Indications for Pacing and Mode Selection

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Pacemaker Indication Classifications

**Class I** – Conditions for which there is evidence and/or general agreement that permanent pacemakers should be implanted

**Class II** – Conditions for which permanent pacemakers are frequently used but there is divergence of opinion with respect to the necessity of their insertion
  - **Class IIa**: Weight of evidence/opinion is in favor of usefulness/efficacy
  - **Class IIb**: Usefulness/efficacy is less well established by evidence/opinion

**Class III** – Conditions for which there is general agreement that pacemakers are unnecessary
Pacemaker Indication Classifications

Evidence supporting current recommendations are ranked as levels A, B, and C:

- **Level A:** Data derived from multiple randomized clinical trials involving a large number of individuals
- **Level B:** Data derived from a limited number of trials involving comparatively small numbers of patients or from well-designed data analysis of nonrandomized studies or observational data registries
- **Level C:** Consensus of expert opinion was the primary source of recommendation
Symptoms

- Syncope or pre-syncope
- Dizziness
- Congestive heart failure
- Mental confusion
- Palpitations
- Shortness of breath
- Exercise intolerance
Sinus Node Dysfunction

- Sinus bradycardia
- Sinus arrest
- SA block
- Brady-tachy syndrome
- Chronotropic incompetence
Persistent slow rate from the SA node. The parameters from this waveform include:

- Rate = 55 bpm
- PR interval = 180 ms (0.18 seconds)
Sinus Node Dysfunction – Sinus Arrest

Failure of sinus node discharge resulting in the absence of atrial depolarization and periods of ventricular asystole

- Rate = 75 bpm
- PR interval = 180 ms (.18 seconds)
- 2.8-second arrest
Sinus Node Dysfunction – SA Exit Block

Transient blockage of impulses from the SA node

- Rate = 52 bpm
- PR interval = 180 ms (.18 seconds)
- 2.1-second pause
Sinus Node Dysfunction – Bradycardia-Tachycardia (Brady-Tachy) Syndrome

Intermittent episodes of slow and fast rates from the SA node or atria

- Rate during bradycardia = 43 bpm
- Rate during tachycardia = 130 bpm
Chronotropic Incompetence

- Max
- Heart Rate
- Rest
- Start Activity
- Time
- Stop Activity
- Quick
- Slow
- Unstable
Sinus Node Dysfunction – Indications for Pacemaker Implantation

Class I Indications

Sinus node dysfunction with documented symptomatic sinus bradycardia

Symptomatic chronotropic incompetence

Class II Indications

Class IIa: Symptomatic patients with sinus node dysfunction and with no clear association between symptoms and bradycardia

Class IIb: Chronic heart rate < 30 bpm in minimally symptomatic patients while awake

Class III Indications

Asymptomatic sinus node dysfunction

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AV Block

First-degree AV block
Second-degree AV block
  – Mobitz types I and II
Third-degree AV block
Bifascicular and trifascicular block
First-Degree AV Block

AV conduction is delayed, and the PR interval is prolonged (> 200 ms or .2 seconds)

- Rate = 79 bpm
- PR interval = 340 ms (.34 seconds)
Second-Degree AV Block – Mobitz I (Wenckebach)

Progressive prolongation of the PR interval until a ventricular beat is dropped

- Ventricular rate = irregular
- Atrial rate = 90 bpm
- PR interval = progressively longer until a P-wave fails to conduct
Second-Degree AV Block – Mobitz II

Regularly dropped ventricular beats

- 2:1 block (2 P waves to 1 QRS complex)
- Ventricular rate = 60 bpm
- Atrial rate = 110 bpm
Third-Degree AV Block

No impulse conduction from the atria to the ventricles

- Ventricular rate = 37 bpm
- Atrial rate = 130 bpm
- PR interval = variable
AV Block – Indications

Class I Indications

3rd degree AV block associated with:

- Symptomatic bradycardia (including those from arrhythmias and other medical conditions)
- Documented periods of asystole ≥ 3 seconds
- Escape rate < 40 bpm in awake, symptom free patients
- Post AV junction ablation
- Post-operative AV block not expected to resolve

Second degree AV block regardless of type or site of block, with associated symptomatic bradycardia
Class II Indications

