ARRHYTHMIA MANAGEMENT IN THE ICU
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DISCLOSURES
- I have no financial interests to disclose.

OBJECTIVES
- Identify risk factors for cardiac arrhythmias in the critically ill population
- List common drugs used in the intensive care unit that put patients at an increased risk for cardiac arrhythmias
- Evaluate an ICU patient and determine optimal treatment for different tachyarrhythmias or bradyarrhythmias
WHICH OF THE FOLLOWING IS NOT CONSIDERED A RISK FACTOR FOR DEVELOPMENT OF ATRIAL FIBRILLATION IN THE ICU?

- SCr >2.0mg/dl
- Hypokalemia (K+ <3.5mEq/L)
- Hypertension
- Use of vasopressors/inotropes

PATIENT CASE

PB is a 70 year old male admitted to the cardiac ICU in acute decompensated HF

PMH: CAD (PCI x1 in LAD), HTN, Hyperlipidemia, and ischemic cardiomyopathy (EF 25%)

Home medications: Aspirin 81mg oral daily, Atorvastatin 80mg oral qHS, Lisinopril 10mg Oral daily, Carvedilol 12.5mg oral BID, Spironolactone 25mg Oral daily, Bumetanide 2mg Oral daily

ECG: Atrial fibrillation with rapid ventricular rate (QTc 500msec)

Vitals on admission: BP 92-110/60-70; HR 130-140

Labs: Na 138, K, 3.0, Cl 135, CO2 22, BUN 32, SCr 2.1

WHICH OF THE FOLLOWING IS NOT AN APPROPRIATE TREATMENT OF THIS PATIENT’S ATRIAL FIBRILLATION?

- Bumetanide 2mg IV qah
- Diltiazem 5mg/IV x2 and continuous infusion
- Metoprolol 5mg Xa
- Amiodarone 150mg x2 and continuous infusion
- DCV
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WHICH OF THE FOLLOWING DRUGS DOES NOT HAVE EVIDENCE IN CRITICALLY ILL PATIENTS TO CARDIOVERT ATRIAL FIBRILLATION?

- Amiodarone
- Procainamide
- Dofetilide
- Ibutilide
- Flecainide

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WHICH OF THE FOLLOWING THERAPIES HAS SUPPORTING EVIDENCE TO PREVENT POAF?

- Amiodarone
- Beta-blockers
- Statins
- Magnesium
- Sotalol

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INTRODUCTION

- Cardiac arrhythmias occur frequently in the ICU
- Primary reason for admission
- Contingency in the critically ill patient
- Most common arrhythmia is sinus tachycardia
- Ventricular arrhythmias are less common but usually more severe
- Not all arrhythmias seen are new onset
- Arrhythmias may cause complications for a patient in the ICU
- Arrhythmias may be prevented in the ICU setting
- Treatment may be difficult, often times optimal therapy is based on understanding the underlying mechanism that caused the arrhythmia
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RISK FACTORS FOR ARRHYTHMIAS
- Male gender
- Age greater than 70 years
- Cardiac disease
- Pulmonary disease
- Thyroid disease
- Critically ill (APACHE score ≥25)
- Volume fluctuations
- Electrolyte disturbances
- Metabolic derangements
- Vasopressors

Tracy C et al; Crit Care Clin 2014;

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CONSEQUENCES OF ARRHYTHMIAS IN THE ICU
- Higher in hospital mortality
- Ventricular Fibrillation
- Symptomatic sinus bradycardia
- Junctional Bradycardia
- Prolonged hospital stay
- Occurs in both the medical ICU population and surgical ICU population


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DETERMINE URGENCY
- Management is determined by acuity
- Is the rhythm causing compromise to the patient?
- Hypotension
- Infection
- Heart failure
- Altered mental status
- Hypoperfusion: hypoxia, decreased urine output

