Cardiology Update 2013

The Challenging ECG

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Case 1:

Patient with ventricular ectopic beats
32 year-old patient with history of intermittent palpitations and presyncope
32 year-old patient with history of intermittent palpitations and presyncope
32 year-old patient with history of intermittent palpitations and presyncope
What is the most probable cause for presyncope?

A. Ventricular tachycardia with SHD
B. Ventricular tachycardia without SHD
C. Supraventricular tachycardia
D. AV block
E. None of the above
32 year-old patient with history of intermittent palpitations and presyncope
A. Ventricular tachycardia with SHD

B. Ventricular tachycardia without SHD

C. Supraventricular tachycardia

D. AV block

E. None of the above
Anatomy of the Human Atrioventricular Node
Mechanism of typical AVNRT
32 year-old patient with history of intermittent palpitations and presyncope
Case 2:

Patient with ventricular ectopic beats
28 year-old patient with history of intermittent palpitations during exercise and chest tightness
What is the most probable cause for the patient’s symptoms?

A. Ventricular tachycardia with SHD
B. Ventricular tachycardia without SHD
C. Supraventricular tachycardia
D. Coronary artery disease
E. None of the above
28-year-old patient with history of intermittent palpitations during exercise and chest tightness.
Arrhythmogenic Right Ventricular Cardiomyopathy

Diffuse / segmental loss of myocardium in RV free wall

Replacement by fibrofatty tissue
Arrhythmogenic Right Ventricular Cardiomyopathy

Depolarisation / Conduction abnormalities
QRS prolongation (>110ms)
Epsilon waves
Late potentials

Repolarisation abnormalities
Inverted T waves

Ventricular arrhythmias
Frequent VES to sustained VT (LBBB morphology)
ARVD/C: Classical localisations
28 year-old patient with history of intermittent palpitations during exercise and chest tightness
Case 3:

Patient with a tachycardia changing to another tachycardia
A 42 year old female presents with recurrent palpitations.

On admission, 12-lead ECG was performed that showed a tachycardia at a rate of 125/min, which then spontaneously changed to a faster tachycardia.
A 42 year old female presents with recurrent palpitations.

On admission, 12-lead ECG was performed that showed a tachycardia at a rate of 125/min, which then spontaneously changed to a faster tachycardia.

What are the arrhythmia mechanisms for Rhythm A and for Rhythm B?
What is the likely diagnosis?

A. SVT and VT
B. SVT and SVT
C. SVT and atrial flutter
D. SVT and atrial fibrillation
E. SVT and artefact
F. None of the above
A. SVT and VT
B. SVT and SVT
C. SVT and atrial flutter
D. SVT and atrial fibrillation
E. SVT and artefact
F. None of the above
Anatomy of the Human Atrioventricular Node
Mechanism of typical AVNRT
Site of Slow Pathway Ablation
Case 4:

Patient with progressive dyspnea
24 year-old male with progressive dyspnea

He complains of a rapid heart rate at 120bpm for several months
24 year-old male with progressive dyspnea

He complains of a rapid heart rate at 120bpm for several months

What is the most likely diagnosis?
What is the most likely diagnosis?

A. Atrial tachycardia
B. Typical AV nodal reentrant tachycardia
C. Atypical AV nodal reentrant tachycardia
D. Typical AV reentrant tachycardia (accessory pathway)
E. Atypical AV reentrant tachycardia (accessory pathway)
A. Atrial tachycardia
B. Typical AV nodal reentrant tachycardia
C. Atypical AV nodal reentrant tachycardia
D. Typical AV reentrant tachycardia (accessory pathway)
E. Atypical AV reentrant tachycardia (accessory pathway)
Narrow complex tachycardia with a CL of 500ms (HR 120bpm)
P-waves are relatively narrow (septal) and are neg. in II and aVF
The RP interval ist longer than the PR interval
Long RP' Tachycardia
PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)
Mechanism of typical AVNRT?
Mechanism of typical AVNRT?
Mechanism of typical AVNRT?
PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP >70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)
Orthodromic AVRT
Antidromic AVRT
PR > RP