Class IIa:

- Asymptomatic CHB with a ventricular rate > 40 bpm
- Asymptomatic Type II 2nd degree AV block
- Asymptomatic Type I 2nd degree AV block within the His-Purkinje system found incidentally at EP study
- First-degree AV block with symptoms suggestive of pacemaker syndrome and documented alleviation of symptoms with temporary AV pacing

Class IIb:

- First degree AV block > 300 ms in patients with LV dysfunction in whom a shorter AV interval results in hemodynamic improvement
AV Block – Indications

Class III Indications

Asymptomatic 1st degree AV block

Asymptomatic Type I 2nd degree AV block at supra-His level

AV block expected to resolve and unlikely to recur (e.g., drug toxicity, Lyme Disease)
Bifascicular Block

Right bundle branch block and left posterior hemiblock
Bifascicular Block

Right bundle branch block and left anterior hemiblock
Bifascicular Block

Complete left bundle branch block
Trifascicular Block

Complete block in the right bundle branch and complete or incomplete block in both divisions of the left bundle branch.
Class I Indications

- Intermittent 3rd degree AV block
- Type II 2nd degree AV block

Class II Indications

Class IIa:
- Syncope not proved to be due to AV block when other causes have been excluded, specifically VT
- Prolonged HV interval (≥100 ms)
- Pacing-induced infra-His block that is not physiological

Class IIb: None

Class III Indications

- Asymptomatic fascicular block without AV block
- Asymptomatic fascicular block with 1st degree AV block
Neurocardiogenic Syncope

Carotid Sinus Syndrome (CSS)

Vasovagal Syncope (VVS)
Hypersensitive Carotid Sinus Syndrome (CSS)

Extreme reflex response to carotid sinus stimulation
Results in bradycardia and/or vasodilation

Can be induced by:
- Tight collar
- Shaving
- Head turning
- Exercise
- Other activities that stimulate the carotid sinus
Mechanisms of Neurocardiogenic Syncope

Cardioinhibitory
- Initiated by inappropriate drop in heart rate

Vasodepressor
- Symptomatic decrease in systolic blood pressure due to vasodilation

Mixed
- Includes components of cardioinhibitory and vasodepressor
Vasovagal Syncope (VVS)

Neurally mediated transient loss of consciousness
Can be precipitated by:
  – Fear, anxiety
  – Physical pain or anticipation of trauma/pain
  – Prolonged standing
Symptoms include:
  – Dizziness
  – Blurred vision
  – Weakness
  – Nausea, abdominal discomfort
  – Sweating
CSS and VVS – Indications

Class I Indications

Recurrent syncope caused by carotid sinus stimulation; minimal carotid sinus pressure induces a period of asystole > 3 seconds in duration (CSS)
Class II Indications

Class IIa:
- Recurrent syncope without clear, provocative events and with a hypersensitive cardioinhibitory response
- Syncope of unexplained origin when major abnormalities of sinus node function or AV conduction are discovered or provoked in EP studies

Class IIb:
- Neurally mediated syncope with significant bradycardia reproduced by a head-up tilt table testing (VVS)
CSS and VVS – Indications

Class III Indications

Asymptomatic with a positive response to carotid sinus massage (CSS)

Recurrent syncope, lightheadedness, or dizziness without a cardioinhibitory response (CSS/VVS)

Situational vasovagal syncope in which avoidance behavior is effective

Vague symptoms such as dizziness, light-headedness, or both, with hyperactive cardioinhibitory response to CS stimulation
Pacing After Cardiac Transplantation

Class I Indications
Symptomatic bradyarrhythmias/chronotropic incompetence not expected to resolve and meets other Class I indications for permanent pacing

Class II Indications
Class IIa: None

Class IIb: Symptomatic bradyarrhythmias/chronotropic incompetence that, although transient, may persist for months and require intervention

Class III Indications
Asymptomatic bradyarrhythmias

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AV Block Associated with Myocardial Infarction – Indications

**Class I Indications**
- Persistent and symptomatic 2nd or 3rd degree AV block
- Persistent Type 2nd degree AV block in the His-Purkinje system with bilateral BBB or 3rd degree AV block within or below the His-Purkinje system
- Transient advanced 2nd or 3rd degree infranodal AV block and associated bundle branch block

