In-person
March 13-16, 2024

Virtual
May – July 31, 2024

45th National Conference on Pediatric Health Care

EKG Interpretation and Dysrhythmias in Children

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Professor & Nurse Practitioner

National Association of Pediatric Nurse Practitioners

Experts in pediatrics. Advocates for children. 1

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Speaker Disclosure

- No disclosures

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Learning Objectives

1. Describe abnormal EKG findings in children
2. Describe methods to help distinguish between dysrhythmias
3. Discuss mainstays of acute and chronic treatment of dysrhythmias

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Indications for a 12 Lead EKG in Children

- Diagnosis and management of congenital heart disease
- Diagnosis and management of arrhythmia
- Diagnosis and management of rheumatic fever, Kawasaki's disease, pericarditis, myocarditis
- Syncope, seizures and "funny turn"
- Cyanotic episodes
- Chest pain or other symptoms related to exertion
- Family history of sudden death or life-threatening event
- Electrolyte abnormalities
- As part of a toxicology workup

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Pediatric EKG Interpretation

- Heavily dependent on patient age
- The ECG changes during childhood, particularly during infancy
  - Why? RV Dominance
- Heart rates are the most obvious manifestation of age-related variability within the pediatric ECG
  - Gradual increase in vagal tone

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EKG Interpretation: Considerations In Children

- P wave: No significant changes during childhood
- Q wave is seen in II, III, aVF, V5 and V6
  - Amplitude doubles over the 1st months of life, reaching max about 3-5 years of age and then declines thereafter
- QRS complex: relative RVH regresses over the 1st few months of life
  - Amplitude of the r waves in the right precordial leads decreases with age while the amplitude increases in the left precordial leads
- T waves

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EKG Intervals in Children

- PR Interval
- QRS duration
- QT interval

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Normal Variations in Rhythm

These common variations in rhythm can be normal in childhood:

- Pronounced sinus arrhythmia
- Short sinus pauses <1.8 seconds
- First degree AVB
- Mobitz type 1 second degree AVB
- Junctional rhythm
- Ventricular or supraventricular extrasystole

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Dysrhythmias

- Bradyarrhythmias are caused by missed generation of the impulse or blocked conduction
- In general, bradycardia is defined as
  - a HR <100 in children up to 3 yrs old
  - <60 bpm in patients 3-9 years old
  - <50 bpm in patients 9-16 years old
  - <40 for those older than 16
- During sleep, these cutoffs are reduced by 15-20%

- Tachyarrhythmias are caused by enhanced automaticity, triggered activity or reentry mechanism
- Tachycardia is defined as a sequence of 3 or more beats at a rate that is more than 25% of the sinus rate at the onset of the arrhythmia.

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Bradyarrhythmias

- 1st degree AVB: prolongation of the AV conduction (PR interval)
  - Clinically silent
- 2nd degree Type 1: progressive prolongation of the PR interval until a p wave is blocked and not followed by a QRS
  - Clinically silent
- 2nd degree type 2 : an intermittent & sudden block in the AV conduction
  - Can be symptomatic or asymptomatic
- 3rd degree AVB: complete interruption of the AV conduction
  - P waves are independent of the QRS complexes
  - Can be symptomatic or asymptomatic

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Supraventricular Tachycardias

- SVT is the most common arrhythmia in children
- Peak onset is during the neonatal and prepubescent ages
- Reentry tachycardias can have a HR from 180-340 bpm
  - In AV nodal reentry tachycardia, the reentry mechanism involves the AV node
  - In AV reentry tachycardia reentry precedes via an accessory pathway
- Atrial Flutter is an intraatrial macroreentry tachycardia and is most commonly seen in patients with CHD
- Ectopic atrial tachycardia represents about 14% of all pediatric SVTs

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Junctional Dysrhythmias

- Junctional ectopic tachycardia
  - Has 2 forms: congenital and postoperative
  - Due to an automatic focus inside the AV junction
  - Idiopathic JET is often incessant
- Permanent junctional reciprocating tachycardia
  - Often presents in infants
  - **Due to an accessory pathway** and often results in incessant tachycardia
  - Often resistant to drug therapy and requires ablation

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Ventricular Tachycardias

- Definition: series of 3 or more repetitive excitations originating from the ventricle
- Ventricular tachycardia in children is **rare**
- Represents 5-10% of all tachyarrhythmias
- Can be monomorphic or polymorphic
- Can be due to structural heart disease (cardiomyopathy, myocarditis, cardiac tumor, electrolyte disorder or a channelopathy)
- Can also be idiopathic
  - Outflow tract VT
  - Fascicular VT
  - Polymorphic VT (CPVT)

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Bradyarrhythmia Management

- Pacemakers are implanted for symptomatic patients
  - Those patients with 2nd degree type 2 or CHB
- Pacemakers can be epicardial or transvenous
  - Type based on age and other comorbidities (CHD)
- No dedicated pediatric pacing systems

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Narrow Complex Tachycardia Management

Short Term

- Adenosine
- Synchronized cardioversion
- Propafenone or Flecainide
- Amiodarone for refractory cases or in those with reduced EF

Long Term

- Antiarrhythmic Therapy
- Transcatheter ablation can be effective in 80-85% of cases, but patients need to be more than 20kg.

