CMC Certification Review
Arrhythmias and Arrhythmia Therapy

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Bradycardias & Blocks
Sinus Node: 60-100 bpm
AV Junction: 40-60 bpm

AV Blocks:
• In the AV node
• Below the AV node

Ventricular escape rhythms: 20-40 bpm

Bradycardias

• Sinus bradycardia
• Sick sinus syndrome
• Junctional rhythm
• 2\textsuperscript{nd} and 3\textsuperscript{rd} degree AV block
• Atrial fibrillation or flutter with high grade AV block
• Ventricular escape rhythms
Bradycardias

- Heart rate < 60
  - Normal in many people
- Don’t treat unless symptomatic
  - Fatigue
  - Dyspnea
  - Dizziness
  - Hypotension
  - Syncope

Drugs That Can Cause Bradycardia

- Beta blockers
  - “olols” (propranolol, metoprolol, atenolol, etc)
- Calcium channel blockers
  - Verapamil, diltiazem
- Antiarrhythmics
  - Amiodarone, propafenone, sotalol, others
- Digitalis
**Sick Sinus Syndrome**
*(Brady-tachy Syndrome)*

- Periods of alternating fast and slow sinus rhythm
- Periods of sinus arrest – long pauses
- Intermittent tachyarrhythmias
  - Atrial flutter
  - Atrial fibrillation
  - SVT

**Causes of SSS**

- Inflammatory cardiac disease
- Cardiomyopathy
- Degeneration of sinus node and conduction system
- Drugs
  - Beta blockers
  - Calcium blockers
  - Antiarrhythmics
Classification of AV Blocks

- 1\textsuperscript{st} Degree
- 2\textsuperscript{nd} Degree
  - Type I
  - Type II
- High Grade (Advanced)
- 3\textsuperscript{rd} Degree
Second Degree AV Block

- One P wave at a time is blocked
- Type I = pathology is usually in the AV node
- Type II = pathology is always below the AV node

2nd Degree AV Block – Type I Wenckebach

- One P wave at a time fails to conduct to ventricles
- Block usually occurs in AV node
- PR intervals progressively lengthen on consecutively conducted beats until one P wave is blocked
- QRS usually narrow (unless BBB)
- “Group Beating”
• Causes
  – Drugs that slow AV conduction (digoxin, beta blockers, calcium blockers)
  – Inferior MI
  – Aortic or mitral valve disease (or surgery)
• Usually asymptomatic and temporary
• Ventricular rate may be slow if conduction ratio = 2:1
Second Degree AV Block
Type II

- One P wave at a time fails to conduct
- Sudden failure of conduction without progressively increasing PR intervals
- QRS usually wide
- Block occurs below the AV node (usually bilateral bundle branch block)

Second Degree Type II

- Causes
  - Chronic degeneration of conduction system
  - Anterior wall MI
  - Disruption of bundle branches during cardiac surgery or interventional procedures
- Much less common but more dangerous than Type I
- Often requires permanent pacing
Second Degree Type II

- Treatment
  - Temporary transvenous pacing
    - May need transcutaneous pacing until transvenous can be initiated
  - Atropine usually doesn’t work and could make situation worse

Atropine ↑ sinus rate and ↑ conduction through AV node but has no effect below AV node where the pathology is located.
High Grade (Advanced) AV Block

- Two or more consecutive P waves are blocked
  - Atrial rate must be “reasonable”: < 135
- If block occurs in AV node = Type I
- If block occurs below AV node = Type II
- Ventricular rate usually quite slow

![Not high grade block!](image1)

![This is high grade block](image2)
Third Degree AV Block
(Complete Block)

- No P waves conduct to ventricles
- QRS is narrow if junctional escape pacemaker
- QRS wide if ventricular escape pacemaker

3rd Degree AV Block

- Causes
  - Acute MI
  - Chronic degeneration of conduction system
  - Congenital
  - Drugs
- Treatment
  - Pacing
## AV BLOCKS

