Sinus nodal reentrant tachycardia:

Diagnosis criteria:

- Initiation and termination by pacing protocols;
- P wave identical to sinus in morphology and activation sequence;
- Endocardia electrophysiological study shows the same activation pattern as sinus rate;
- A-V nodal block may exist without affecting SVT;
- Vagal maneuvers and adenosine slow and abruptly terminate SVT.
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<tr>
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<th>IST</th>
<th>SNR</th>
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<td><strong>Initiation</strong></td>
<td>Adrenergic stimulation</td>
<td>Programmed pacing</td>
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<td><strong>Onset</strong></td>
<td>Gradual (seconds/minutes)</td>
<td>Sudden</td>
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<td><strong>Shift in Focus</strong></td>
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<td><strong>Termination</strong></td>
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<td><strong>Vagal Maneuvers</strong></td>
<td>Slowing</td>
<td>Abrupt termination</td>
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Focal AT

- **Definition:** Atrial activation starts at a small area (focus) from which it spreads centrifugally.
- **ECG:** HR 130-250bpm, but may be 100-300bpm.
- **P morphology and activation sequence are different from SNR.**
- **Clear isoelectric baseline between P waves.**
- **A-V nodal block or bundle branch block may exist without affecting SVT**
Focal AT

I
II
III
AVR
AVL
AVF
V₁
V₂
V₃
V₄
V₅
V₆
Focal AT

Mechanism:
abnormal automaticity, triggered activity and microreentry.
Focal AT: automaticity
Sinus rhythm mapping

AT mapping
Focal AT: Triggered activity

![ECG graph with annotations and measurements](image-url)
Focal AT: Microreentry

<table>
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<tr>
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<th>Automaticity</th>
<th>Triggered activity</th>
<th>Microreentry</th>
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<td><strong>Initiation</strong></td>
<td>Adrenergic stimulation</td>
<td>Adrenergic stimulation, Burst pacing, Programmed stimulation</td>
<td>Programmed stimulation</td>
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<td><strong>Onset</strong></td>
<td>Gradual (seconds/minutes)</td>
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<td></td>
<td>Warm up-cool down</td>
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<tr>
<td><strong>Termination</strong></td>
<td>Gradual</td>
<td>Sudden</td>
<td>Sudden</td>
</tr>
<tr>
<td><strong>Overdriving pacing</strong></td>
<td>Transiently suppress</td>
<td>Accelerate/suppress</td>
<td>Initiate/terminate</td>
</tr>
<tr>
<td><strong>Vagal Maneuvers, Adenosine</strong></td>
<td>Transiently suppress</td>
<td>Abrupt termination</td>
<td>No effect</td>
</tr>
</tbody>
</table>
Locations of Focal AT

Features consistent with LA origin

- CS activation from distal to proximal,
- Earliest activation in RA<30ms pre-P wave
- Early activation along Bachman’s bundle, septum, or CS ostium
- Variable RA cycle length with fixed LA cycle length.
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Macorreentrant AT

- **Mechanism**: reentrant activation around a large central obstacle (>2cm in diameter). The obstacle can be fixed and/or functional.

- **ECG**: no isoelectric baseline between P waves. Rate range is very wide.
Macroeentrant AT

- Typical atrial flutter
- Reverse typical atrial flutter
- Atypical atrial flutter non-cavotricuspid isthmus dependent
Typical atrial flutter

- Reentry circulate counterclockwisely around TA.
- Anterior boundary: TA; posterior boundary: CT, ER, CSO, SVC, IVC.
- Isthmus is anterior rim of the IVC and the inferior rim of the TA--- (cavotricuspid isthmus).
Typical atrial flutter

ECG:
- Sawtooth pattern F waves.
- The F waves rate is 250-300bpm.
- Positive in lead V1
- Negative in leads II, III, avF.
Typical atrial flutter

Activation and entrainment
Reverse typical AFL

Typical AFL

Reverse typical AFL
Reverse typical flutter:

ECG:

- F waves are wider than that of typical flutter.
- Negative in lead V1,
- Positive in leads II, III, avF.
Atypical atrial flutter

- All non-cavotricuspid isthmus dependent atrial reentrant attachycardia.
- Usually related with the structural heart disease or heart surgery.
- Various at circuit location, size, and ECG.
RA MRAT

RA incision MRAT
LA MRAT

Post atrial fibrillation ablation: 1.2-20%.

Two types of postablation MRAT:

- the macroreentry circuit involves conduction gaps within the ablation line created around the pulmonary antrum;
- within the mitral isthmus or rooflines.
Possible Circuits in LA Macro Re-entry

Packer D. Advanced Ablation Course, 2007
Differentiating Macroeentrant from Focal Atrial Tachycardia

Features of macroeentrant circuits:

• Lack of an isoelectric line on surface ECG
• Entrainment from multiple regions
• Ability to map > 90% tachycardia cycle length
• The center obstacle diameter > 2cm
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Atrial fibrillation

ECG:
- f wave, 350-600bpm,
- no isoelectrics,
- very irregular
The mechanisms of the AF

- Multiple wavelets
- Localized reentry
- Focal electrical discharges

Concealed APD’s RSPV
AF initiation RSPV
AF could be resulted from a focal trigger arising from the PVs and is maintained as a rapid reentrant circuit within the PVs – LA junction.
Substrate of AF: PVs

Anatomy
Substrate of AF: PVs

Electrophysiology

- Automaticity: P cells, Purkinje cells
- Triggered activity: Calcium current, EAD, DAD
- Reentry: Short ERP with decremental and slow conduction; Shorter refractory periods at distal PV

Substrate of AF: LA Posterior wall

- Myocardial fiber orientation

- Electrophysiology: high frequent potentials (automaticity, reentry)
Evidences of critical role of the LA posterior wall

- Post PV isolation, sustained PV tachycardia decreases dramatically (2%-6%),
- AF termination occurs before completely PV isolation, which indicates LA substrate for AF is essential.
- Ablation of High frequent activation sites in the posterior LA leads to termination of the arrhythmia.
Substrate of AF
Autonomic: Ganglionic plexis

Evidences of autonomic role

- Vagal stimulation shortens the atrial ERP, shortens the action potential duration, which in turn facilitates reentrant atrial arrhythmias.
- ANS activation facilitates early afterdepolarization and triggered activity by prolonging the intracellular calcium (Cai) transient, and shortening the action potential duration.
- Clinically, imbalance between sympathetic tone and vagal tone has been observed before AF patients.
- Ablation of ganglionic plexis has showed the optimistic results in AF treatment.
Possible mechanisms of AF

Atrial fibrillation (AF) is a complex disease with multiple possible mechanisms. At present, it is well accepted that AF requires:

- a trigger for initiation and a substrate for maintenance.
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Summary

Focal AT, MRAT and AF:

- **Originate locations:** RA, LA, or the connected vessels.
- **Substrates:** complex structure of atria; heterogenesis of atrial tissue; conduction block/delay.
- **Mechanisms:** automaticity, triggered activity and reentry
- **Diagnosis:** ECG, initiation and termination pattern, endocardia electrophysiological study and 3-D electroanatomic mapping.