*Recommendations with regard to indications and dosage in pediatric patients are limited and based largely on expert consensus.

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Wide Complex Tachycardia Management

Short Term

- Adenosine can terminate outflow tract VT
- **Verapamil** and Lidocaine can also terminate outflow tract VT
- DCCV or Defibrillation if unstable

Long Term

- Beta blockers
- Calcium channel blockers
- AATx: procainamide, flecainide, amiodarone
- Ablation at the area of earliest ventricular activation
- +/- ICD

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EKG Clues to Diagnosis

- Heart rate
- Narrow vs. wide complex
- Regular vs. irregular
- Abrupt vs. gradual onset and termination
- P wave relationship to QRS

- Hints:
  - Continuous EKG tracing during administration of adenosine

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Innovations in Cardiac Rhythm Management

- Ivabradine
- Leadless pacemakers
- Subcutaneous ICDs

- On the Horizon?
  - Batteryless Pacing
  - Leadless ICDs

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Ivabradine

- Works by inhibiting channels responsible for the generation of action potentials in pacemaker myocytes
- Selective inhibition of these channels permits a negative chronotropic effect without affecting inotropy
- Used for the reduction of intrinsic sinus rate
  - Needed for inappropriate sinus tachycardia and POTS
- More recently, used to treat arrhythmias of enhanced automaticity
  - AET, JET
  - By inhibiting spontaneous depolarization of ectopic pacemaker myocytes, you can achieve rate reduction or restoration of sinus rhythm

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Ivabradine

- Available for oral administration only
- Dosage is 0.05 mg/kg twice daily in children <40kg in weight
  - Maximum dose is up to 7.5 mg
- Approved by the FDA in 2015 for heart failure therapy.
  - Not yet incorporated into the pediatric arrhythmia guidelines
- Half life is up to 6 hours with peak plasma levels within 1-2 hrs

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Leadless Pacemakers

- Therapeutic alternative to conventional pacing system
- Eliminates potential transvenous lead and pacemaker pocket related complications
- Two available systems:
  - Micra Transcatheter Pacing System (TPS) by Medtronic
  - Nanostim system by St. Jude Medical
- Pacing mode is similar to VVIR pacemakers
- Battery longevity is expected to be 5-10 years

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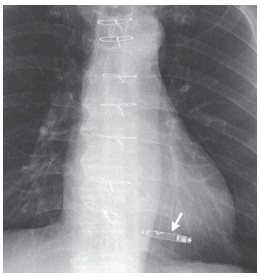

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Advantages of Leadless Pacemakers

- Elimination of potential complications r/t conventional pacemakers
  - Venous access and implantation of the lead
  - Chronic lead related complications
  - Pocket related complications
- Probably safe for MRI
- ?Lower Complication Rates
  - Studies have shown complication rates between 0.8 -6.5%
  - Complications include pericardial effusions, cardiac perforation, dislodgement

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Who are candidates for a leadless pacemaker?

- Upper central venous system is damaged/occluded
  - Chest surgery, radiation, trauma, indwelling catheter infections
- Hemodialysis patients
  - Spares upper venous system
  - These patients also have higher rate of transient bacteremia which predisposes them to infection during dialysis
- Recurrent cardiogenic syncope patients with documented asystole of 30 seconds

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Subcutaneous ICD (S-ICD)

- Subcutaneous : No transvenous lead
- Approved in the US in 2012
- Weighs 130 grams
- Projected battery life of 7+ years
- Uses 2 sensing electrodes on the subcutaneous lead and the canister itself as the third sensor, there are 3 sensing vectors to for detection of VT
- Implantation is guided by anatomical landmarks

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Why an S-ICD?

- Avoids procedural risk of transvenous lead placement and cardiac access and removes the risk of future lead extraction
- Indicated in those with
  - Limited or no vascular access
  - High risk
  - Prior intravascular infections
  - Younger patients

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S-ICD Safety and Efficacy

- 99 to 100% accuracy in detection of ventricular arrhythmias
- 98% accuracy in SVT determination
- Complication Rates
- Long term follow up in a retrospective study
- Rate of complications similar but the nature of complication different significantly
- Appropriate and inappropriate shocks were delivered at equal rates in both groups

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Who should get an S-ICD?