<table>
<thead>
<tr>
<th>Type of Block</th>
<th>Number of P Waves Dropped</th>
<th>P-R Interval</th>
<th>QRS Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Degree</td>
<td>None</td>
<td>Long, constant</td>
<td>Normal unless BBB present</td>
</tr>
<tr>
<td>Second Degree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type I</td>
<td>1 at a time</td>
<td>Progressive increase (except with 2:1 conduction)</td>
<td>Normal unless BBB present</td>
</tr>
<tr>
<td>Type II</td>
<td>1 at a time</td>
<td>Constant (usually normal)</td>
<td>Usually wide (unless intra-His block present)</td>
</tr>
<tr>
<td>High Grade</td>
<td>2 or more in a row</td>
<td>Normal or long, constant</td>
<td>Normal if Type I, wide if Type II</td>
</tr>
<tr>
<td>Third Degree</td>
<td>All</td>
<td>No relationship</td>
<td>Normal if junctional escape rhythm, wide if ventricular escape rhythm</td>
</tr>
</tbody>
</table>
Treatment of Symptomatic Bradycardia

- Atropine 0.5 IV
  - ↑ rate of sinus node or junctional pacemaker
  - Speeds AV conduction if there is any
  - Does not work for 3rd degree block or Type II block
- Pacing
  - External
  - Temporary transvenous or epicardial
  - Permanent

Indications for Pacing

- Symptomatic bradycardia
  - Sinus node dysfunction
  - AV conduction system dysfunction
  - Drug induced bradycardia
Indications for Pacing

- Hypersensitive Carotid Sinus Syndrome
- Arrhythmia Suppression
  - Torsades de Pointes
  - Congenital Long QT Syndrome
- Cardiomyopathy
- Heart Failure (bi-ventricular pacing)
- Antitachycardia Pacing

Types of Permanent Pacemakers

- **Single chamber** – one pacing lead, usually in the ventricle but can be in the atrium
- **Dual chamber** – two pacing leads, one in the right atrium and one in the right ventricular apex
- **Biventricular** – three pacing leads, one in the right atrium, one in the right ventricular apex, and one inserted via the coronary sinus into a lateral or posterior LV vein for pacing the left ventricle
Temporary Pacemakers

- External Pacing via two large adhesive pads placed on the chest. (Intended for emergency use and is only used until transvenous pacing can be established)

- Transvenous pacing - lead inserted via a peripheral or central vein into the RV apex for ventricular pacing

- Epicardial pacing - pacing leads tacked on to the atria and/or ventricles during cardiac surgery and pulled through the chest wall so they can be accessed when needed

Pacemaker code

<table>
<thead>
<tr>
<th>Position I: Chamber Paced</th>
<th>Position II: Chamber Sensed</th>
<th>Position III: Response to Sensing</th>
</tr>
</thead>
<tbody>
<tr>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
</tr>
<tr>
<td>A = Atrium</td>
<td>A = Atrium</td>
<td>T = Triggered</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
<td>I = Inhibited</td>
</tr>
<tr>
<td>D = Dual (A + V)</td>
<td>D = Dual (A + V)</td>
<td>D = Dual (T + I)</td>
</tr>
</tbody>
</table>
Position IV: Rate Modulation

<table>
<thead>
<tr>
<th>O = None</th>
<th>O = None</th>
</tr>
</thead>
<tbody>
<tr>
<td>R = Rate Modulation</td>
<td>A = Atria</td>
</tr>
<tr>
<td></td>
<td>V = Ventricles</td>
</tr>
<tr>
<td></td>
<td>D = Dual (A &amp; V)</td>
</tr>
</tbody>
</table>