RP very short (<70 ms) $\rightarrow$ AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP >70 ms $\rightarrow$ AV reentry tachycardia (with an accessory pathway; orthodromic)

$\rightarrow$ Atrial tachycardia (with AV block)
PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia  
(typical AVNRT; slow-fast type)

RP > 70 ms → AV reentry tachycardia  
(with an accessory pathway; orthodromic)

→ Atrial tachycardia (with AV block)

RP > PR

→ Atrial tachycardia
Atriale Tachykardie
PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP > 70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)

→ Atrial tachycardia (with AV block)

RP > PR

→ Atrial tachycardia

→ Atypical AVNRT
AV Nodal Reentrant Tachycardia

90% typical AVNRT
  • slow-fast type

10% atypical AVNRT
  • fast-slow type
  • slow-slow type
PR > RP

RP very short (<70 ms) $\rightarrow$ AV nodal reentrant tachycardia
(typical AVNRT; slow-fast type)

RP >70 ms $\rightarrow$ AV reentry tachycardia
(with an accessory pathway; orthodromic)

$\rightarrow$ Atrial tachycardia (with AV block)

RP > PR

$\rightarrow$ Atrial tachycardia

$\rightarrow$ Atypical AVNRT

$\rightarrow$ Atypical AV reentry tachycardia
Narrow QRS tachycardia (QRS duration less than 120 ms)

Regular tachycardia?

Yes

Visible P waves?

No

Atrial fibrillation
Atrial tachycardia/flutter with variable AV conduction
MAT

Yes

Atrial rate greater than ventricular rate?

No

Atrial flutter or Atrial tachycardia

Yes

Atrial flutter or Atrial tachycardia

Short (RP shorter than PR)

RP shorter than 70 ms

AVNRT

RP longer than 70 ms

AVRT

Atrial tachycardia

PJRT

Atypical AVNRT

No

Analyze RP interval

Long (RP longer than PR)

Atrial tachycardia

PJRT

Atypical AVNRT
PJRT
PJRT = permanent junctional reciprocating tachycardia
PJRT = permanent junctional reciprocating tachycardia

Macoreentry
  Antegrade conduction via AV node & His bundle
  Retrograde conduction via accessory pathway
PJRT = permanent junctional reciprocating tachycardia

Macrotelemetry
  Antegrade conduction via AV node & His bundle
  Retrograde conduction via accessory pathway

No preexcitation during sinus rhythm (no delta wave)

The accessory pathway has decremental conduction
  *decremental* = AV node like, and therefore → RP > PR

The accessory pathway has posteroseptal location
  → superior axis
  → narrow, septal P-waves
PJRT = permanent junctional reciprocating tachycardia

Young patients (children, adolescents, young adults)
PJRT = permanent junctional reciprocating tachycardia

Young patients (children, adolescents, young adults)

The tachycardia is incessant (present 50-100% of the time)
PJRT = permanent junctional reciprocating tachycardia

Young patients (children, adolescents, young adults)
The tachycardia is incessant (present 50-100% of the time)
Relatively slow tachycardia
Tachycardia-induced cardiomyopathy is not rare
PJRT = permanent junctional reciprocating tachycardia

Acute therapy:

- Vagal maneuvers
- Adenosine
- Verapamil
- Betablockers
- Class I AA (Flecainide)
- Overdrive Pacing
- Cardioversion
PJRT = permanent junctional reciprocating tachycardia

Acute therapy:

- Vagal maneuvers
- Adenosine
- Verapamil
- Betablockers
- Class I AA (Flecainide)
- Overdrive Pacing
- Cardioversion

Chronic therapy:

- Catheter ablation (success > 95%)
44 year-old man presents with palpitations

Intermittent palpitations for 10 years

What is the likely diagnosis?
What is the likely diagnosis?