- Patients with indication for ICD who do not have pacing needs or prior history of recurrent monomorphic VT
- Limited to no vascular access
- Intracardiac shunts or abnormal cardiac chambers
- Patients at high risk for infection
- Younger patients who will require long term arrhythmia protection

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S-ICD Limitations

- Inability to provide pacing
- Not appropriate for those who need CRT
- Does not provide ATP
- No direct comparison of safety and efficacy between transvenous ICDs and S-ICDs

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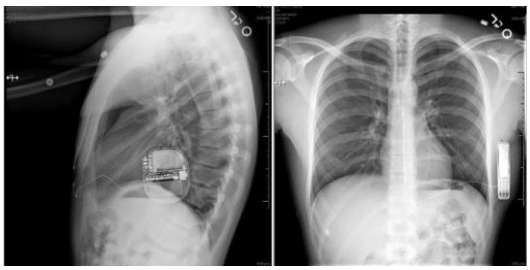

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EKGs & Dysrhythmia Management

- Let's now:
  - Review some normal EKGs
  - Review some abnormal EKGs & dysrhythmias
  - Discuss cases along with their management

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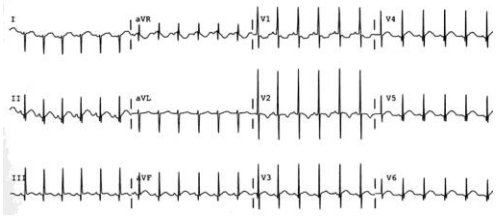
Infant EKG



(O'Connor, et al 2008a)

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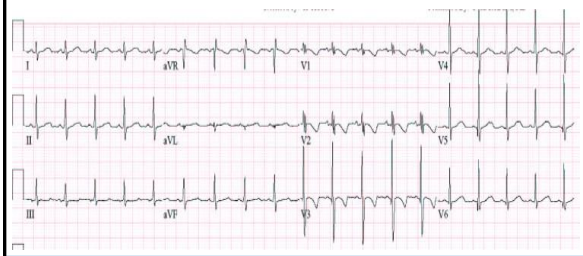
Pediatric EKG



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(Chan, et al 2008)

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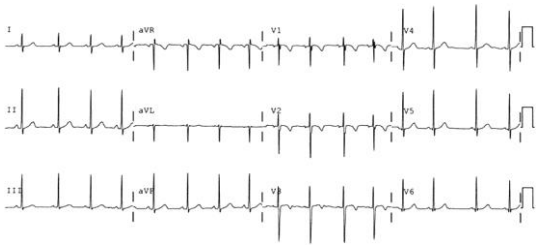
Pediatric EKG



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(O'Connor, et al 2008a)

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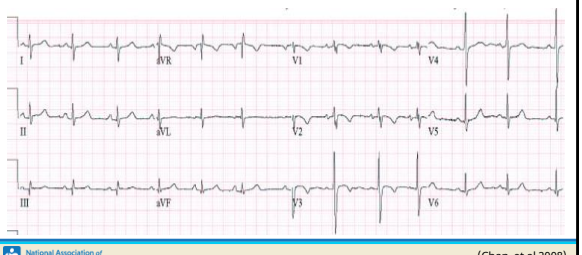
Pediatric EKG



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(Chan, et al 2008)

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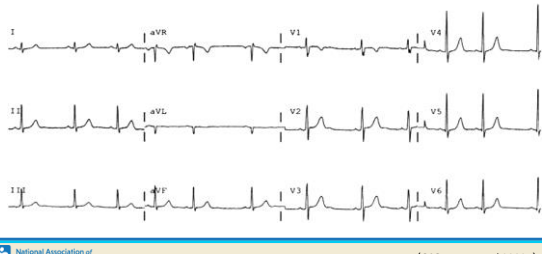
Adolescent EKG



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(O'Connor, et al 2008a)

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Abnormal EKGs

- Let's review the following cases
- Look for abnormal EKG findings and dysrhythmias

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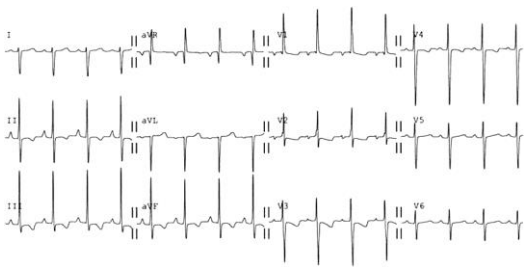