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IDENTIFY UNDERLYING CAUSES

- Multiple electrolyte abnormalities and acid-base abnormalities
- Hypokalemia and hypomagnesemia increase incidence of VT
- Hypoxemia/Hypoventilation
- Hypovolemia/Hypervolemia
  - Volume overload leading to atrial stretch
- Hypothermia
- Coronary ischemia
- Trauma
- Mechanical stimulation
- Intoxication
- Acute pulmonary process

Macdonald JE et al J Am Coll Cardiol 2004;43:115

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MECHANISMS OF ARRHYTHMIAS

Bradyarrhythmias
- Problems with impulse generation
  - Sinus bradycardia
  - Sinus pause or arrest
- Problems with impulse conduction
  - First degree, Second degree, Third degree heart block

Tachyarrhythmias
- Increased automaticity
  - Reentry
  - AVNRT
  - AVRT
- Reentry
- Ventricular tachycardia
- Triggered activity
  - Sudden death syndromes
  - Drug toxicity

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Tachyarrhythmias

Narrow Complex
- Sinus Tachycardia
- Atrial Tachycardia
- Atrial Flutter
- AVNRT/AVRT

Wide Complex
- Ventricular Tachycardia
- SVT with pre-existing BBB
- SVT with rate-dependent BBB

Narrow Complex
- MAT
- Atrial Fibrillation
- Atrial Flutter with variable block

Wide Complex
- Torsades de Pointes
- Ventricular fibrillation

Regular
- Irregular
TACHYARRHYTHMIAS

- Supraventricular tachyarrhythmias
  - Atrial fibrillation (AF)
  - Atrial flutter (AFL)
  - AV-nodal reentrant tachycardia with RVR (AVNRT)
  - Atrial ectopic tachycardia
  - Preexcitation syndromes

- Ventricular tachyarrhythmias
  - Monomorphic and polymorphic ventricular tachycardia (VT)
  - Torsade de pointes
  - Ventricular flutter (VFL)
  - Ventricular fibrillation (VF)

INCIDENCE & EPIDEMIOLOGY OF AF

- The incidence of new-onset AF in critically ill patients is 6-50%.
- In sepsis, that incidence increases up to 50% of patients.
- In ACS, new-onset AF occurs 6-21%.
- Cardiac surgery (particularly mitral valve and CABG) documented rates reaching 30-60%.
- Leads to more hospitalizations than any other arrhythmia.
- Associated with longer ICU stays and higher inpatient mortality.
- Leads to more hospitalizations than any other arrhythmia when accompanied with MI.
- Reduces quality of life.
- Complications:
  - Rapid ventricular rate
  - Heart Failure Syndrome
  - Stroke

RISK FACTORS FOR AF

AF
- Advanced age
- Structural heart disease
- Chronic conditions
- Hypertension
- Renal failure
- COPD

AF in ICU
- Hypoperfusion
- Vasopressors or inotropes
- Septic shock
- Fluid overload
- Heart failure
- Electrolyte imbalance
- Postoperative status
AF IN THE ICU

RISK FACTORS FOR ATRIAL FIBRILLATION

**Medical ICU**
- Electrolyte abnormalities
- High cardiac filling pressures
- Hypoxemia
- Septic shock
- New onset atrial fibrillation

**Surgical ICU**
- Post-op hypotension
- Post-op sepsis
- PA catheters
- Blunt force trauma

TREAT UNDERLYING CAUSE
MANAGEMENT

- Rate Control vs. Rhythm Control
- Has not been studied in the critically ill population
- Extrapolate non-ICU patients
- Anticoagulation
- Hemodynamically Unstable
  - Rhythm Control
  - Electrical, synchronized cardioversion
- Hemodynamically Stable
  - Rate vs. Rhythm Control
  - Rhythm Control may be pharmacologic