**Class II Indications**

- **Class IIa**: None
- **Class IIb**: Persistent 2nd or 3rd degree AV block at the AV node level

**Class III Indications**
- Transient AV block in absence of intraventricular conduction defect
- Pre-existing 1st degree AV block with bundle branch block
Advanced second- or third-degree AV block associated with symptomatic bradycardia, congestive heart failure, or low cardiac output

Sinus node dysfunction with correlation of symptoms during age inappropriate bradycardia; the definition of bradycardia varies with the patient’s age and expected heart rate

Postoperative advanced second- or third-degree AV block that is not expected to resolve or persists at least 7 days after cardiac surgery
Class I Indications

Congenital third-degree AV block with a wide QRS escape rhythm or ventricular dysfunction

Congenital third-degree AV block in the infant with a ventricular rate < 50 to 55 bpm or with congenital heart disease and a ventricular rate < 70 bpm

Sustained pause-dependent VT, with or without prolonged QT, in which the efficacy of pacing is thoroughly documented
Class II Indications

Class IIa:

- Bradycardia-tachycardia syndrome with the need for long-term antiarrhythmic treatment other than digitalis
- Congenital third-degree AV block beyond the first year of life with an average heart rate < 50 bpm or abrupt pauses in ventricular rate that are two or three times the basic cycle length
- Long QT syndrome with 2:1 AV or third-degree AV block
- Asymptomatic sinus bradycardia in the child with complex congenital heart disease with resting heart rate < 35 bpm or pauses in ventricular rate > 3 seconds
Class IIb Indications

- Transient postoperative third-degree AV block that reverts to sinus rhythm with residual bifascicular block

- Congenital third-degree AV block in the asymptomatic neonate, child, or adolescent with an acceptable rate, narrow QRS complex and normal ventricular function

- Asymptomatic sinus bradycardia in the adolescent with congenital heart disease with resting heart rate < 35 bpm or pauses in ventricular rate > 3 seconds
Children and Adolescents

Class III Indications

Transient postoperative AV block with return of normal AV conduction within 7 days

Asymptomatic postoperative bifascicular block with or without first degree AV block

Asymptomatic Type I second-degree AV block

Asymptomatic sinus bradycardia in the adolescent when the longest RR interval is < 3 seconds and the minimum heart rate is > 40 bpm
Summary of Pacemaker Indications

- Sinus node dysfunction
- AV block
- Bifascicular and trifascicular block
- Hypersensitive Carotid Sinus Syndrome (CSS)
- Vasovagal Syncope (VVS)
- Pacing after cardiac transplantation
- AV block associated with myocardial infarction
- Children and adolescents
<table>
<thead>
<tr>
<th>I Chamber Paced</th>
<th>II Chamber Sensed</th>
<th>III Response to Sensing</th>
<th>IV Programmable Functions/Rate Modulation</th>
<th>V Antitachy Function(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V: Ventricle</td>
<td>V: Ventricle</td>
<td>T: Triggered</td>
<td>P: Simple programmable</td>
<td>P: Pace</td>
</tr>
<tr>
<td>D: Dual (A+V)</td>
<td>D: Dual (A+V)</td>
<td>D: Dual (T+I)</td>
<td>C: Communicating</td>
<td>D: Dual (P+S)</td>
</tr>
<tr>
<td>O: None</td>
<td>O: None</td>
<td>O: None</td>
<td>R: Rate modulating</td>
<td>O: None</td>
</tr>
<tr>
<td>S: Single (A or V)</td>
<td>S: Single (A or V)</td>
<td>O: None</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mode Selection Decision Tree

1. Symptomatic bradycardia
   - Are atrial tachyarrhythmias present?
     - No
     - Yes
       - Is AV conduction intact?
         - No
         - Yes
           - Is SA node function presently adequate?
             - No
             - Yes
               - AAIR
               - DDDR
     - Yes
       - DDIR with SV PVARP
       - DDDR with MS
2. Is AV conduction intact?
   - No
   - Yes
     - Are they chronic?
       - No
       - Yes
         - VVI
         - VVIR
     - Is SA node function presently adequate?
       - No
       - Yes
         - DDD, VDD
         - DDDR

