Pediatric Dysrhythmias
Early Recognition & Management

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Pediatric Dysrhythmias
Outline

• Introduction – the basics
• “Typical” scenarios
• Clinical stability
• General diagnosis & management issues
• Specific presentations
• Pitfalls
Pediatric Dysrhythmias

- **Bradydysrhythmias**
  - Sinus bradycardia
  - Junctional & indioventricular rhythms
  - AV blocks
- **Tachydysrhythmias**
  - Sinus tachycardia
  - PSVT
  - Ventricular tachycardia
  - Wolff-Parkinson-White Syndrome-related rhythms
- **Cardiac arrest rhythms**
  - Ventricular tachycardia / fibrillation
  - Pulseless electrical activity
  - Asystole
- **Toxic-metabolic rhythms**
  - Toxins
  - Electrolytes

Pediatric Dysrhythmias

- **Common**
- **Rhythm possibilities span spectrum of severity**
  - from benign & of no clinical consequence
  - to malignant with immediate life threat
- **Frequently a consequence of another issue**
- **Focus on not only the rhythm but also the primary event**
Pediatric Dysrhythmias

• Largely “secondary” events
  – Respiratory
  – Vascular
  – Metabolic
  – Toxicologic
  – Congenital

• Much less commonly “cardiac” in origin
  – ....though primary cardiac causes are seen

Pediatric Dysrhythmias
“Typical” scenarios

• Young child with cough and fever
  – Lethargy with low oxygen saturations
  – Slow pulse
  – DX: Pneumonia with hypoxia & sinus bradycardia

• Teenager with illicit drug use
  – Agitated
  – Tachycardic
  – Combative behavior
  – DX: Sympathomimetic ingestion with sinus tachycardia
Pediatric Dysrhythmias
“Typical” scenarios

• 2 year-old female
  – Cardiac arrest
  – s/p fall from significant height
  – Wide complex / bradycardia
  – DX: PEA cardiac arrest with idioventricular rhythm

• 14 year-old female
  – Weak & dizzy
  – Rapid pulse noted
  – DX: PSVT

Pediatric Dysrhythmias
Clinical Stability

1. Hypotension / hypoperfusion
   a. Hypotension – age-related normals
   b. Hypoperfusion – normal BP in compensated shock

2. Altered mental status

3. Chest pain -- coronary ischemic

4. Dyspnea -- pulmonary edema

5. Extreme rates

#1-4 as described by the AHA
ACLS & PALS Curricula
Pediatric Dysrhythmias
Clinical Stability

• Extreme rates & instability
  – Bradycardia – reasonably obvious
  – Tachycardia – less so
• Extreme tachycardia
  – As rate increases, time for cardiac filling & coronary perfusion decreases
  – Increased hypoperfusion
  – Development of acidosis
  – More irritable myocardium
  – Increasing opportunity for R-on-T event
Pediatric Dysrhythmias
Clinical Stability

- Stability is not entirely dependent upon the specific rhythm
- Must consider both the rhythm & its impact on the patient

Pediatric Dysrhythmias
General Diagnostic Issues

- Rate
- QRS complex width
- Regularity of QRS complex
- P waves
- Association of P waves to QRS complexes
Pediatric Dysrhythmias
General Diagnostic Issues

Key Issues
• Slow vs fast
• Wide vs narrow
• Regular vs irregular

RATE

Fast vs Slow

QRS Width

Narrow QRS Tachycardia
  Regular
  Sinus Tach PSVT A-Flutter PAT

Irregular
  A-Fib A-Flutter MAT PAT ST PAC / PVC

Wide QRS Tachycardia
  Regular
  VT SVT-aberrant

Irregular
  PVT A-Fib

Narrow QRS Bradycardia
  Sinus Brady A-Fib / Flutter Junctional 1:1 AV II 2 AVB / I or II 3 AVB