GENERAL TREATMENT OPTIONS

- Pharmacologic Options
  - Rhythm Control Method: Pharmacologic
    - Class IA: Procainamide*
    - Class IC: Flecainide, Propafenone*
    - Class III: Amiodarone*, Sotalol, Ibutilide*, Dofetilide, Dronedarone
  - Rate Control Method
    - Class II: Esmolol, Metoprolol
    - Class IV: Verapamil, Diltiazem
    - Class V: Digoxin
- Direct Current Cardioversion (DCCV)

DIRECT CURRENT CARDIOVERSION (DCCV)

- Used for patients who are hemodynamically unstable
- If AF <48 hours:
  - Begin IV UFH or LMWH immediately
- If AF >48 hours:
  - Anticoagulation considered mandatory 3 weeks prior, and 4 weeks post
  - Therapeutic anticoagulation should be performed and UFH or LMWH should be administered and continued with the presence of risk factors
  - TEG Guided Cardioversion
  - Alternative to 3-week pre-cardioversion anticoagulation
  - MARGAI: Monitor atrial fibrillation on UFH or LMWH
  - LAA thrombus present: DCC is contraindicated
PHARMACOLOGIC CARDIOVERSION

- Pharmacologic cardioversion may be appropriate for those patients not experiencing ischemia or hemodynamic compromise as a result of the arrhythmia.
- Class IA, IC, and III agents used (IC and III primarily due to tolerability)

<table>
<thead>
<tr>
<th>Medication</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibutilide</td>
<td>1mg IV over 10 minutes</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>150mg IV over 10 minutes then IV drip 1mg/min for 6 hours and 0.5mg/min for 18 hours</td>
</tr>
</tbody>
</table>

RATE VS. RHYTHM CONTROL

- In non-ICU patients rate vs. rhythm control seems to make no difference
- No randomized controlled trials to assess this
- Extrapolate non-ICU patients
- ICU patients may not tolerate loss of atrial kick
- Up to 25% reduction in CO
- Most patients with new onset a.fib in the ICU will require a trial of chemical cardioversion
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RATE VS. RHYTHM CONTROL

- The AFFIRM trial and AF-CHF trial show that rate control is non-inferior to rhythm control.
- Rate control is also associated with less incidence of adverse drug effects and hospitalizations.

- What is our goal heart rate?
- RACE II answered this question.
- Lenient versus Strict rate control.
- Goal HR should be <110 bpm.

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RATE CONTROL

- Should be used for hemodynamically stable patients to control ventricular rate.
- Beta blockers are particularly effective when adrenergic/sympathetic tone is elevated.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metoprolol</td>
<td>2.5mg-5mg IV over 2-5 minutes, then oral 10-20mg/8h</td>
</tr>
<tr>
<td>Atenolol</td>
<td>50-150mg IV over 2 min, then oral 25mg/8h</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>0.25mg/kg IV over 2 min, then IV drip 2.5-7.5mg/hr</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Loading dose of 0.35 mg/kg over 2 hours in divided doses</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>150mg IV over 10 min, then IV drip 1.0-1.5mg/hr, then oral 0.15-0.25mg/hr</td>
</tr>
</tbody>
</table>

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NEW-ONSET ATRIAL FIBRILLATION IN NON-CARDIAC ICU PATIENTS

- 143 patients total (76% AF).
- Amiodarone: 26
- Procainamide: 14
- Magnesium: 18
- Flecainide: 15
- Esmolol: 28
- Verapamil: 15
- Diltiazem: 27

<table>
<thead>
<tr>
<th>Drug</th>
<th>Conversion rate</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amiodarone</td>
<td>50-70%</td>
<td>12h</td>
</tr>
<tr>
<td>Procainamide</td>
<td>70%</td>
<td>12h</td>
</tr>
<tr>
<td>Flecainide</td>
<td>80%</td>
<td>12h</td>
</tr>
<tr>
<td>Magnesium</td>
<td>50%</td>
<td>12h</td>
</tr>
<tr>
<td>Verapamil</td>
<td>50%</td>
<td>12h</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>50%</td>
<td>12h</td>
</tr>
<tr>
<td>Esmolol</td>
<td>60%</td>
<td>12h</td>
</tr>
</tbody>
</table>
ANTICOAGULATION