Note: (SSS) and (CSS, VVS) for specific cases.
Determining the Optimal Pacing
Mode: Mrs. Peacock

Patient information:

- Documented symptomatic sinus bradycardia
- When exercise tested, rate does not increase appropriately with increasing work loads
- At present, AV conduction is intact
Patient information:

- Professor Plum has intermittent 2nd degree Type II AV block with symptoms
- Professor Plum’s atrial rate responded appropriately to an exercise test
Determining the Optimal Pacing
Mode: Colonel Mustard

Patient information:

- Colonel Mustard has complete heart block and intermittent atrial flutter
- Colonel Mustard’s heart rate does not reach 100 bpm in response to an exercise stress test
Patient information:

- Mr. Green has brady-tachy syndrome with intact AV conduction
- Mr. Green’s heart rate does not reach 100 bpm in response to an exercise stress test
Patient information:

- Mrs. White has chronic atrial fibrillation with an irregular ventricular rate
- Mrs. White’s heart rate does not reach 100 bpm in response to an exercise stress test
Documented episode of cardiac arrest due to ventricular fibrillation without a preceding reversible cause. (Secondary prevention)

Documented sustained ventricular tachycardia (secondary prevention)
Documented familial or inherited conditions with a high risk of life threatening VT such as familial long QT syndrome or familial hypertrophic cardiomyopathy
Coronary artery disease with a documented prior MI, a measured LVEF $\leq 0.35$ and inducible, sustained VT or VF at EP study. (MADIT I, MUSTT)

The MI must precede implantation $> four$ weeks
Indications for ICD (cont.)

Documented prior MI and a measured LVEF \( \leq 0.30 \). (MADIT II)

The MI must precede implantation > four weeks

Coronary intervention or revascularization surgery must precede implantation > three months.
Indications for ICD (cont.)

Patients with ischemic cardiomyopathy NYHA class II or III CHF and a measured LVEF \( \leq 0.35 \) (SCD-HeFT)

Patients with non-ischemic dilated cardiomyopathy > nine months, NYHA class II or III CHF and a measured LVEF \( \leq 0.35 \) (SCD-HeFT)
Patients who meet all current CMS coverage requirements for cardiac resynchronization therapy (CRT) device and have NYHA class IV CHF. (COMPANION)
Conclusion

Current indications for device therapy is based upon large clinical trials.

Future direction may focus upon hemodynamic monitoring to assist with the treatment of CHF.
The Chronicle ®

Diagram showing various cardiac parameters:
- R-R Interval
- RV Unipolar EGM
- PA Pressure
- RV Pressure
- RV +dP/dt
- RV dP/dt

Medtronic ®
Mode Selection for Optimal Pacing Therapy
Providing Optimal Pacing Therapy

- Heart rate increase
- Stroke volume maximization
- Atrial based pacing
- Normal ventricular activation sequence
Cardiac Output

\[ CO = HR \times SV \]
Heart Rate

Heart Rate (BPM) vs. Cardiac Output (L/Min)

## Proven Benefits of Atrial Based Pacing

<table>
<thead>
<tr>
<th>Study</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higano <em>et al.</em> 1990</td>
<td>Improved cardiac index during low level exercise (where most patient activity occurs)</td>
</tr>
<tr>
<td>Gallik <em>et al.</em> 1994</td>
<td>Increase in LV filling</td>
</tr>
<tr>
<td>Santini <em>et al.</em> 1991</td>
<td>30% increase in resting cardiac output</td>
</tr>
<tr>
<td>Rosenqvist <em>et al.</em> 1991</td>
<td>Decrease in pulmonary wedge pressure</td>
</tr>
<tr>
<td></td>
<td>Increase in resting cardiac output</td>
</tr>
<tr>
<td>Sulke <em>et al.</em> 1992</td>
<td>Increase in resting cardiac output, especially in patients with poor LV function</td>
</tr>
<tr>
<td></td>
<td>Decreased incidence of mitral and tricuspid valve regurgitation</td>
</tr>
</tbody>
</table>
# Proven Benefits of Atrial Based Pacing