Wide QRS Bradycardia
  Idioventricular Bradycardia w/ BBB 2 AVB / II 3 AVB
Pediatric Dysrhythmias
General Diagnostic Issues

• And do not forget about clinical stability
• ......or lack there of

• And the underlying cause of the dysrhythmia

Pediatric Dysrhythmias
General Management Issues

• ABCs
• IV-\(O_2\)-monitor
• General therapies
  – Bradycardias
  – Tachycardias
### Pediatric Dysrhythmias
#### General Management Issues

#### Bradycardia
- **Oxygen**
- **IV normal saline**
  - 20 ml/kg
- **Atropine**
  - 0.02 mg/kg IV
  - Min: 0.1 mg
  - Max: 0.5 mg
- **Epinephrine**
- **Bolus**
- **Infusion**
- **Glucagon**
  - 0.05 mg/kg IV
- **Electrical pacing**

#### Tachycardia
- **Oxygen**
  - Minimal to maximal
- **IV normal saline**
  - 20 ml/kg IV
- **Adenosine**
  - 0.1 mg/kg IV (max 6 mg)
  - 0.2 mg/kg IV (max 12 mg)
- **Beta-blockers**
- **Calcium channel blockers**
- **Amiodarone**
  - Pulse: 5 mg/kg IV over 20-60 min
  - Pulseless: 5 mg/kg IVP
- **Lidocaine**
  - 1-2 mg/kg IV
- **Electrical cardioversion**
  - Cardioversion - 0.5-2 J/kg
  - Defibrillation - 2-4 J/kg
Pediatric Dysrhythmias
Some Important Questions

• Q: Is a specific rhythm diagnosis required in all cases?

• Q: Are you a poor provider if you cannot diagnose a specific rhythm in each & every case?

• A: No, focus on the general rhythm type.

• Q: Are you a poor provider if you cannot diagnose a specific rhythm in each & every case?

• A: Again no, adjust therapy to the patient presentation, including the vital signs, symptoms / signs, & the rhythm.
The Cases
Case One

- 6 year-old male
- Fever with N/V
- Cough with increased work of breathing
- Lethargy
- Floppy & pale
- BP ?, P 30, R 12
- O$_2$ saturation 88%

Bradycardia

- Very compromising bradycardia
- What’s going on?
  - Febrile illness with....
    - Gastroenteritis with dehydration -- VOLUME DEPLETION
    - Possible pneumonia -- HYPOXIA
- Does the ultimate diagnosis matter at this point?
Types of Bradycardia

*Slow Ventricular Rate*

- **Sinus bradycardia** - P to QRS relationship
- **Junctional bradycardia** - No P wave w/ narrow QRS complex
- **Idioventricular bradycardia** – No P wave w/ widened QRS complex

**Causes of Compromising Bradycardia in Children**

- **Cardiac** 18%
- **Non-cardiac** 82%
- **Resp** 36%
- **Tox** 13%
- **Shock** 14%
- **Trauma** 10%
- **Other** 9%
Bradycardia

• ABCs

• Respiratory support
  – Bag-mask ventilation with 100% O₂
  – IV fluid (normal saline) bolus – 20 ml / kg

Bradycardia

• Cardiovascular support
  – Medications
    • Atropine
    • Epinephrine
    • Glucagon
    • Dopamine
  – Transcutaneous pacing
Bradycardia
• .....and do not for get about the “D” in ABCDs
• Hypoglycemia
  – Serum glucose determination
  – Dextrose / glucagon
• Must treat both rhythm & underlying issue

Case One
  Closure
• Bag-mask ventilation
• IV fluid bolus
• Atropine
• Improved oxygenation, perfusion, & mental status at ED arrival
• Ultimate diagnosis: pneumonia with severe dehydration
Case Two

- 8 month-old male
- “Fussy & pale”
- 8 hours
- No other complaints
- PMH -- none

- Alert & consolable
- Pale
- P 260+, R 50, POX 93%
- Very tachycardic
- Prolonged CRT
Paroxysmal Supraventricular Tachycardia

