EKG Approach

Normal EKG Values By Age

AGE	0-7 days	1 wk–1 mo	1 mo-6 mo	6 mo-1 yr	1 yr-5 yr	5-10 yr	10-15 yr	>15 yr
Rate (beats/min)	90-160 (125)	100-175 (140)	110-180 (145)	100-180 (130)	70-160 (110)	65-140 (100)	60-130 (90)	60-100 (80)
QRS axis (degrees)	70-180 (120)	45-160 (100)	10-120 (80)	5-110 (60)	5-110 (60)	5-110 (60)	5-110 (60)	5-110 (60)
PR lead II (msec)	80-150 (100)	80-150 (100)	80-150 (100)	80-150 (100)	80-150 (120)	80-150 (120)	90-180 (140)	100-200 (160)
QRS duration (msec)	40-70 (50)	40-70 (50)	40-70 (50)	40-70 (50)	45-80 (65)	45-80 (65)	50-90 (70)	60-90 (80)
Maximum QTc[1] (msec)	450 max	450 max	450 max	450 max	440 max	440 max	440 max	430 max
QRS V_1 Q (mm)	0	0	0	0	0	0	0	0
R (mm)	5-25 (15)	3-22 (10)	3-20 (10)	2-20 (9)	2-18 (8)	1-15 (5)	1-12 (5)	1-6 (2)
S (mm)	0-22 (7)	0-16 (5)	0-15 (5)	1-20 (6)	1-20 (10)	3-21 (12)	3-22 (11)	3-13 (8)
QRS V_5 Q (mm)	0-1 (0.5)	0-3 (0.5)	0-3 (0.5)	0-3 (0.5)	0-5 (1)	0-5 (1)	0-3 (0.5)	0-2 (0.5)
R (mm)	2-20 (10)	3-25 (12)	5-30 (17)	10-30 (20)	10-35 (23)	13-38 (25)	10-35 (20)	7-21 (13)
S (mm)	2-19 (10)	2-16 (8)	1-16 (8)	1-14 (6)	1-13 (5)	1-11 (4)	1-10 (3)	0-5 (2)
QRS V_6 Q (mm)	0-2 (0.5)	0-2 (0.5)	0-2 (0.5)	0-3 (0.5)	0-4 (1)	0-4 (1)	0-3 (1)	0-2 (0.5)
R (mm)	1-12 (5)	1-17 (7)	3-20 (10)	5-22 (12)	6-22 (14)	8-25 (16)	8-24 (15)	5-18 (10)
S (mm)	0-9 (3)	0-9 (3)	0-9 (3)	0-7 (3)	0-6 (2)	0-4 (2)	0-4 (1)	0-2 (1)
T-wave V_1 (mm)	*0-4 days* = −3 to +4 (0) *4-7 days* = −4 to +2 (−1)	−6 to −1 (−3)	−6 to −1 (−3)	−6 to −1 (−3)	−6 to −1 (−3)	−6 to +2 (−2)	−4 to +3 (−1)	−2 to +2 (+1)

Values are 2nd – 98th percentile (mean) From Keane et al. *NADAS' Pediatric Cardiology*. 2006.

CXR	• **Heart Size**: >50-60% of thorax is abnormal on PA film (confounded by: poor inspiration, AP technique, thymic shadow) • **Lung Fields**: increased pulmonary blood flow (increased pulm. vasc. markings, engorged vessels) = sign of overcirc. • Decreased vascular markings indicate decreased pulmonary blood flow. • Pulmonary edema and effusions may indicate CHF. • **Thymic Shadow**: lack of a thymic shadow in neonates should raise suspicion for 22q11 del. and assoc. cardiac defects • **Aortic Arch**: sidedness (left-sided aortic arch is normal) • **Heart Border**: Left or right atrial enlargement • **Rib Notching**: suggests the presence of collateral vessels, as can be seen in coarctation.
What To Do Next	• 4-extremity BP: Upper > Lower (or less commonly R arm > Lt arm) suggests obstruction of the aorta (e.g. interrupted arch, coarctation). Exception to the rule: L arm > R suggests aortic obstruction w/ aberrant right subclavian. • Pre- and post-Ductal O2 sats (measure on right arm and either foot) • Hyperoxia Test: PaO2 < 100 mm Hg on 100% RA suggests cyanotic congenital heart disease. >200 suggests pulmonary etiology. Pulse oximetry can be used as approximation if unable to obtain ABG. • Consult cardiologist
When To Start Prostaglandins	• After workup, if high suspicion for cyanotic heart disease start PGE1 0.05 mcg/kg/min as soon as possible • Monitor for apnea and hypotension • Consider securing airway if patient requires transport