<table>
<thead>
<tr>
<th>Study</th>
<th>Results</th>
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<tbody>
<tr>
<td>Rosenquist 1988</td>
<td>Less atrial fibrillation (AF), less CHF, improved survival after 4 years compared to VVI</td>
</tr>
<tr>
<td>Santini 1990</td>
<td>Less AF, improved survival after 5 years average</td>
</tr>
<tr>
<td>Stangl 1990</td>
<td>Less AF, improved survival after 5 years compared to VVI</td>
</tr>
<tr>
<td></td>
<td>Suppression of atrial dysrhythmias</td>
</tr>
<tr>
<td>Zanini 1990</td>
<td>Improved morbidity (less AF, CHF, embolic events) after 3 plus years, compared to VVI</td>
</tr>
</tbody>
</table>
Patient Mode Preference

- DDDR 59%
- DDIR 13%
- Any Dual 9%
- No Preference 9%
- VVIR 5%
- DDD 5%

Ventricular Activation Sequence

Normal Sequence

Paced Sequence
Mode Selection for Optimal Pacing Therapy
Is AV conduction intact?

If Yes, follow DDIR with SVPVARP

If No, follow DDDR with MS

Is AV conduction intact?

If Yes, follow VVI or VVIR

If No, follow DDD, VDD DDDR

Are atrial tachyarrhythmias present?

If Yes, follow Symptomatic bradycardia

If No, follow Is AV conduction intact?

Is SA node function presently adequate?

If Yes, follow AAIR DDRR

If No, follow (SSS) DDD, DDI with RDR

Are they chronic?

If Yes, follow VVI or VVIR

If No, follow DDD, VDD DDDR

Is SA node function presently adequate?

If Yes, follow DDD, VDD DDDR

If No, follow DDDR

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N

Y N
Mode Selection Decision Tree: Mrs. Peacock

Symptomatic bradycardia

Are atrial tachyarrhythmias present?

Is AV conduction intact?

Are they chronic?

Is SA node function presently adequate?

- Y: VVI, VVIR
- N: AAIR, DDDR

- Y: DDDR, VDD DDDR
- N: DDDR with MS, DDIR with SVPVARP

- Y: DDD, DDI with RDR
- N: (CSS, VVS)
Mode Selection Decision Tree: Mrs. Peacock

Symptomatic bradycardia

Are atrial tachyarrhythmias present?

Is AV conduction intact?

Is SA node function presently adequate?

Are they chronic?

Is SA node function presently adequate?

DDIR with SVPVARP

DDDR with MS

Is AV conduction intact?

Are they chronic?

Is SA node function presently adequate?

Y

N

Y

N

Y

N

Y

N

Y

N

Y

N

N

(NSS)

(NSS, VVS)

AAIR

DDDR

DDDR, DDI with RDR

DDD, VDD

DDD DR

VVI

VVIR

IDD, VDD

DDD DR
## Optimal Mode Selection Evaluation: Mrs. Peacock (AAIR or DDDR)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Yes</th>
<th>No</th>
</tr>
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<tbody>
<tr>
<td>Provides heart rate increases?</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Provides opportunity for stroke volume maximization?</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Promotes atrial electrical stability?</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Allows normal ventricular activation sequence?</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Mode Selection Decision Tree:
Prof. Plum

- Symptomatic bradycardia
  - Are atrial tachyarrhythmias present?
    - N
    - Y
      - Is AV conduction intact?
        - N
          - AAIR
          - DDDR
        - Y
          - DDIR with SVPVARP
          - DDDR with MS

- Is AV conduction intact?
  - N
    - N
      - DDD, VDD
    - Y
      - DDD, VDD DDDR

- Is SA node function presently adequate?
  - N
    - N
      - (SSS)
      - (CSS, VVS)
  - Y
    - VVI

- Are they chronic?
  - Y
    - VVI
    - VVIR
  - N
    - DDDR
Mode Selection Decision Tree: Prof. Plum

- Symptomatic bradycardia
  - Are atrial tachyarrhythmias present?
    - N
    - Y
      - Is AV conduction intact?
        - N
        - Y
          - Is SA node function presently adequate?
            - N (SSS)
            - N (CSS, VVS)
              - AAIR
              - DDD, DDI with RDR
            - Y
              - DDD, VDD
              - DDDR
            - N
              - DDDR
- DDIR with SVPVARP
  - DDDR with MS
- Is AV conduction intact?
  - N
  - Y
    - Are they chronic?
      - N
      - Y
        - Is SA node function presently adequate?
          - N
          - Y
            - VVI
            - VVIR
          - N
            - DDDR
Symptomatic bradycardia

Are atrial tachyarrhythmias present?