Position V: Multisite Pacing

• Most common pacing modes:
  – VVI – single chamber ventricular pacing for patients with chronic atrial fibrillation
    • Commonly used mode for temporary pacing in MI or cardiac surgery patients
  – DDD – dual chamber pacing indicated in most patients
    • Maintains AV synchrony
    • Supports rate in bradycardia
    • Can be done with epicardial atrial and ventricular wires post cardiac surgery
Main Functions of a Pacing System

- **Capture** – ability of the pacing stimulus to depolarize the chamber being paced.
  - ECG shows pacing spike immediately followed by either a P wave or a QRS complex
- **Sensing** – ability of the pacemaker to recognize and respond to intrinsic cardiac depolarizations

Asynchronous / Fixed Rate

- No sensing occurs
- Pacemaker paces at the set rate regardless of patient’s own intrinsic rhythm
  - Potential for pacing on T wave and causing VT/VF
Demand / Inhibited

- Pacemaker senses intrinsic activity (P waves or QRS complexes)
- Pacemaker only paces when intrinsic activity is slower than rate set in pacemaker (on demand)

What Type of Pacing is Indicated?

- If your patient has atrial and ventricular epicardial wires, which ones would you use for each of these situations?
Initiating Transvenous Pacing

- Connect negative terminal of pacemaker to distal end of pacing wire
- Connect positive terminal of pacemaker to proximal end of pacing wire
- Set rate 60-80 (or ordered rate)
- Set output 2-3 times higher than capture threshold
- Set sensitivity at 2 mV

Initiating Epicardial Pacing

- Connect the negative terminal of the pacemaker to an epicardial wire on the ventricle
- Connect the positive terminal of pacemaker to another ventricular epicardial wire (or to the ground wire if only one ventricular wire is present)
- Set rate 60-80
- Set output at 5 mA, then 2-3 time higher than capture threshold
- Set sensitivity at 2 mV
Capture

- Pacing stimulus results in depolarization of chamber being paced
- Each spike should be followed by a QRS unless it falls in heart’s refractory period

Loss of Capture

- Increase mA until capture achieved then set 2-3 times threshold
- Reposition patient until pacing wire can be repositioned
Sensing

- Pacemaker sees and responds to intrinsic activity
- Must be given opportunity to sense
  -- Must be in demand mode
  -- Must be intrinsic activity to be sensed

Loss of Sensing

- Increase sensitivity by turning sensitivity dial clockwise (makes the mV number smaller – pacemaker can see smaller signals)
Oversensing

- Pacer sensitivity is too high so it sees extraneous electrical signals that it thinks are QRSs and inhibits its output
  - Decrease sensitivity (turn mV number higher - counterclockwise)
  - Decrease mA if set very high
  - Verify lead position with X-ray (may be sensing P waves)

Tachycardias: Supraventricular & Ventricular
Types of SVT

- Sinus Tachycardia
- Atrial Tachycardia
- Atrial Flutter
- Atrial Fibrillation
- Junctional Tachycardia
- AV Nodal Reentry Tachycardia (AVNRT)
- Circus Movement Tachycardia (CMT)

Narrow QRS Tachycardias

Atrial Tachycardia
- P waves visible in front of QRS or may be hidden in T wave
- Atrial rhythm is regular: 150-250
- Ventricular rate usually same (unless AV block present)

Atrial Flutter
- Atrial rate 250-350 with flutter waves
- Ventricular rhythm regular or irregular
- Ventricular rate depends on amount of AV block: 150 or lower

Atrial Fibrillation
- Atrial rate very fast with irregular fib waves
- Ventricular rhythm always irregular
- Ventricular rate depends on amount of AV block: can be up to 200 or so

Ca++ blocker or beta blocker best therapy (Diltiazem)  Adenosine not appropriate
Narrow QRS Tachycardias

**AV Nodal Reentry Tachycardia**
- Regular at rates 140-200
- P waves usually not seen (sometimes peek out at end of QRS)
- Term "SVT" appropriate
- AV node is part of reentry circuit that maintains the tachycardia

