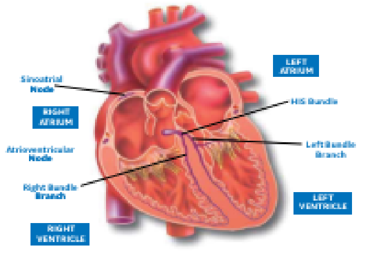
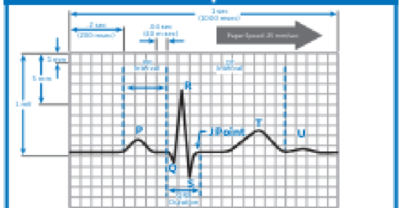
Cardiac Conduction System



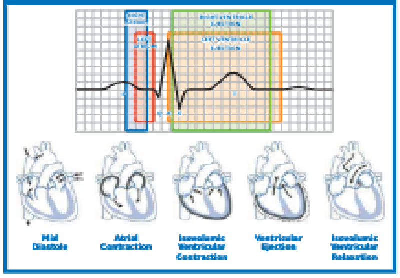
ECG Components



Vertical Axis
1 Small Square = 1 mm (0.1 mV)
1 Large Square = 5 mm (0.5 mV)
2 Large Squares = 1 mV

Horizontal Axis
1 Small Square = .04 sec (40 msec)
1 Large Square = .2 sec (200 msec)
5 Large Squares = 1 sec (1000 msec)

Electrical and Mechanical Events

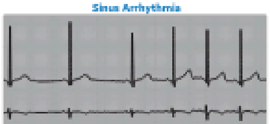


Sinus Rhythms

Normal Sinus Rhythm

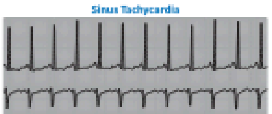
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
60 - 100 bpm	Regular	Before each QRS, identical	0.12 to 0.20	< 0.12

Sinus Arrhythmia



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
60 - 100 bpm	Irregular	Before each QRS, identical	0.12 to 0.20	< 0.12

Sinus Tachycardia



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
> 100 bpm	Regular	Before each QRS, identical	0.12 to 0.20	< 0.12

Sinus Bradycardia

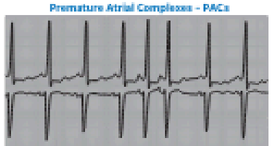
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
< 60 bpm	Regular	Before each QRS, identical	0.12 to 0.20	< 0.12

Sinus Arrest or SA Block

Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
40 - 100 bpm	Irregular	Identical before each QRS. P to P interval may be fixed before and after the pause	0.12 to 0.20	< 0.12

Supraventricular Rhythms

Premature Atrial Complexes - PACs

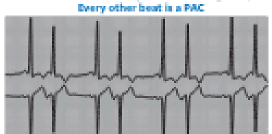


Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	Irregular	Premature and abnormal. May be hidden	0.12 to 0.20	< 0.12

Premature Atrial Complex - Isolated PAC

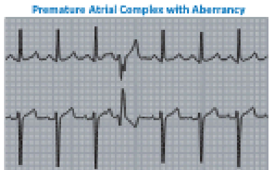
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	Irregular	Premature and abnormal. May be hidden	0.12 to 0.20	< 0.12

Premature Atrial Complexes (Atrial Bigeminy) Every other beat is a PAC



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	Irregular	Premature and abnormal. May be hidden	0.12 to 0.20	< 0.12

Premature Atrial Complex with Aberrancy

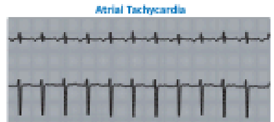


Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	Irregular	Premature and abnormal. May be hidden	0.12 to 0.20	> 0.12 Abnormal Shape

Nonconducted Premature Atrial Complex

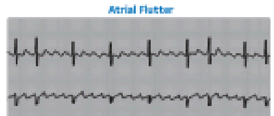
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	Irregular	Premature and abnormal. May be hidden	None	Absent

Atrial Tachycardia



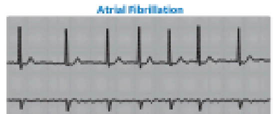
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
160 - 250 bpm	Regular	Abnormal P before each QRS (difficult to see)	0.12 to 0.20	< 0.12

Atrial Flutter



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
A: 240-350 bpm V: Varies with conduction ratio	A: Regular V: Regular, group beating or variable	Flutter (F) waves, usually the negative component; sawtooth in II, III, aVF and positive in V1	N/A	< 0.12

Atrial Fibrillation

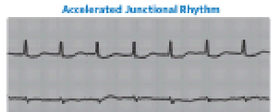


Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
A: 350-650 bpm V: Slow to rapid	Irregular	Absent. Fibrillatory (f) waves	N/A	< 0.12