- Also known as PSVT
- Not uncommon
- Most often results from a problem in AV node – the focus for therapy

Paroxysmal Supraventricular Tachycardia

- Rapid
- Regular
- Narrow QRS complex
- P wave present – retrograde conduction
- No P-QRS relationship
Paroxysmal Supraventricular Tachycardia

- Can be compromising
- Usually not associated with significant underlying heart disease
- Considered to be a nuisance-type dysrhythmia
- Also consider WPW-related NCT

Paroxysmal Supraventricular Tachycardia

- ABCs
- Stable vs unstable
### Paroxysmal Supraventricular Tachycardia

- **Stable**
  - Use of AV nodal blocking agents
    - Adenosine
    - Beta-blockers
    - Calcium channel blockers
  - Electrical cardioversion

- **Unstable**
  - Adenosine
  - Electrical cardioversion
- **WPW-related NCT**
  - Similar therapies
Case Two
Closure

- IV access established
- Adenosine
- Improved perfusion at ED arrival
- Ultimate diagnosis: PSVT with normal cardiac function
Case Three

- 8 year-old male
- MVC --- roll-over
- Weakness
- Abdominal pain
- Alert & distressed
- Pale
- BP ?, P 170, R 38
- Left flank -- bruising

If in doubt...... look at another lead
Lead II vs Lead I
Sinus Tachycardia

• A “reactive” rhythm
  – Hypovolemia
  – Hypoxia
  – Pain
  – Anxiety
  – Fever
  – Medication (toxicologic) effect

Causes of Sinus Tachycardia in the Pediatric Emergency Department
Sinus Tachycardia

- Consider & treat cause rather than rhythm
  - Exception: toxicologic presentation
- Sympathomimetic agents
  - Cocaine & methamphetamine
  - Caffeine & other stimulants
  - Albuterol & other adrenergic agonists
- Therapy
  - IV fluids
  - Benzodiazepines
  - Antihypertensive agents – caution unopposed beta-blockers

Sinus Tachycardia
Extremely Rapid Rates

10 year-old with blunt abdominal trauma

13 year-old with cocaine ingestion
Case Three
Closure

- IV fluid resuscitation at (20 ml/kg)
- Splenic rupture noted after ED arrival
- To OR for splenectomy
Case Four

• 8 year-old female
• SOB
• Used albuterol
• PMH
  – Asthma on albuterol
  – Palpitations w/ albuterol
• Alert & distressed
• Mild distress
• BP 110/70, P 240
• Lungs minimal expiratory wheeze

Ventricular Tachycardia

• Unusual but not impossible rhythm in children
• ECG differential considerations -- WCT
  – Ventricular tachycardia
  – SVT with aberrant conduction
  – Tox-related rhythms
  – Hyperkalemia
Ventricular Tachycardia Monomorphic

- Rapid rate
- Wide QRS complex
- Regular rhythm
Ventricular Tachycardia Polymorphic

- Rapid rate
- Wide QRS complex
- Changing morphology
- Irregular rhythm
Causes of VT in Children


Ventricular Tachycardia

- ABCs
- Stable vs unstable
- Stable
  - Amiodarone
  - Lidocaine
  - Procainamide
- Unstable
  - Electrical cardioversion
Case Four
Closure

• Amiodarone IV
• Hypotension develops
• Electrical cardioversion at 2 J/Kg
• Admitted to ICU
• Etiology -- myocarditis
Case Five

- 11 year-old male
- Syncope
- History of palpitations
- Alert
- Pale
- BP ?, P 225, R 40s

12-lead ECG
Narrow Complex Tachycardia
AVRT / Orthodromic Tachycardia
With Therapy

• Patient in shock – medication vs electricity?
• Electrical cardioversion at 2 J/Kg
• Sedation