 (O'Connor, et al 2008a)

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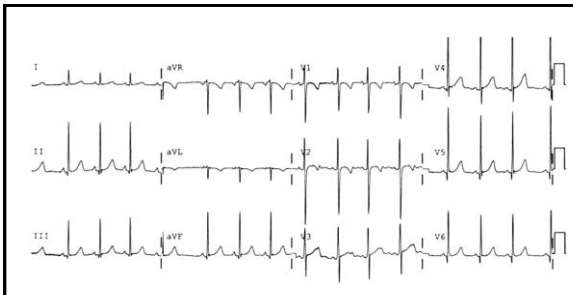

 (O'Connor, et al 2008a)

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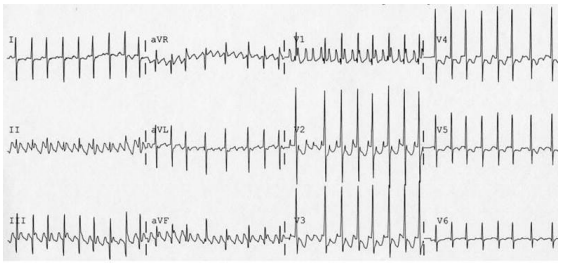

 (O'Connor, et al 2008b)

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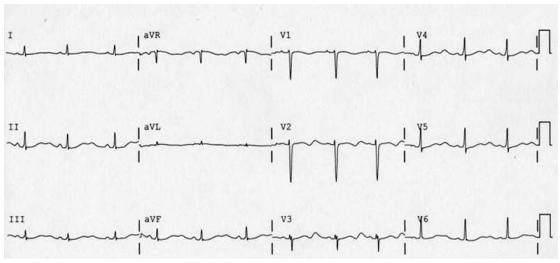

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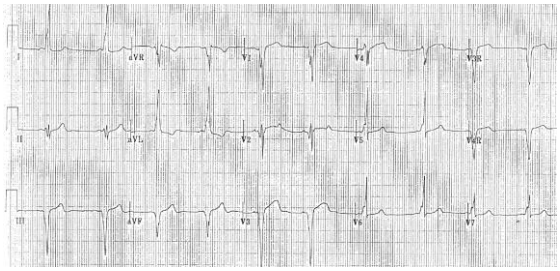

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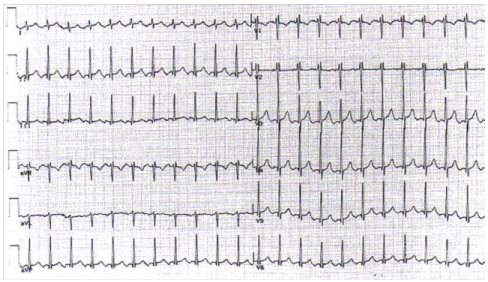

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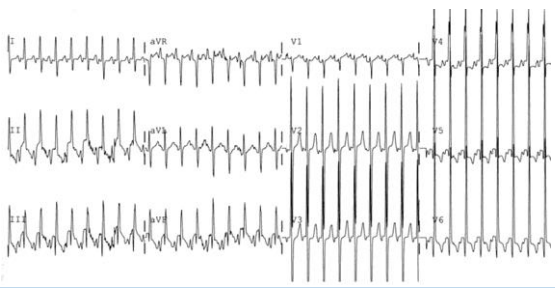

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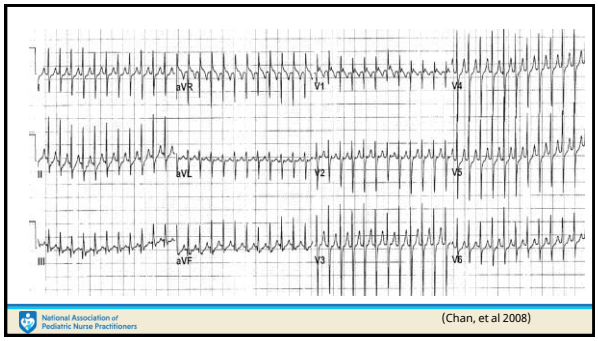
aVR
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V4
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(Chan, et al 2008)

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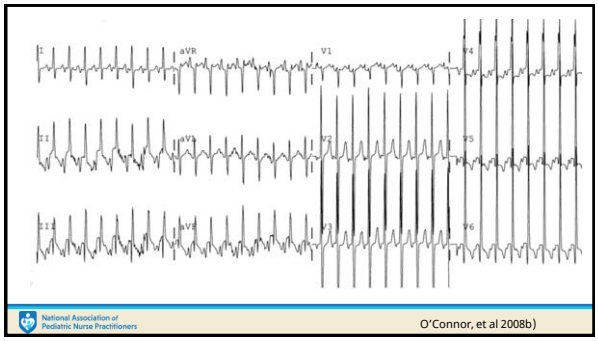
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O'Connor, et al 2008b)