**Circus Movement Tachycardia**
- Regular at rates 140-280
- P waves not easily seen – appear in ST segment when seen
- Term "SVT" is appropriate
- AV node is part of reentry circuit that maintains the tachycardia

Vagal maneuver
Adenosine is appropriate
Beta blocker or Ca++ blocker also work

Accessory Pathways
Impulse Conduction Over AP During NSR

Preexcitation

Maximal Preexcitation

Concealed AP

Posterior Accessory Pathway
Anterior Accessory Pathway

Arrhythmias Associated with Accessory Pathways

- Treatment: adenosine, beta blockers, verapamil, diltiazem
- Treatment: try adenosine, beta blockers, amiodarone
- Treatment: cardiovert, amiodarone, procainamide, AVOID AV nodal blockers!
Causes of Wide QRS

- Bundle Branch Block
- Ventricular Rhythm
- Accessory Pathway Conduction

Monomorphic VT

Treatment:
- Defibrillate if pulseless
- Sedate and cardiovert if hemodynamically unstable but not unconscious
  - Amiodarone is drug of choice
  - Lidocaine still OK but not drug of choice
  - ICD is treatment of choice for recurrent VT not responsive to drug therapy
Polymorphic VT
(normal QT interval)

Treatment:
• Treat ischemia
• Correct electrolytes
• Beta blockers often helpful
• Lidocaine often effective if ischemic VT
• Amiodarone OK if QT is normal
• Defibrillate if it becomes sustained with loss of consciousness

QT = 320 ms  QTc = 414 ms

Torsades de Pointes
(long QT interval)

Treatment:
• Defibrillate if sustained with loss of consciousness
• Correct underlying cause
  • DC suspicious drugs
  • Correct electrolyte imbalances
• IV Magnesium
• Overdrive pacing at rates of 100-110

QT = 800 ms!
**RBBB Morphology**

- **Lead V₁:** rsR' pattern
- **Lead V₁:** R or qR with taller LEFT rabbit ear
- **Lead V₆:** qRs
- **Lead V₆:** QS or rS

**LBBB Morphology**

- **In Leads V₁ or V₂:**
  - Wide r wave (> .03 sec)
  - Slurred downstroke
  - > .06 sec to nadir of S wave

- **In Leads V₁ or V₂:**
  - Narrow r wave (< .04 sec)
  - Straight downstroke of QRS
  - < .06 sec to nadir of S wave

- **In Lead V₆:**
  - Any q (QS or qR)
Practice Alert
Dysrhythmia Monitoring

Lead Placement for a 5-Lead System

- Arm electrodes on shoulders close to where arm joins torso
  - Front, top, or back of shoulder
- Leg electrodes low on thorax or on hips
- Chest electrode placed according to V lead desired
  - $V_1$ = 4th right intercostal space
  - $V_6$ = 5th intercostal space, left mid-axillary line
- Most 5-lead systems allow monitoring of 2 leads simultaneously
Lead Placement for a 3-Lead System

- Electrode and wire placement
  - RA wire on left shoulder electrode
  - LA wire at V₁ position
  - LL wire at V₆ position
- To monitor MCL₁, select Lead I on bedside monitor
- To monitor MCL₆, select Lead II on bedside monitor

Best Practice for Bedside Monitoring

- Use multiple leads whenever possible
  - Continuous 12 lead monitoring is the best
  - A 5-lead system is better than a 3-lead system
  - If two leads are available, use V₁ as arrhythmia monitoring lead and Lead III or AVF for second lead (good for ST segment monitoring too)
- If only one lead is available, select lead based on patient’s arrhythmias
  - Lead V₁ to differentiate wide QRS rhythms
  - Lead V₆ if V₁ unavailable due to dressings etc.
  - Lead II or III for atrial arrhythmias (AACN)
- When given a choice of MCL₁ or V₁ – choose V₁
QT Interval Monitoring