A. Sinus tachycardia
B. Atrial tachycardia
C. AV nodal reentrant tachycardia
D. AV reentry tachycardia (accessory pathway)
E. Atrial flutter
F. Ventricular tachycardia
A. Sinus tachycardia
B. Atrial tachycardia
C. AV nodal reentrant tachycardia
D. AV reentry tachycardia (accessory pathway)
E. Atrial flutter
F. Ventricular tachycardia
Narrow complex HR 120 bpm
Wide complex HR 240/min

A. Sinus tachycardia
B. Atrial tachycardia
C. AV nodal reentrant tachycardia
D. AV reentry tachycardia (accessory pathway)
E. Atrial flutter
F. Ventricular tachycardia
A. Sinus tachycardia  
B. Atrial tachycardia  
C. AV nodal reentrant tachycardia  
D. AV reentry tachycardia (accessory pathway)  
E. Atrial flutter  
F. Ventricular tachycardia
AVNRT
2:1 conduction

AVNRT
Variable conduction

AVNRT
1:1 conduction
SVT-VT Differential Diagnosis

- AV-Dissociation?
  - no

- no “RS” in precordial leads?
  - no

- R-S >100 ms in one precordial lead?
  - no

- morphology criteria for V1 and V6 are met?
  - no

SVT with Aberration
RSB

V1

monophasic

L > R

V6

Q

R/S < 1

LSB

V1

R >30 ms

R-S >60 ms

“notched” S

V6

Q
42-year-old male patient with dilated CMP

- Left ventricular EF 25%
- History of paroxysmal atrial fibrillation / atrial flutter
Main complaints

- Exercise intolerance
- Dyspnea on exertion
- Occasional palpitations with presyncope
What is the arrhythmia diagnosis?

A. Atrial flutter
B. Atrial tachycardia with aberration
C. AVNRT with aberration
D. AVRT (accessory pathway)
E. Ventricular tachycardia
Bundle Branch Reentrant VT

- Macroreentrant circuit involving the His-Purkinje system, usually with antegrade conduction over the right bundle and retrograde conduction over the left bundle
Bundle Branch Reentry

Atrium

AV

His

Ventricle

RB

LB
Bundle Branch Reentrant VT

• The most characteristic VT in patients with dilated cardiomyopathy
• 40% of VTs in patients with dilated cardiomyopathy
• Mechanism responsible for VT in 5-6% of patients with ischemic cardiomyopathy
Bundle Branch Reentrant VT

- Usually rapid with a mean CL of 280-300ms
- Syncope occurs in the majority of patients
- Degeneration to VF can occur
- Baseline ECG shows typically a nonspecific IVCD or LBBB.
Bundle Branch Reentrant VT

Electrophysiologic properties:

• HV intervals recorded during sinus rhythm are characteristically prolonged.
• His deflection preceeds each QRS
• Spontaneous tachycardia CL variations are preceeded by similar H-H variations
Therapy?

A. Medication?
B. Ablation?
C. ICD?
D. (1)+(2)
E. (1)+(3)
F. all of the above?
Therapy

• Catheter ablation of the RBB
  – Success: 95%
Bundle Branch Reentrant VT

Electrophysiologic properties:

• Important arrhythmia to recognize because ablation of the right bundle is curative

• Some patients may require a PM, particularly those with a preceeding LBBB
Bundle Branch Reentry
Bundle Branch Reentrant VT

• The RBB has been most commonly targeted for ablation because it is easily accessible.
• ECG pattern of LV conduction delay is common, suggesting that antegrade conduction through the RB might be more stable.
• Therefore, ablation of the LB might have a lower risk of AV block.
Bundle Branch Reentrant VT

- On the other hand, there is concern that LBBB may have adverse hemodynamic effects in patients with impaired ventricular function.
- Therefore, RB ablation remains the favored approach for the present.
Follow-up

- symptomatic improvement
- LVEF
  - after 6 weeks: 25% -> 45%
  - after 3 months 55%
- no adequate ICD discharges so far
Which is a likely explanation for this pacemaker ECG?

A. Positive AV – Hysterese
B. A undersensing
C. V oersensing (in AV-Intervall)
D. V oversensing (vor P-Welle)
E. T-wave oversensing
F. All of the above
Absence of an RS complex in all precordial leads?

Yes

VT

sens = .21
spec = 1.0

R to S interval >100 MS in one precordial lead?

Yes

VT

sens = .66
spec = .98

Atrioventricular dissociation?

Yes

VT

sens = .82
spec = .98

Morphology criteria for VT present both in precordial leads V1-2 and V6?