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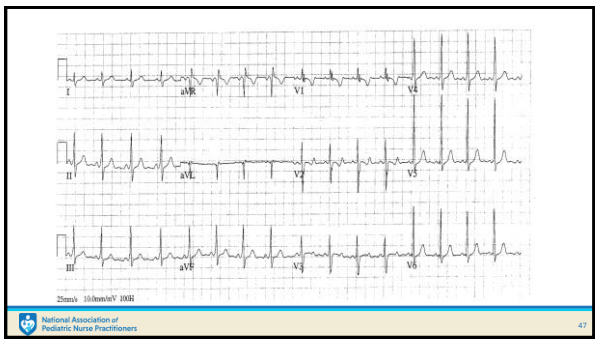
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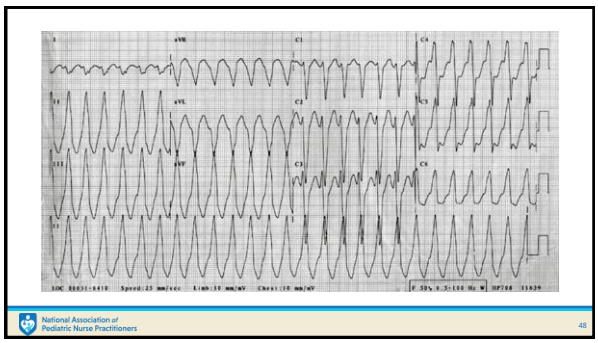
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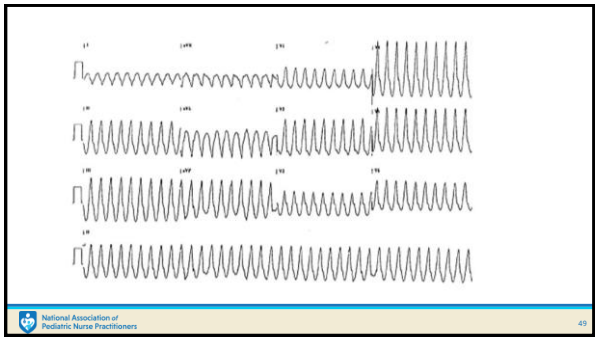
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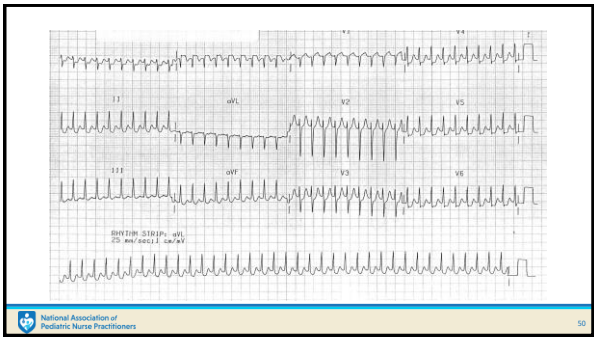
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RHYTHM STRIP: aVL
25 mm/sec; 1 cm/mV
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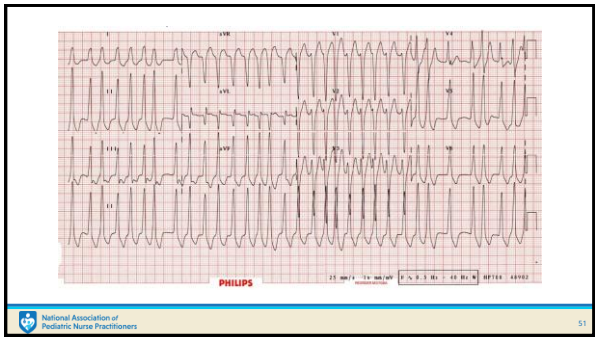
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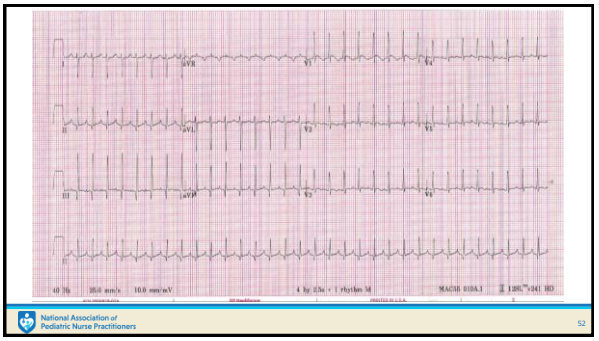