- Approximate measure of the duration of ventricular repolarization.
- Measured from the beginning of the QRS to the end of the T wave.
- Varies with heart rate:
  - Lengthens with bradycardia
  - Shortens with tachycardia

QTc Interval

- QT interval corrected for heart rate (QTc)
- Formula for calculating QTc (Bazett’s formula)

![Formula](QTc = \frac{QT}{\sqrt{RR}})

- Normal QT is no more than half the R-R interval at normal heart rates.
- QTc > 0.50 seconds (500 ms) considered dangerously prolonged and is associated with a higher risk of Torsades de Pointes.
Monitor QT interval for patients at high risk for Torsades de pointes

- Antiarrhythmic drugs (require hospital monitoring)
  - Norpace (disopyramide)
  - Tikosyn (dofetilide)
  - Corvert (ibutilide)
  - Pronestyl (procainamide)
  - Betapace (sotalol)
  - Quinidine (rarely used anymore)
  - Amiodarone (monitoring for high risk patients only)
- New onset bradycardias
- Severe hypokalemia or hypomagnesemia
- Overdoses of drugs known to cause Torsades
  - Tricyclic antidepressants
  - Thorazine
  - Clarithromycin (Biaxin)
  - Motilium (anti-emetic)
  - Inapsine (droperidol)
  - Pentamidine
  - Erythromycin
  - Haldol
  - Propulsid
  - Vascor (bepridil)
  - Others

www.torsades.org

Causes of Sudden Cardiac Death

Ischemic Heart Disease
- Coronary artery disease with MI or angina
- Coronary artery embolism
- Nonatherogenic coronary artery disease (arteritis, dissection, congenital coronary artery anomalies)
- Coronary artery spasm

Nonischemic Heart Disease
- Hypertrophic cardiomyopathy
- Dilated cardiomyopathy
- Valvular heart disease
- Congenital heart disease
- Arrhythmogenic right ventricular dysplasia
- Myocarditis
- Acute pericardial tamponade
- Acute myocardial rupture
- Aortic dissection

No Structural Heart Disease
- Primary electrical disease (idiopathic VF)
- Brugada syndrome
- Long QT syndrome
- Preexcitation syndrome
- Complete heart block
- Familial sudden cardiac death
- Chest wall trauma (commotio cordis)

Noncardiac Disease
- Pulmonary embolism
- Intracranial hemorrhage
- Drowning
- Pickwickian syndrome
- Drug-induced
- Central airway obstruction
- SIDS
**Indications for ICD**

- Cardiac arrest secondary to VT/VF that is not due to a correctable cause (like ischemia, drug effect, electrolyte imbalance)
- Spontaneous sustained VT associated with structural heart disease
- Familial or inherited high-risk conditions
  - LQTS
  - Brugada Syndrome
  - Hypertrophic cardiomyopathy

22% - 55% reduction in mortality when compared to drugs. Beta blockers, amiodarone & sotalol are most effective drugs.

**Types of ICDs**

- Single or dual chamber pulse generators with pacing capability (VVI/R, DDD/R)
- Tiered therapy devices with ATP, low energy cardioversion, and defibrillating capability
- CRT devices for biventricular pacing in heart failure patients
• Transvenous systems
  – Active can: current flows from LV defibrillating lead to the housing of the generator ("hot can")
    • Generator has to be in pectoral position
  – Current can flow from LV lead to lead in SVC
    • Generator can be in pectoral position or in abdomen
  – Both usually equally effective

Functions of an ICD

• Arrhythmia Detection
  – Recognize VT and VF

• Arrhythmia Treatment
  – Deliver therapy to terminate VT or VF

• Backup Pacing
  – Single or dual chamber
Arrhythmia Detection

- Heart rate

![Heart rate chart]

- Sudden Onset
  - Detects sudden shortening of cycle length (sudden heart rate increase)
  - Sinus tachycardia usually has gradual onset while VT is sudden onset