Yes

VT

sens = .987
spec = .965

SVT

No

VT

sens = .965
spec = .987

No

SVT
### Bayesian Diagnostic Algorithm for Wide QRS Complex Tachycardia

<table>
<thead>
<tr>
<th>ECG features</th>
<th>Likelihood ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QRS width</strong></td>
<td></td>
</tr>
<tr>
<td>≤0.14 second</td>
<td>0.31</td>
</tr>
<tr>
<td>&gt;0.14 and ≤0.16 second</td>
<td>0.46</td>
</tr>
<tr>
<td>&gt;0.16 second</td>
<td>22.86</td>
</tr>
<tr>
<td><strong>QRS axis</strong></td>
<td></td>
</tr>
<tr>
<td>Right superior (−90 to +/− 180 degrees)</td>
<td>7.86</td>
</tr>
<tr>
<td>Left (−60 to −90 degrees) with RBBB pattern</td>
<td>8.21</td>
</tr>
<tr>
<td>Right (+120 to +/− 180 degrees) with LBBB pattern</td>
<td>3.93</td>
</tr>
<tr>
<td>None of the above</td>
<td>0.47</td>
</tr>
<tr>
<td><strong>V1 morphology in RBBB pattern</strong></td>
<td></td>
</tr>
<tr>
<td>Taller left “rabbit ear” (double-peaked R wave)</td>
<td>50</td>
</tr>
<tr>
<td>Biphasic Rs or qR</td>
<td>4.03</td>
</tr>
<tr>
<td>Triphasic RSR’</td>
<td>0.21</td>
</tr>
<tr>
<td>None of the above</td>
<td>1.41</td>
</tr>
<tr>
<td><strong>V1 or V2 morphology in LBBB pattern</strong></td>
<td></td>
</tr>
<tr>
<td>Any one of:</td>
<td>50</td>
</tr>
<tr>
<td>(a) R ≥0.04 second</td>
<td></td>
</tr>
<tr>
<td>(b) Notched downstroke of S wave</td>
<td></td>
</tr>
<tr>
<td>(c) Delayed nadir of S wave &gt;0.06 second</td>
<td></td>
</tr>
<tr>
<td>None of the above</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>Interval from QRS onset to peak in V6</strong></td>
<td></td>
</tr>
<tr>
<td>≥0.08 second</td>
<td>19.30</td>
</tr>
<tr>
<td>&lt;0.08 second</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>V6 morphology</strong></td>
<td></td>
</tr>
<tr>
<td>Monophasic QS</td>
<td>50</td>
</tr>
<tr>
<td>Biphasic rS (R smaller than S) with RBBB pattern</td>
<td>50</td>
</tr>
<tr>
<td>Triphasic qRs (R larger than S) with RBBB pattern</td>
<td>0.13</td>
</tr>
<tr>
<td>None of the above</td>
<td>0.57</td>
</tr>
</tbody>
</table>
Differentiation of WCT in the presence of preexcitation

- **Predominantly negative QRS complexes in the precordial leads V4 to V6?**
  - Yes: Certainly VT, sens = 0.64, spec = 1
  - No:...
SVT-VT Differential Diagnosis

- AV-Dissociation?
  - no

- no “RS” in precordial leads?
  - no

- R-S >100 ms in one precordial lead?
  - no

- morphology criteria for V1 and V6 are met?
  - no

SVT with Aberration
RSB

V1

monophasic

L > R

V6

Q

R/S < 1

LSB

V1

R >30 ms

R-S >60 ms

“notched” S

V6

Q
SVT-VT Differential Diagnosis

VT:
- Capture beats, Fusion beats
- VT with the same morphology as VES in SR
- QRS axis < - 30°
- LSB with right axis
- LSB with QRS > 160 ms
- RSB with QRS > 140 ms
- St. p. myocardial infarction
Ablation ? ICD ? Ablation and ICD ?
Right Ventricular Outflow Tract VT (RVOT VT)
Right Ventricular Outflow Tract VT (RVOT VT)