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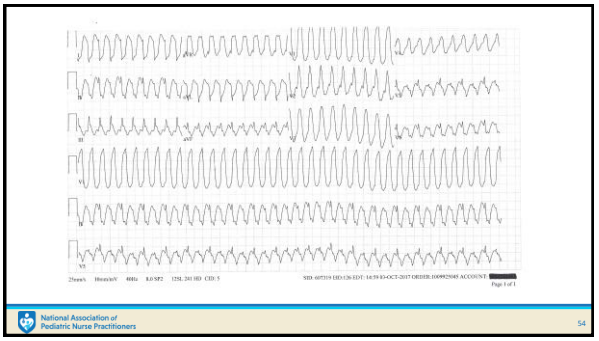
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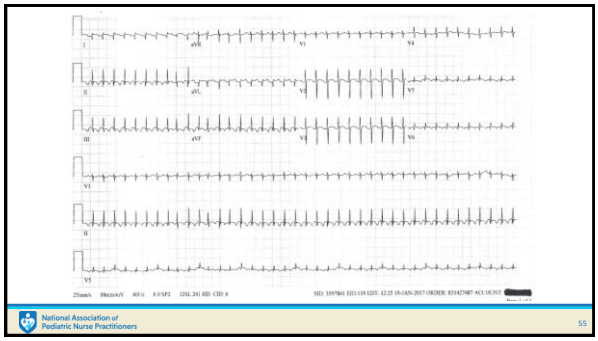
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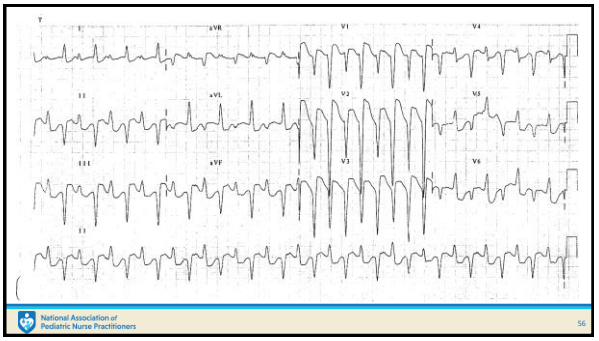
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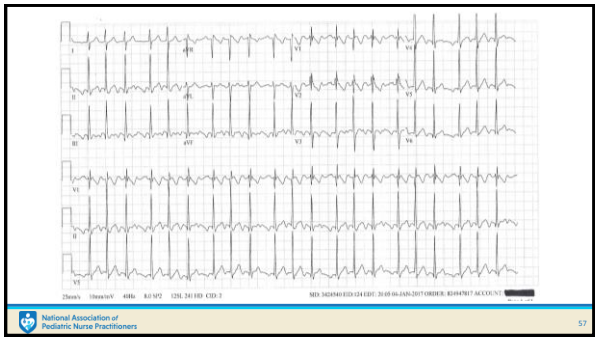
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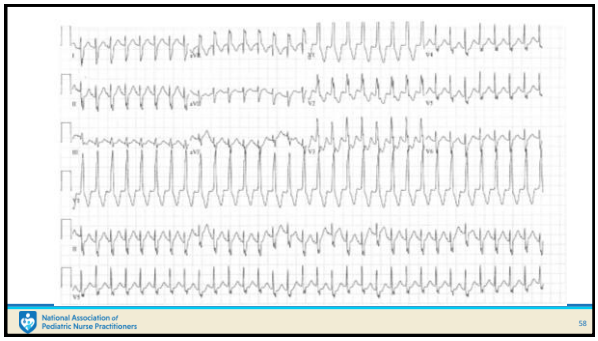
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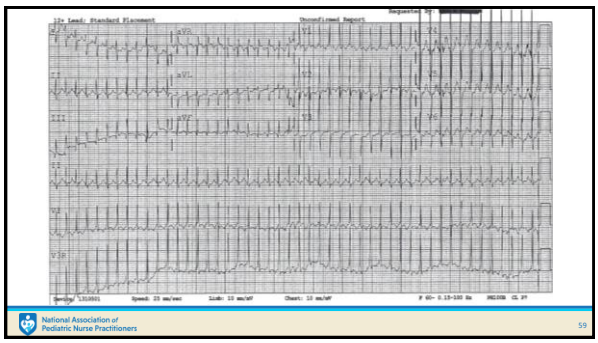
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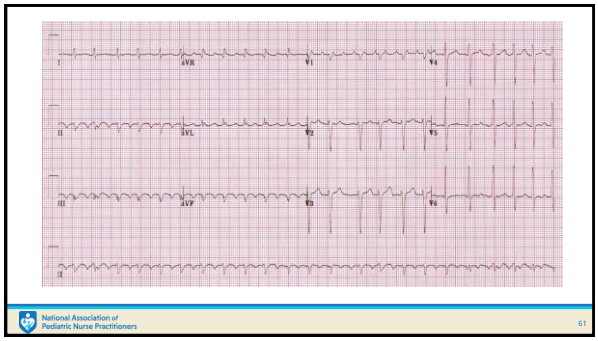