Benefits of anticoagulation for stroke prevention in the ICU have not been determined, weigh risks versus benefits of bleeding versus stroke in the critically ill patient

Short term versus long term risk of anticoagulation

CHADS\textsubscript{2} FOR ESTIMATING RISK OF STROKE:

<table>
<thead>
<tr>
<th>SCORE</th>
<th># of patients</th>
<th>Annual Stroke Risk</th>
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<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>1.9 (1.2—3)</td>
</tr>
<tr>
<td>1</td>
<td>463</td>
<td>2.8 (2—3.8)</td>
</tr>
<tr>
<td>2</td>
<td>119</td>
<td>4.3 (3.3—5.6)</td>
</tr>
<tr>
<td>3</td>
<td>337</td>
<td>5.9 (4.6—7.6)</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
<td>8.5 (6.3—13)</td>
</tr>
<tr>
<td>5</td>
<td>65</td>
<td>11.5 (8.3—17)</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>18.0 (12.1—24)</td>
</tr>
</tbody>
</table>

Lip GYH; Chest 2010; 1

CHA\textsubscript{2}DS\textsubscript{2}-VAS\textsubscript{c} FOR ESTIMATING RISK OF STROKE:

<table>
<thead>
<tr>
<th>SCORE</th>
<th>% Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.6%</td>
</tr>
<tr>
<td>1</td>
<td>1.6%</td>
</tr>
<tr>
<td>2</td>
<td>3.9%</td>
</tr>
<tr>
<td>3</td>
<td>1.9%</td>
</tr>
<tr>
<td>4</td>
<td>3.2%</td>
</tr>
<tr>
<td>5</td>
<td>3.6%</td>
</tr>
<tr>
<td>6</td>
<td>8%</td>
</tr>
<tr>
<td>7</td>
<td>10%</td>
</tr>
<tr>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>9</td>
<td>100%</td>
</tr>
</tbody>
</table>

Lip GYH; Chest 2010; 1
ACCF/AHA 2014 RECOMMENDATIONS:

<table>
<thead>
<tr>
<th>CHADS2 Score</th>
<th>Stroke or TIA</th>
<th>≥2 Risk Factor</th>
<th>No Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAC (IB) or VKA (IA)^</td>
<td>NOAC or VKA (IB)^ or OR</td>
<td>No AT Therapy</td>
<td>No AT Therapy</td>
</tr>
</tbody>
</table>

NOAC: Dabigatran, Rivaroxaban, or Apixaban
VKA (Vitamin K Antagonist): Warfarin Target INR (2—3)

ACCP 2012 RECOMMENDATIONS:

<table>
<thead>
<tr>
<th>CHADS2 Score</th>
<th>Stroke or TIA</th>
<th>≥2 Risk Factor</th>
<th>No Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAC (2B) ^‡</td>
<td>OAC (2B) ^‡ or Aspirin (2B)†</td>
<td>No AT therapy (2B) or Aspirin (2B)†</td>
<td>Aspirin (2B)†</td>
</tr>
</tbody>
</table>

‡ Dabigatran preferred over dose adjusted warfarin
† No AT therapy preferred over aspirin

OAC: Oral Anticoagulant including warfarin and dabigatran
Warfarin: Target INR (2—3)
Aspirin: 75mg—325mg

HAS-BLED SCORE FOR ESTIMATING BLEEDING:

- HAS-BLED: Maximum 7 points
  - H = Hypertension
  - A = Abnormal renal/liver function
  - S = Stroke
  - B = Bleeding history/predisposition
  - L = Labile INR (TTR <60%)
  - E = Elderly >65yo
  - D = Drugs/alcohol