NCT at 225 bpm

s/p cardioversion

s/p Cardioversion
Alert & Oriented in No Distress
WPW NSR

WPW NSR
Wolff-Parkinson-White Syndrome

• Classic triad
  – Shortened PR interval
  – Delta wave
  – Widened QRS complex

Wolff-Parkinson-White Syndrome
Narrow Complex Tachycardia

• ABCs
• Approach similar to PSVT for this WPW rhythm
• AV nodal blocking agent safe in this WPW rhythm
  – Not true in other WPW rhythms
Wolff-Parkinson-White Syndrome

• AV nodal blocking agents
  – Adenosine
  – Beta-blockers
  – Calcium channel blockers
• Procainamide
• Electrical cardioversion

Case Five
Closure

• Adenosine
• Converts to NSR
• Alert and oriented
• Dx: Wolff-Parkinson-White syndrome-related NCT
• Admitted to hospital
• Electrophysiologic study with ablation
Case Six

- 1 month old with lethargy
- Limited feeding
- Otherwise no issues
- PMD – slow pulse noted – 911 called
- Lethargic infant
- “Floppy”
- Poor perfusion
- P 40s, R 60, SAT 90%
- RA
- Extremities cool
Complete Heart Block

- Third-degree heart block
- Uncommon but malignant
- Usually very symptomatic
  - Shock
  - Respiratory compromise

Causes
- Maternal systemic lupus erythematosis (SLE)
- Consequence of congenital heart disease surgery
- Others

Third Degree Block (complete)

<table>
<thead>
<tr>
<th>P Wave</th>
<th>PR Interval</th>
<th>QRS Rate</th>
<th>Rhythm</th>
<th>Pacemaker</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal configuration</td>
<td>No relationship between P &amp; QRS</td>
<td>Atrial &gt; Vent</td>
<td>Atrial &amp; ventricular complexes are regular...but dissociated</td>
<td>Ventricular escape as pacemaker</td>
<td>Usually very compromising</td>
</tr>
</tbody>
</table>
Complete Heart Block

- IV & oxygen
- Atropine
- Glucagon
- Epinephrine
- Transcutaneous pacing

Case Six

Closure

- EMS
  - Atropine & IV fluid
  - Medical Command – IV epinephrine & transcutaneous pacing
- After hospital arrival
  - Congenital heart block
  - Pacemaker placed
  - Discharged on hospital Day #4
Case Seven

• 10 year-old male
• MVC
• Ejected
• Multiple trauma noted

• No pulse noted
• ECG rhythm as below
• IV
• Airway
• Medications
Initial Cardiac Arrest Rhythms
Pediatric Patients

Causes
1. SIDS
2. Trauma
3. Airway compromise
4. Near drowning

Outcome
• Resuscitation attempted 57%
• Survival 15%
• Adequate neuro status 10%

Kuisma et al, Resuscitation 1995

What is PEA?

“PEA is a rhythmic display of some type of electrical activity other than VT, but without an accompanying pulse that can be palpated by any artery.”

AHA – 2005 ACLS & PALS Curricula
Potential Electrical Rhythms in the PEA Presentation

Cardiac Electrical Activity (Rhythm-type) in Pulseless Electrical Activity
PEA is a Survivable Rhythm

Key to Survival: Rapidly determining underlying causes

6 H’s
- Hypovolemia
- Hypoxia
- Hydrogen Ion (acidosis)
- Hyper/hypo-kalemia
- Hypothermia
- Hypoglycemia

6 T’s
- Tablets, toxins
- Tamponade, Cardiac
- Tension Pneumothorax
- Thrombosis, Cardiac
- Thrombosis, Pulmonary
- Trauma

Rhythm Characteristics in PEA
Relative to Resuscitation Outcome

![Graph showing rhythm prevalence and success rate](image-url)
Case Seven
Closure

- Full PALS therapy provided
- No return of pulse
- Resuscitation stopped after 30 minutes
- Patient pronounced expired
- Autopsy – large epidural hematoma with pneumothorax & splenic fracture
Case Eight