Junctional Rhythm

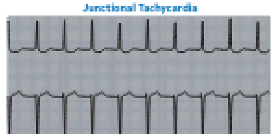
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
40 - 60 bpm	Regular	Inverted in inferior leads, before, during or after the QRS, may be absent	< 0.12	< 0.12

Accelerated Junctional Rhythm



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
60 - 100 bpm	Usually AV dissociation because of digitalis toxicity	May be sinus P wave (AV dissociation)	< 0.12	< 0.12

Junctional Tachycardia



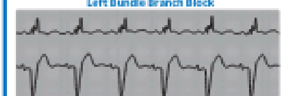
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
Usually < 180 bpm	Regular	Inverted, Absent or after QRS	< 0.12	< 0.12

Conduction Defects

Right Bundle Branch Block

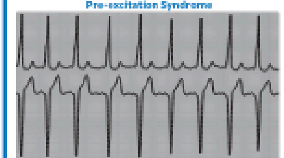
P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	0.12 to 0.20	≥ 0.12	RSR' in V1

Left Bundle Branch Block



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	0.12 to 0.20	≥ 0.12	QS or rS in V1 & V2. ST elevation

Pre-excitation Syndrome



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	< 0.12	Usually > 0.12	Delta wave distorts initial QRS

First-Degree AV Block

P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	> 0.20	< 0.12	Regular rhythm

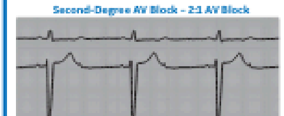
Second-Degree AV Block - Type I (AV Wenckebach or Mobitz type I)

P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Conduction intermittent	Increasingly prolonged	< 0.12	QRS dropped in a repeating pattern

Second-Degree AV Block-Type II (Mobitz type II)

P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Sinus	Usually normal and identical before and after a blocked impulse	Broad > 0.12	Some P waves are not conducted

Second-Degree AV Block - 2:1 AV Block



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Sinus	Normal or prolonged	Narrow or broad	2:1 AV conduction

Third Degree (Complete) AV Block

P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Normal but not related to QRS	N/A	Narrow or broad	AV dissociation

Arrhythmia Recognition (poster 1 of 2)

This is part one of two posters to assist healthcare professionals in recognizing basic arrhythmias. According to the Practice Standards for Electrocardiographic Monitoring in Hospital Settings (Circulation. 2004;110:2721-2746) in general, the mechanisms of arrhythmias are the same in both adults and children. However, the ECG appearance of the arrhythmias may differ due to developmental issues such as heart size, baseline heart rate, sinus and AV node function, and autonomic innervation.

ECG terminology and diagnostic criteria often vary from text to text and from one teacher to another. There are often several terms describing similar findings (for example: Premature Atrial Contraction, Atrial Premature Complex, Atrial Extrasystole, Supraventricular Ectopic Beat, etc.) It is important to correlate the ECG interpretation with the clinical observation of the patient.

Normal ECG Standards for Children Age

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heart Rate (bpm)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PR Interval Lead II (seconds)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
QRS Interval V5 (seconds)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

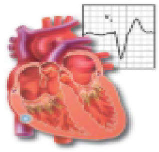
All values 2nd – 98th percentile; numbers in parentheses, means. Adapted from Davignon A, et al. 1979;1:123.

This poster includes Premature Ventricular Conduction, Pacemaker Lead Placement, ST Segment Depression, Ventricular Rhythms, Pacemaker Rhythms, Full Compensatory Pause and ECG Artifact. The ECG rhythm strips display lead II as the top waveform and lead V1 as the bottom waveform. Classic examples are shown for each rhythm to provide basic visualization and avoid complexities. The intended use of this poster is to complement a text and/or course – in addition to a reference guide for arrhythmia recognition.

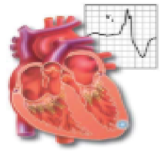
The most common ECG rate, interval, and duration measurements Are from the following publications:

–Clinical Electrocardiography (Post Graduate Institute for Medicine).
–Understanding Electrocardiography (Mary Boudreau Conover).
–How to Quickly and Accurately Master Arrhythmia Interpretation (Dale Davis).
–Principles of Clinical Electrocardiography (M. J. Goldman).
–Basic Dysrhythmias Interpretation and Management (Robert Huszar).
–An Introduction to Electrocardiography (Leo Schamroth).
–Interpretation of Arrhythmias (Emanuel Stein).