Is AV conduction intact?

Is SA node function presently adequate?

Are they chronic?

Is AV conduction intact?

Is SA node function presently adequate?

AAIR DDDR

DDD, DDI with RDR

DDIR with SVPVARP

DDDR with MS

VVI VVIR

DDD, VDD DDDR

DDD
## Optimal Mode Selection Evaluation: Professor Plum (DDD, VDD, or DDDR)

<table>
<thead>
<tr>
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<tr>
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<td>✓</td>
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</tbody>
</table>
Mode Selection Decision Tree: Colonel Mustard

- **Symptomatic bradycardia**
  - Are atrial tachyarrhythmias present? [N]
  - Is AV conduction intact? [N] → (SSS)
    - AAIR
    - DDDR
  - Is SA node function presently adequate? [N] → (CSS, VVS)
    - DDD, VDD
    - DDDDR

- **DDIR with SVPVARP**
  - Is AV conduction intact? [Y] → VVI
    - VVIR
  - DDDDR with MS

- **Is AV conduction intact?**
  - Y → Are they chronic? [Y] → VVI
    - VVIR
  - N → Is SA node function presently adequate? [N] → DDD
    - DDDDR
  - Y → DDD, VDD
    - DDDDR
Symptomatic bradycardia

Are atrial tachyarrhythmias present?

Y N

Is AV conduction intact?

Y N

Is SA node function presently adequate?

Y N

Are they chronic?

Y N

Is AV conduction intact?

Y N

Is SA node function presently adequate?

Y N

Mode Selection Decision Tree:

Collected Mustard
Mode Selection Decision Tree: Colonel Mustard

Symptomatic bradycardia

Are atrial tachyarrhythmias present? N Y

Is AV conduction intact? N Y

Is SA node function presently adequate? N Y

Are they chronic? N Y

Is AV conduction intact? N Y

Is SA node function presently adequate? N Y

DDIR with SVPVARP

DDDR with MS

Y N

VVI VVIR

VDD DDDR

DDD, DDI with RDR

AAIR DDDR

(SSF, CSS, VVS)
## Optimal Mode Selection Evaluation: Colonel Mustard (DDDR with Mode Switch)

<table>
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<tr>
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<tr>
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<td>✓</td>
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</tbody>
</table>
Mode Selection Decision Tree: Mr. Green

- Symptomatic bradycardia
  - Are atrial tachyarrhythmias present?
    - No
    - Is AV conduction intact?
      - No
        - Is SA node function presently adequate?
          - No (SSS)
            - AAIR
          - (CSS, VVS)
            - DDD, DDI with RDR
        - Yes
          - Are they chronic?
            - Yes
              - VVI VVIR
            - No
              - Is SA node function presently adequate?
                - Yes
                  - DDD, VDD DDDR
                - No
                  - DDDR
Mode Selection Decision Tree: Mr. Green

Symptomatic bradycardia

Are atrial tachyarrhythmias present?

Is AV conduction intact?

Is SA node function presently adequate?

Y

Y

Y

N

Y

N

N

N

N

N

N

Y

Y

N

Y

N

Y

N

N

N

N

Is AV conduction intact?

Are they chronic?

Is SA node function presently adequate?

DDIR with SVPVARP

DDDR with MS

VVI

VVIR

AAIR

DDDR

DD, VDD

DDDR

DDD, DDI with RDR

(SSS)

(CSS, VVS)

(SSF)
Mode Selection Decision Tree:
Mr. Green

- Symptomatic bradycardia
  - Are atrial tachyarrhythmias present?
    - N
    - Y
      - Is AV conduction intact?
        - N
        - Y
          - Are they chronic?
            - N
            - Y
              - Is SA node function presently adequate?
                - N
                - Y
                  - DDD, VDD DDDR
                  - DDDR
                  - VVI
                  - VVIR
                - (SSS)
                - (CSS, VVS)
                - AAIR
                - DDDR, VDD DDDR
              - (SSS)
              - (CSS, VVS)
            - Y
              - DDDR with SVPVARP
              - DDDR with MS
            - N
              - DDD, DDI with RDR
## Optimal Mode Selection Evaluation: Mr. Green (DDIR with Sensor Varied PVARP)

<table>
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</tr>
<tr>
<td>Allows normal ventricular activation sequence?</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>
Mode Selection Decision Tree: Mrs. White

Symptomatic bradycardia

Are atrial tachyarrhythmias present?