- benign!
- young adults
- structurally normal heart
- LBBB, inferior axis
- often induced with exercise
- mechanism: triggered or automaticity
- therapy: acute: adenosine, vagal manoeuvres
- chronic: beta-Blockers, Ca-antagonists
- success of ablation > 90%
RVOT VT
RVOT VT: Activation Mapping

Ablationssignal

AM prox

ABL dist

22 ms

Page: ABLATION  Speed: 100 mm/s
Left Ventricular Fascicular VT

- benign!
- young men (80%)
- structurally normal heart
- RBBB, left axis deviation
- At rest, sometimes induced with exercise
- Purkinje-reentry
- induction with atrial pacing
- verapamil sensitive
- success of ablation: 85-90%
VT in the absence of structural heart disease
Twelve lead ECG recorded in a patient with RMVT from the LVOT. This electrocardiogram (ECG) illustrates repetitive monomorphic ventricular tachycardia (RMVT) with a right bundle, inferior axis morphology signifying its left ventricular site of origin. This VT was localized to the area of the aorto-mitral continuity in the left ventricular outflow tract (LVOT).
**Idiopathic left ventricular tachycardia**  ILVT originates from the inferior portion of the ventricular septum. Surface leads (I, II, III, V1, and V6), and intracardiac recordings from the high right atrium (HRA), His bundle region (HBE), right ventricular apex (RVA), right ventricular outflow tract (RVOT), and several recordings from the left ventricle at the site of successful ablation (LV fixed, LV var, LV bipol, LV uni) are shown. The presence of a sharp potential in the LV recordings (arrow) is consistent with local activation of the Purkinje system. This potential precedes the onset of the QRS during VT by 40 msec. (Reprinted with permission of Futura Publishing Company.)
Electrocardiogram of an idiopathic left ventricular tachycardia The typical ECG features of an idiopathic left ventricular tachycardia are QRS complexes that are relatively narrow (0.12 sec) and have a right bundle branch morphology (tall R waves in V1 and V2 and a terminal S wave in V5 and V6); the frontal plane axis is extremely leftward (negative QRS complexes in leads II, III and aVF), suggesting a left anterior fascicular block. The tachycardia was localized to the inferior apical left ventricular septum, accounting for the extreme leftward axis.
Patients with a QRS duration $\geq 0.10$ second without criteria for either LBBB or RBBB are classified as having intraventricular conduction disease (IVCD)
Medications

• Bisoprolol 5 mg
• Enalapril 5mg
• Hydrochlorothiazid 25 mg
**Intracardiac recordings in a patient with bundle branch reentrant ventricular tachycardia**  
Shown are five surface ECG leads (I, II, aVF, V1, V6) and intracardiac recordings from the His bundle region (HBE2-3, 1-2), the right ventricular apex (RVA3-4), and a mapping catheter (USER1) positioned distal to the His catheter along the RV septum to record a right bundle potential (arrow). The right bundle potential was recorded 30 ms after the His potential (H). A=atrial electrogram, V=ventricular electrogram.
Radiofrequency catheter ablation of the right bundle branch  Shown are five surface ECG leads (I, II, aVF, V1, V6) and intracardiac recordings from the His bundle region (HBE2–3,1–2), the right ventricular apex (RVA3–4), and a mapping catheter (USER1) positioned distal to the His catheter along the RV septum. Application of radiofrequency (RF) energy to the tip of the mapping catheter causes two accelerated beats with a typical left bundle branch block (LBBB) morphology (black arrow), likely from heating and activating the right bundle branch. After these beats, complete right bundle branch block (RBBB) is present (red arrow), as evidenced by the change in QRS morphology, particularly in lead V1. Following right bundle branch ablation, the HV interval increased to 105 ms, though no infranodal A-V block was noted. Right bundle branch reentrant tachycardia was no longer inducible. A permanent pacemaker was placed because of the markedly prolonged HV interval. H=His bundle electrogram. A=atrial electrogram. V=ventricular electrogram.
Junger Mann mit interm. Herzrasen im Notfall
Seine Tachykardie hat sich spontan terminiert
44 jähriger Mann mit intermittierenden Palpitationen
Breitkomplex Tachykardie mit spontaner Terminierung
Normale Koronarien; EF 25%, globale Hypokinesie

Was ist hier die Diagnose?