Arrhythmias and Pacemakers

Premature Ventricular Contractions (PVCs)

Presentation	Range: asymptomatic → **palpitations, lightheadedness**. Irregular pulse on exam
Pathophys	Re-entry, enhanced automaticity, triggered activity
Workup	**EKG, 24-48 Holter, chem10, thyroid panel**. May require echo or exercise testing. (dependent
Treatment	Usually none. **Trx underlying cause** (if one exists, e.g. a drug). Beta blockers or CCBs if symptomatic. If refractory, radiofrequency catheter ablation.

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Arrhythmias and Pacemakers

Premature Atrial Contractions (PACs)

Presentation	Range: asymptomatic → **palpitations, lightheadedness.** Irregular pulse on exam
Pathophys	Re-entry, enhanced automaticity, triggered activity from after depolarizations
Workup	Similar to work up for PVCs
Treatment	Rarely required. **Beta-blockade** can be considered for symptomatic PACs

Bradyarrythmia

Presentation	Usually asymptomatic; lightheadedness, SOB, exercise intolerance or syncope and cardiovascular collapse; poor feeding, irritability and/or respiratory abnormalities in infants • Newborn to 3 years: < 90-100 bpm • 3 to 9 years: < 60 bpm • 9-16 years: < 50 bpm • Well trained adult athletes: <40 bpm
Pathophys	Caused by increased ICP, **medications** (beta blockers, digoxin, acetylcholinesterase inhibitors, analgesics and sedatives as well as alpha 2 blockers), structural CHD, myocarditis, anorexia
Workup	Assess for **perfusion**, Hx for causes and medications; **EKG**
Treatment	• Observation if asymptomatic • Complete block or advanced 2nd degree block: **pacemaker** • **CPR if HR <60** w/ per perfusion, consider epinephrine, atropine, transcutaneous pacing

AV Block

Degree	PR Interval	Pathophys
1st Degree	**Prolonged PR interval** Birth- 4 wks: 0.08-0.12 1-3 mos: 0.08-0.13 3-12 mos: 0.08-0.14 1-3 yrs: 0.08-0.15 3-5 yrs: 0.1-0.15 5-8 yrs: 0.09-0.16 8-12 yrs: 0.1-0.17 12-16 yrs: 0.1-0.18	**Increased vagal tone, idiopathic, acute rheumatic fever (ARF), Lyme dz,** hypothermia, cardiomyopathy, electrolyte disturbances
2nd Degree Mobitz I (Wenkebach)	**Progressive lengthening of PR** → non-conducted P wave	• At the level of the AV node **(does not progress to complete heart block)** • Healthy individuals during sleep
2nd Degree Mobitz II	**Normal PR interval, intermittent nonconducted P waves** (ratio of P waves: QRS, e.g. 2:1 = 2 P waves per 1 QRS)	**BELOW level of AV node** (e.g., His bundle pathology, a/w CHD or cardiac surgery) → **may progress to complete heart block**
3rd Degree (Complete)	**Complete AV dissociation**	• Narrow QRS (junctional beats) vs. **wide QRS (ventricular beats) → may cause hemodynamic collapse** • Congen. heart block in infants of mothers w/**SLE** (anti-Ro/anti-La Ab), L-TGA • Acquired heart block: myocarditis, **Lyme dz**, ARF, MI