<table>
<thead>
<tr>
<th>Score</th>
<th>Major bleeding rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.9%</td>
</tr>
<tr>
<td>1</td>
<td>3.4%</td>
</tr>
<tr>
<td>2</td>
<td>4.1%</td>
</tr>
<tr>
<td>3</td>
<td>5.8%</td>
</tr>
<tr>
<td>4</td>
<td>8.9%</td>
</tr>
<tr>
<td>5</td>
<td>9.1%</td>
</tr>
<tr>
<td>6</td>
<td>9.4%</td>
</tr>
</tbody>
</table>

Atrial fibrillation is the most common complication of postcardiac surgery and has significant economic and clinical complications.

- Prolonged postoperative ICU and hospital lengths
- 25-40% of patients following coronary artery bypass graft (CABG)
- Up to 60% after CABG and valve surgery
- Incidence usually occurs on days 2 and 3 post-op

POAF Consequences:
- Increased thromboembolic risk/stroke
- Hemodynamic compromise

PATHOPHYSIOLOGY OF POST-OP ATRIAL FIBRILLATION
RISK FACTORS FOR A.FIB POSTOPERATIVELY

- Age
- Type of surgery
- Temporary pacing
- Inotropic support
- Increased NYHA class
- Complicated weaning of CABG
- Obesity and Metabolic syndrome

PREVENTION OF POAF

- Oral Beta-blockers should be used to prevent POAF in patients undergoing cardiac surgery
- Pre-operative administration of prophylactic amiodarone reduces risk of POAF in high risk patients
- Sotalol has been studied as preventative drug
  - One study found a higher prevalence of bradyarrhythmias post operatively
- Smaller studies showing magnesium administration may be as effective as antiarrhythmics in reducing POAF
- HMG-CoA Reductase Inhibitors have shown to reduce POAF after CABG likely by reducing inflammation

TREATMENT - RATE CONTROL

- Beta blockers are first line options in POAF
- N-DHP Calcium channel blockers also effective
- Digoxin less effective in this setting
- Amiodarone effective in controlling rate
TREATMENT - RHYTHM CONTROL

- In difficult patients to control, conversion may be needed
- Electrically or Pharmacologically
- Long-term treatment with antiarrhythmics is usually unnecessary
- Duration of 4-6 weeks post-operatively

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DRUG-INDUCED QTC PROLONGATION

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RISK FACTORS FOR PROLONGED QT

- Factors associated with the intensive care unit
- Comorbid conditions
- Drug-induced
MECHANISM OF DRUG INDUCED QTc PROLONGATION

- Myocardial repolarization is primarily mediated by efflux of potassium ions.
- Delayed rectifier K+ current (IKr rapid) and IKs (slow) responsible for repolarization.
- All drugs that block IKr will prolong QTc.
- Prolonged QTc may cause early after depolarizations (EADs) due to activation of inward depolarization currents.
- Consequence: Torsades de pointes.

DRUGS ASSOCIATED WITH PROLONGED QT

- Macrolide antibiotics
- Antipsychotics
- Class IA and Class III antiarrhythmics
- Combination of CYP 3A4 inhibitors and these drugs

TORSADES DE POINTES

- Magnesium
- Isoproterenol
BRADYARRHYTHMIAS

- Often the result of medical conditions, medications or respiratory status
- Usually reversible in the ICU setting
- Drug induced: Propofol, dexmedetomidine
- Symptomatic bradycardia requires treatment
  - Atropine
  - Transcutaneous pacing
  - Dobutamine

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- Labs: Na 138, K 3.0, Cl 113, CO2 22, BUN 32, SCR 2.1

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- Metoprolol 5mg x1
- Amiodarone 150mg x1 and continuous infusion
- DCCV

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WHICH OF THE FOLLOWING THERAPIES HAS SUPPORTING EVIDENCE TO PREVENT POAF?

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QUESTIONS???

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REFERENCES