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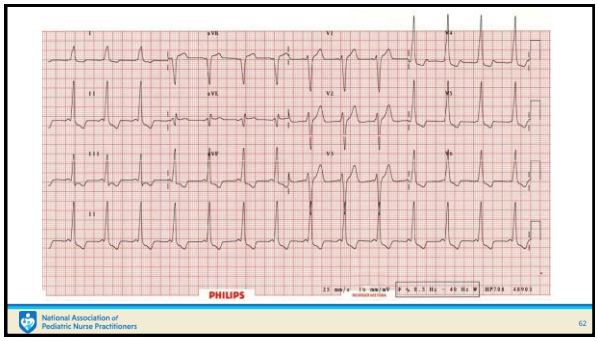
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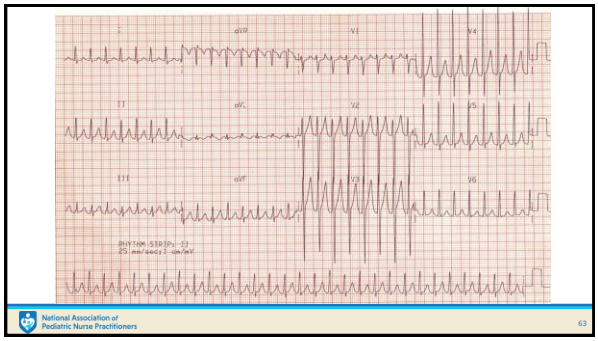
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RHYTHM STRIPS II
25 mm/sec; 1 cm/mV
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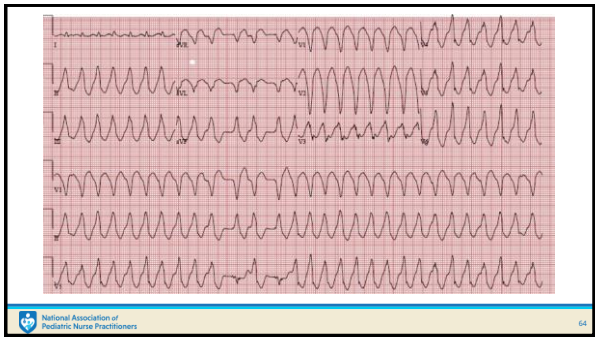
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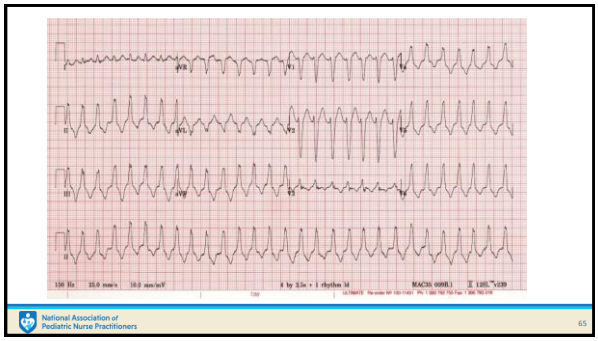
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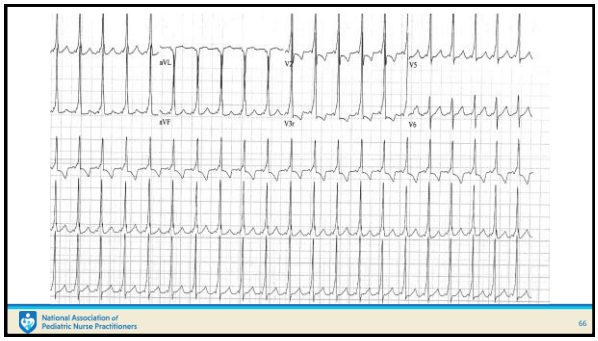
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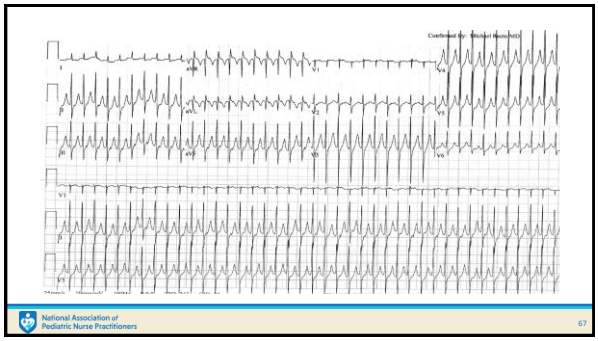