A. Atriale Tachykardie
B. AV Knoten Reentry Tachykardie
C. AV Reentry Tachykardie
D. Vorhofflattern
E. Kammertachykardie
Tachykardie QRS ähnlich wie QRS im SR

LSB-Bild und langer PR Intervall
SR → lange PR und LSB

Tachykardie 1 → HF 145/min LSB (ähnlich wie im SR)

Tachykardie 2 → HF 200/min RSB

Dilatative Kardiomyopathie (EF 25%)
Wie würden Sie den Patienten therapieren?

A) Antiarrhythmische Therapie
B) Katheter Ablation
C) ICD
D) [A] und [B]
E) [A] und [C]
F) [B] und [C]
G) [A] und [B] und [C]
Wie würden Sie den Patienten therapieren?

A) Antiarrhythmische Therapie
B) Katheter Ablation
C) ICD
D) [A] und [B]
E) [A] und [C]
F) [B] und [C]
G) [A] und [B] und [C]
Bundle Branch Reentry

- Atrium
- Ventricle
- AV
- His
- RB
- LB
Bundle Branch Reentrant VT

- Macroeentry im His-Purkinje System
- 30% der VTs in dilatativer KMP
- Selten in ischämischer KMP (ca. 5%)
- Rasche Tachykardien (häufig >200/min) → Synkope
- Leitungsstörungen bereits im SR
typischerweise LSB oder nicht-spezifischer IVCD.
HV 70 ms
Bundle Branch Reentrant VT

- Tachykardie meistens mit LSB Morphology
- Auslösbare, monomorphe, terminierbare VT (Reentry)
- VA-Dissoziation
- RF Ablation ist 95% kurativ.
Bundle Branch Reentry

Atrium

AV

His

Ventricle

RB

LB
Follow-up

• Symptomatische Verbesserung
• LVEF
  nach 6 Wochen: 25% -> 45%
  nach 3 Monaten 55%
• Keine adäquate ICD Schocks bisher
38 j. Patient mit interm. Präsynkope

Patient ist sonst kardial gesund
Idiopathische linksventrikuläre VT
Idiopathische linksventrikuläre VT

- strukturell normales Herz
- junge Männer
- RSB, superiore oder rechtsseitige Achse
- benigne!
- getriggert
- Therapie: akut und chronisch: Verapamil
- Ablationserfolg: 85-90%
Ventrikuläre Tachykardien
die abladiertbar sind:

- Bundle Branch Reentry VT
- Rechts Ventrikuläre Ausflusstrakt VT (RVOT VT)
- Idiopathische Links Ventrikuläre VT
Bundle Branch Reentrant VT

• The RBB has been most commonly targeted for ablation because it is easily accessible.
• ECG pattern of LV conduction delay is common, suggesting that antegrade conduction through the RB might be more stable.
• Therefore, ablation of the LB might have a lower risk of AV block.
Bundle Branch Reentrant VT

• On the other hand, there is concern that LBBB may have adverse hemodynamic effects in patients with impaired ventricular function.
• Therefore, RB ablation remains the favored approach for the present.
Bundle Branch Reentrant VT

- In patients with interfascicular VT and focal VT involving the Purkinje system, ablation of the RB is unlikely to be effective.
A  NSR w/LBB disease  

B  BBRT: Expected  

C  BBRT: Observed  

HV < NSR (LBBB Morph)  

HV ≥ NSR (LBBB Morph)
Supraventricular Arrhythmias/Atrial Fibrillation

Class I

1. Sustained atrial fibrillation and atrial flutter in patients with hemodynamic compromise or ongoing ischemia should be treated with one or more of the following:
   a. Synchronized cardioversion with an initial monophasic shock of 200 J for atrial fibrillation and 50 J for flutter, preceded by brief general anesthesia or conscious sedation whenever possible. (Level of Evidence: C)

   b. For episodes of atrial fibrillation that do not respond to electrical cardioversion or recur after a brief period of sinus rhythm, the use of antiarrhythmic therapy aimed at slowing the ventricular response is indicated. One or more of these pharmacological agents may be used:
      i. Intravenous amiodarone. (Level of Evidence: C)

      ii. Intravenous digoxin for rate control principally for patients with severe LV dysfunction and heart failure. (Level of Evidence: C)
Supraventricular Arrhythmias/Atrial Fibrillation