N

Is AV conduction intact?

N

Are they chronic?

Y

VVI

VVIR

N

Is SA node function presently adequate?

Y

DDD, VDD

DDD, VDD

DDD, VDD

N

N

DDDR with SVPVARP

Y

DDDR with MS

N

Is AV conduction intact?

Y

N

Are they chronic?

Y

VVI

VVIR

N

Is SA node function presently adequate?

Y

DDD, VDD

DDD, VDD

DDD, VDD

N

N

DDDR

N

(VSS)

(CSS, VVS)

AAIR

DDDR

DDDR

DDDR

DDDR
Mode Selection Decision Tree: Mrs. White

Symptomatic bradycardia

Are atrial tachyarrhythmias present?

N

Is AV conduction intact?

Y

Is SA node function presently adequate?

N (SSS)

AAIR DDDR

N (CSS, VVS)

DDD, DDI with RDR

Y

DDIR with SVPVARP

Y

Is AV conduction intact?

N

Are they chronic?

Y

VVI VVIR

N

Is SA node function presently adequate?

Y

DDD, VDD DDDR

N

DDD
# Optimal Mode Selection Evaluation: Mrs. White (VVI or VVIR)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides heart rate increases?</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Provides opportunity for stroke volume maximization?</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Promotes atrial electrical stability?</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Allows normal ventricular activation sequence?</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Pacing Technologies for Newer Pacing Indications
Pacing in Patients with Hypersensitive Carotid Sinus Syndrome (CSS)

AAI pacing is contraindicated because 70% of CSS patients exhibit reflex AV block.

VVI is prone to causing pacemaker syndrome in CSS patients.

DDD or DDI pacing are better modes for most CSS patients because they maintain AV synchrony and rate support.
Pacing in Patients with Vasovagal Syncope (VVS)

Because cardioinhibitory VVS is associated with bradycardia or asystole, high-rate pacing may be an effective therapy

Class II indication

Pacing is not indicated for pure vasodepressor VVS
Rate Drop Response Therapy
Summary of Indications and Mode Selection Module

- Impulse formation and conduction disturbances
- Indications for pacing therapy
- Mode selection for optimal pacing therapy
- New indications and technologies available for pacing therapy
Indications and Mode Selection
Objectives:

- Identify indications for permanent cardiac pacing
- Discuss components of optimal pacing therapy
- Describe the NBG pacing code
- Select the best pacing mode for optimal pacing therapy
- Discuss the new indications and new technologies available for pacing therapy
Normal Heart Function

Sinoatrial Node
Normal Heart Function

Atrioventricular Node
Normal Heart Function

Bundle of HIS
Normal Heart Function

Left Bundle Branch (LBB)
Posterior Fascicle of LBB
Anterior Fascicle of LBB
Right Bundle Branch (RBB)
Normal Heart Function

Purkinje Fibers
Normal Heart Function
Normal Heart Function
Intervals Are Often Expressed in Milliseconds

One millisecond = 1 / 1,000 of a second
Converting Rates to Intervals and Vice Versa

Rate to interval (ms):

- \( 60,000 / \text{rate (in bpm)} = \text{interval (in milliseconds)} \)
- Example: \( 60,000 / 100 \text{ bpm} = 600 \text{ milliseconds} \)

Interval to rate (bpm):

- \( 60,000 / \text{interval (in milliseconds)} = \text{rate (bpm)} \)
- Example: \( 60,000 / 500 \text{ ms} = 120 \text{ bpm} \)
Normal Sinus Rhythm

Atrial rate: 60-100 bpm
- PR interval: 120-200 ms (.12-.20 seconds)
- QRS interval: 60-100 ms (.06-.10 seconds)
- QT interval: 360-440 ms (.36-.44 seconds)
Other Indications