- Interval Stability
  - Looks for variable cycle lengths
  - A Fib usually very irregular while VT is usually regular
Arrhythmia Detection

• Morphology
  – Measures width of ventricular electrogram and only treats if width greater than a programmed value

Combinations of detection criteria can be individualized for each patient’s arrhythmia characteristics

Tiered Arrhythmia Therapies

• ATP (antitachycardia pacing)
  – Burst – delivery of a programmable number of pacing stimuli into tachycardia to interrupt reentry circuit
• Cardioversion Shock
  – Delivers shocks from 0.1 to 30 joules
  – Synchronized on R wave

• Defibrillating Shocks
  – High energy (20-34 joules) unsynchronized shocks for VF

Postoperative Care
Pacemaker / ICD

• Routine patient care
  – Monitor for 24 hours, then discharge
  – Arm immobilized in sling
  – Monitor for signs of infection
    • Redness, swelling, discharge from insertion site; fever; elevated WBC
  – Monitor for signs of tamponade
    • Chest pain, SOB, hypotension, elevated neck veins, paradoxical pulse
Emergency Care for VT/VF

- Therapy delivered within 10-15 seconds
- DO NOT WAIT for all therapies if patient unstable
- Defibrillate externally as usual
  - Avoid placing paddles over generator
  - Use 360 joules
  - Alternate paddle placement if first shock ineffective
- Notify physician

Radiofrequency Ablation

- Electrical energy produced by high frequency alternating current
- Creates heat which causes thermal injury and local tissue destruction
- Destroys arrhythmogenic focus or part of conduction pathway responsible for may tachyarrhythmias to prevent their recurrence
Indications for RF Ablation

• AVNRT (AV Nodal Reentry Tachycardia)
• CMT – Accessory Pathways
• AV Node Ablation
• Atrial Tachycardia
• Atrial Flutter
• Atrial Fibrillation – pulmonary vein ablation
• Ventricular Tachycardia – if VT tolerated well enough for mapping

The Ablation Procedure

• Cardiac Catheterization
  – Right femoral vein (up to 3 catheters)
  – Left femoral vein
  – Left subclavian (coronary sinus)
  – Right internal jugular (coronary sinus)
  – Brachial vein
  – Right femoral artery for left sided ablations
  – Trans-septal left atrial catheterization for left sided ablations
• Diagnostic EPS done to identify location of arrhythmogenic focus or reentry pathway
• Ablation catheter placed at target area
• RF energy applied to target area
  – Numerous burns may be required
• Programmed stimulation repeated to verify that induction of tachycardia is no longer possible

Potential Complications of Ablation
(overall incidence < 4%)

• Cardiac perforation
• Tamponade
• Venous thrombosis
• Pulmonary embolism
• Pneumothorax
• Infection / sepsis
• Bleeding
• Damage to coronary arteries
Nursing Care of the Ablation Patient
Post-procedure

• Bedrest 4-6 hours, legs straight
  – Can elevate head of bed 20-30 degrees
• Routine checks every 15” x 1 hr, then every 30” x 1 hr, then every 1-4 hours as needed
  – VS
  – Pedal pulses
  – Groin sites for bleeding, hematoma
  – Other insertion sites if used
• Cardiac monitoring - watch for return of arrhythmia

Monitor for signs of complications

• Cardiac perforation or tamponade
  • Hypotension, tachycardia, elevated neck veins, pulsus paradoxus, dyspnea, chest pain
• Pneumothorax
  • Dyspnea, unequal breath sounds, chest discomfort
• Pulmonary embolus
  • Sudden dyspnea, chest pain, tachycardia, hypoxia
• Venous or arterial thrombosis
  • Decreased pedal pulses, cool extremities, numbness or tingling in legs, discolored extremities (pale, flushed, cyanotic)
• May be discharged after bedrest period