Class I

Sustained atrial fibrillation and atrial flutter in patients with ongoing ischemia but without hemodynamic compromise should be treated with one or more of the following:

a. Beta-adrenergic blockade is preferred, unless contraindicated. (Level of Evidence: C)

b. Intravenous diltiazem or verapamil. (Level of Evidence: C)

c. Synchronized cardioversion with an initial monophasic shock of 200 J for atrial fibrillation and 50 J for flutter, preceded by brief general anesthesia or conscious sedation whenever possible. (Level of Evidence: C)

For episodes of sustained atrial fibrillation or flutter without hemodynamic compromise or ischemia, rate control is indicated. In addition, patients with sustained atrial fibrillation or flutter should be given anticoagulant therapy. Consideration should be given to cardioversion to sinus rhythm in patients with a history of atrial fibrillation or flutter prior to STEMI. (Level of Evidence: C)
Supraventricular Arrhythmias/Atrial Fibrillation

Class I

Reentrant paroxysmal supraventricular tachycardia, because of its rapid rate, should be treated with the following in the sequence shown:

a. Carotid sinus massage. (Level of Evidence: C)

b. Intravenous adenosine (6 mg 1 over 1 to 2 seconds; if no response, 12 mg IV after 1 to 2 minutes may be given; repeat 12 mg dose if needed. (Level of Evidence: C)

c. Intravenous beta-adrenergic blockade with metoprolol (2.5 to 5.0 mg every 2 to 5 minutes to a total of 15 mg over 10 to 15 minutes) or atenolol (2.5 to 5.0 mg over 2 minutes to a total of 10 mg in 10 to 15 minutes). (Level of Evidence: C)

d. Intravenous diltiazem (20 mg [0.25 mg/kg]) over 2 minutes followed by an infusion of 10 mg/h). (Level of Evidence: C)

e. Intravenous digoxin, recognizing that there may be a delay of at least 1 hour before pharmacological effects appear (8 to 15 mcg/kg [0.6 to 1.0 mg in a person weighing 70 kg]). (Level of Evidence: C)
<table>
<thead>
<tr>
<th>ECG</th>
<th>Recommendation*</th>
<th>Classification</th>
<th>Level of Evidence</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow QRS-complex tachycardia (SVT)</td>
<td>Vagal maneuvers</td>
<td>I</td>
<td>B</td>
<td>15, 17, 18</td>
</tr>
<tr>
<td></td>
<td>Adenosine</td>
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<td>Wide QRS-complex tachycardia</td>
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<td>• SVT + BBB</td>
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<td>B</td>
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<td>Beta blockers§</td>
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<td>• Wide QRS-complex tachycardia of unknown origin in patients with poor LV function</td>
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<td>AVNRT with infrequent or single episode in patients who desire complete control of arrhythmia</td>
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<td>Documented PSVT with only dual AV-nodal pathways or single echo beats demonstrated during electrophysiological study and no other identified cause of arrhythmia</td>
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<td>Vagal maneuvers</td>
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<td>Pill-in-the-pocket</td>
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<td>WPW syndrome (with AF and rapid-conduction or poorly tolerated AVRT)</td>
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<td>B. Rate regulation (in absence of digitalis therapy)</td>
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Hemodynamically stable regular tachycardia

Narrow QRS

SVT

- Vagal maneuvers
- IV adenosine†
- IV verapamil/diltiazem
- IV beta blocker

Termination

Yes

No, persistent tachycardia with AV block

- IV ibutilide**
- IV procainamide
- IV flecainide

- plus AV-nodal-blocking agents

or overdrive pacing/DC cardioversion, and/or rate control

Wide QRS

Definite SVT (see narrow QRS)

Pre-excited SVT*

VT or unknown mechanism

- IV procainamide
- IV sotalol
- IV lidocaine
- (IV amiodarone in patients with poor LV function)

Termination

Yes

No

DC cardioversion