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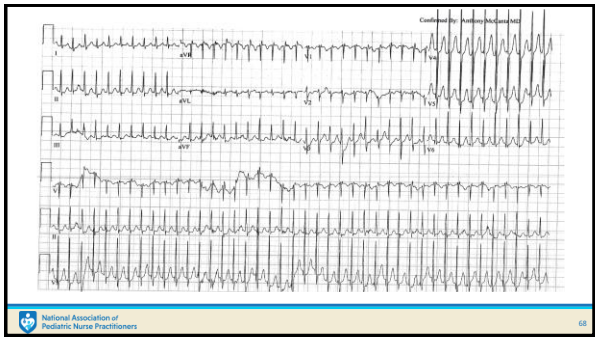
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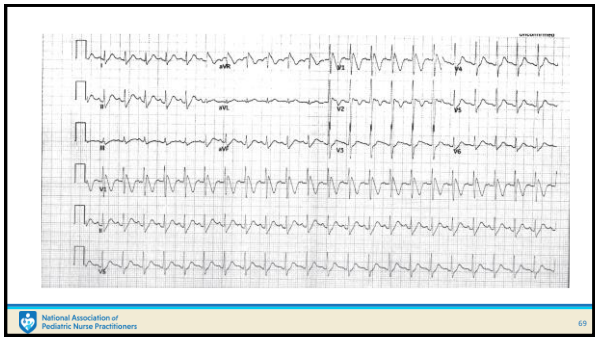
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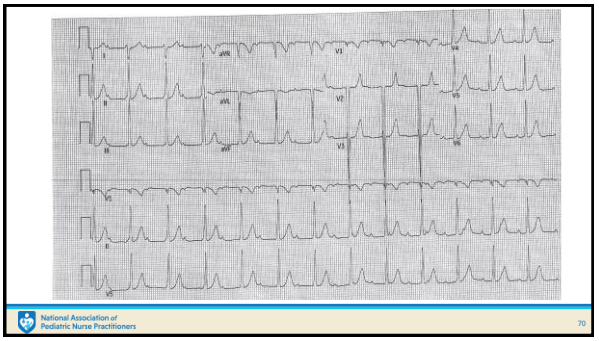
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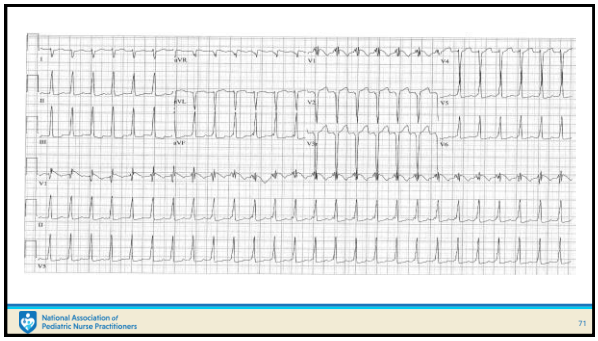
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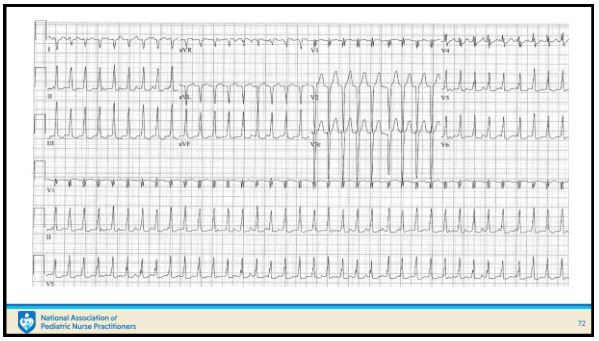
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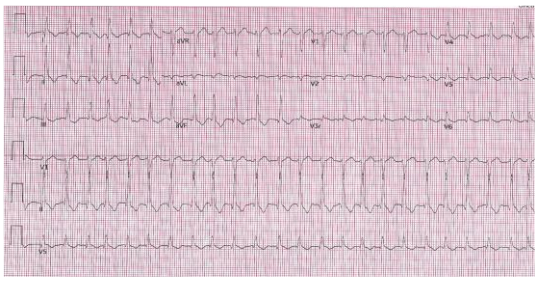

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