Supraventricular Tachycardia (SVT)

Presentation	• **Paroxysmal** palpitations, chest pain, shortness of breath, dizziness or syncope w/ sudden onset and sudden resolution • HR characteristically invariable and is generally > 220 bpm in infants and > 180 bpm in children
Workup	EKG w/ narrow QRS complex, delta waves, retrograde P waves or not visible P waves
Treatment	• **Vagal** maneuvers (ice to face for babies, Valsalva maneuvers, blowing through a straw) • Give **adenosine** 0.1 mg/kg (max dose 6-12 mg) as a rapid IV push through an IV as close to the heart as possible, followed by very rapid NS flush (this may be repeated at 0.2 mg/kg) • Immediate **synchronized cardioversion** is indicated if the patient is unstable

Arrhythmias and Pacemakers

Pre-Excitation	
Presentation	Episodes of paroxysmal supraventricular tachycardia or asymptomatic/incidental finding on EKG
Pathophys	Early conduction of atrial impulses to the ventricle defined by **short PR interval, wide QRS, delta wave**
Workup	Echo to r/o structural heart disease (Ebstein's anomaly); exercise testing
Treatment	**Catheter ablation** is curative; beta-blocker or other antiarrhythmic medications
Ventricular Tachycardia and Ventricular Fibrillation	
Presentation	Range: asymptomatic → palpitations, chest pain, dizziness or syncope→ hemodynamic collapse and rapid death
Pathophys	Can be due to drugs, electrolyte abnormalities that prolong QT, underlying cardiac disease, syndromes including LQTS, Brugada syndrome, CPVT and ARVC can also predispose to these rhythms, as well as accessory pathways (as in WPW)
Workup	EKG, electrolytes, blood gas, and toxicologic screening
Treatment	**VTach w/ a pulse**: • **Amiodarone** (5 mg/kg over 20-60 mins), Lidocaine (1 mg/kg over 2-4 minutes) • **Synchronized cardioversion** 0.5-1 J/kg initially, repeat w/ up to 2 J/kg. May be used w/ or instead of medical therapy • Magnesium (25 mg/kg over 10-20 minutes) if torsade de pointes is suspected **VFib or pulselss VTach**: • **CPR** immediately • **Defibrillate** initially w/ 2 J/kg, repeat at 4 J/kg w/ a maximum of 10 J/kg every 2 mins • If not converted, use **Epinephrine** (0.01 mg/kg = 0.1 ml/kg of 1:10,000 IV), may repeat every 3-5 mins • Consider Lidocaine, Amiodarone and Magnesium Sulfate
Long QT Syndrome	
Presentation	• Range: incidental findings → syncope, palpitations, arrhythmia, seizures, or sudden death. • Often provoked by exercise, fright and rapid temperature changes (such as diving into cold water)
Pathophys	• **Congenital forms**: ion channelopathies (Romano-Ward, Jervell and Lange-Nielsen Syndrome, Andersen syndrome) • **Acquired causes of Long QT**: Electrolyte abnormalities (hypokalemia, hypomagnesemia and hypocalcemia) Macrolides, quinolones, metronidazole, multiple antifungals, most anti-emetics, SSRIs and TCAs, many antipsychotics, multiple antiarrhythmics, methadone and diphenhydramine
Workup	• **EKG** w/ prolonged QTc (upper limit of normal 400-460 ms), T-wave alternans, notched T-waves or low resting HR; electrolytes • Often want to test family members as well for genetic LQT syndromes as AD transmission most common.
Treatment	Adequate magnesium, potassium and calcium level; Avoid any medications that may prolong QTc (a full list can be found at **www.crediblemeds.org**) and activities known or suspected to provoke it; **Beta blockers**, ICD placement and left thoracic sympathectomy are options for high-risk patients

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