- 5 year-old male
- Weakness, confused, & vomiting
- Recent renal transplant
- Lethargic
- BP ?, P 60, R 12
- Saturations – 90% RA
- Active emesis
- Graft tender

Hyperkalemia

- Elevated serum potassium
  - “Irritates” the myocardium
    - PVCs
    - VT / VF
  - Disrupts conduction
    - Blocks
    - Bradycardia
Prominent T Waves
Widened QRS Complex

Widened QRS Complex
Widened QRS Complex
*Bundle Branch Block Mimic*

Sinoventricular Rhythm
Sinoventricular Rhythm

Hyperkalemia
Management

- **Membrane stabilizer**
  - Calcium

- **Potassium shift**
  - Bicarbonate (only if pH <7.35)
  - Adrenergic agonists
  - Glucose / insulin
  - Magnesium

- **Potassium removal**
  - GI binding resin
  - Hemodialysis
Suspicion for Hyperkalemia

Consider ABCs: Airway, Breathing, & Circulation

Cardiorespiratory Arrest: Impending or Established? YES

Compromising Dysrhythmia? YES

QRS Complex Widening? YES

Prominent T Wave? YES

No ECG Manifestation of Hyperkalemia

ECG-guided Management Algorithm

- General Advanced Life Support Therapies & Focused Hyperkalemia Therapies (Membrane Stabilization & Cellular Shift)
- General Antidysrhythmic Therapies & Focused Hyperkalemia Therapies (Membrane Stabilization, Cellular Shift, & Potassium Removal)
- Focused Hyperkalemia Therapies (Membrane Stabilization, Cellular Shift, & Potassium Removal)
- Focused Hyperkalemia Therapies (Membrane Stabilization & Potassium Removal)
- Focused Hyperkalemia Therapies (Potassium Removal)

Hyperkalemia

ECG Response to Therapy
Case Eight

Closure

• Serum potassium 7.8 (normal < 4.8)
• Continued medications
• Hemodialysis
• Treated for graft rejection
• Improved renal function
• No further hemodialysis
Case Nine

- 16 year-old female
- Ingestion
- Cocaine & alcohol use
- Elavil overdose

- Lethargic
- BP 120/80, P 135, R 12
- Pupils mid range
- Otherwise no findings

Ion Channels

Phase 0 Rapid Influx is Lessened
Sodium Channel Blockers

- Amantadine
- Amitriptyline
- Amoxapine
- Carbamazepine
- Chloroquine
- Cocaine
- Desipramine
- Diltiazem
- Diphenhydramine
- Disopyramide
- Doxepin
- Encainide
- Flecaainide
- Hydroxychloroquine
- Imipramine
- Loxapine
- Maprotiline
- Moricizine
- Nortriptyline
- Orphenadrine
- Phenothiazines
- Procainamide
- Propranolol
- Propafenone
- Propoxyphene
- Thioridazine
- Quinidine
- Quinine
Sinus Tachycardia

QRS Complex Widening
Terminal Rightward Axis Deviation

\[ S_I + R_{avR} \] Pattern

“Bundled” Abnormalities

- Sinus tachycardia
- Widened QRS complex
- Terminal rightward axis
17 year-old Female with Unknown Purposeful Ingestion

----------ultimately diagnosed with TCA ingestion

Progression of ECG over 45 minutes
TCA Ingestion
Management

in brief

• ABCs
• Low threshold for intubation
• Benzodiazepines, etc
• IVF
• Vasopressors
• Sodium bicarbonate

Case Nine
Closure

• Progressive lethargy
• Intubated by EMS
• IV saline & HCO₃
• Diagnosed with mixed ingestion
  – Sedative
  – Stimulant
  – Sodium Channel blocker
Pitfalls

- Non-use of age-related parameters

- Lack of rhythm interpretation within the clinical context of the patient

- “Kids can’t have VT!”

- Reluctance to escalate therapy
The End
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