Premature Ventricular Conduction

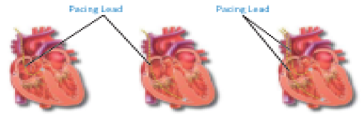


Right Ventricular PVC



Left Ventricular PVC

Pacemaker Lead Placement

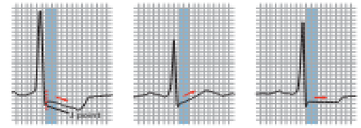


Atrial Pacing
The pacing lead is inserted into the atrium to cause atrial depolarization.

Ventricular Pacing
The pacing lead is inserted into the ventricle to cause ventricular depolarization.

AV Sequencial Pacing
The pacing lead is inserted into the both the atrium and ventricle stimulating at set intervals.

ST Segment Depression



Downsloping ST | Upsloping ST | Horizontal ST

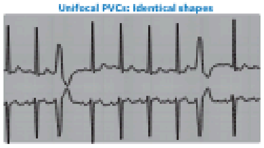
The J point occurs at the end of the QRS complex.
The ST segment begins at the J point and extends to a user-defined interval.

Ventricular Rhythms

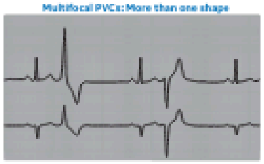
Premature Ventricular Complex - PVC

Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	Irregular with PVCs	N/A	N/A	≥ 0.12

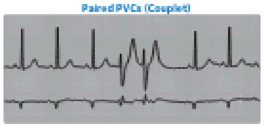
Unifocal PVCs: Identical shapes



Multifocal PVCs: More than one shape

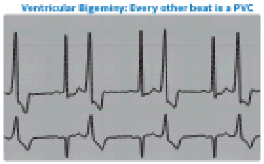


Paired PVCs (Couplet)

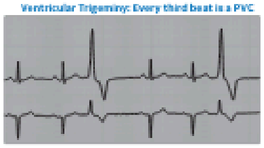


R on T Phenomenon: PVC occurs at the peak of the of T wave of the preceding beat

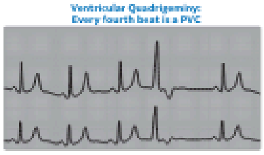
Ventricular Bigeminy: Every other beat is a PVC



Ventricular Trigeminy: Every third beat is a PVC



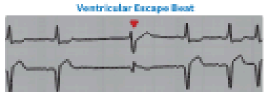
Ventricular Quadrigeminy: Every fourth beat is a PVC



Ventricular Fusion Beat

Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
N/A	N/A	Present	Same as sinus rhythm or shorter	≥ 0.12

Ventricular Escape Beat

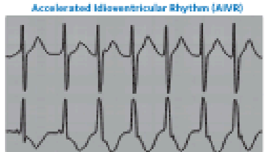


Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
< 40 bpm	Irregular	Absent	Absent	≥ 0.12

Idioventricular Rhythm

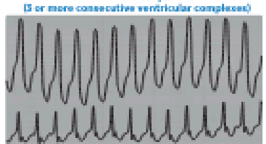
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
20 - 40 bpm	Regular	Absent or not related	N/A	≥ 0.12

Accelerated Idioventricular Rhythm (AIVR)



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
40 - 100 bpm	Regular	Absent, not related or retrograde conduction	N/A	≥ 0.12

Ventricular Tachycardia (3 or more consecutive ventricular complexes)



Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
> 100 bpm	Regular	Absent, not related or retrograde conduction 1:1, 1:2, or VA Wenckebach	N/A	≥ 0.12

Ventricular Fibrillation

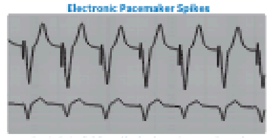
Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
300 - 600 bpm	Extremely irregular	Absent	Absent	Absent

Ventricular Asystole

Heart Rate	Rhythm	P Wave	PR Interval (in seconds)	QRS (in seconds)
Absent	Absent	Absent or present	Absent	Absent

Pacemaker Rhythms

Electronic Pacemaker Spikes



Electrical stimuli delivered by the electronic pacemaker to the endocardium are seen as a spike on the surface ECG.

Ventricular Pacemaker (single chamber)

Single spike producing a wide QRS complex (ventricular capture).

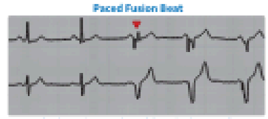
Atrial Pacemaker (single chamber)

Single spike producing paced P wave (atrial capture) followed by an intrinsic QRS complex.

AV Sequential Pacemaker (dual chamber)

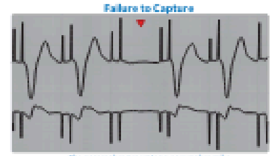
First spike followed by a paced P wave (atrial capture) followed by a second spike producing a wide QRS complex (ventricular capture).

Paced Fusion Beat



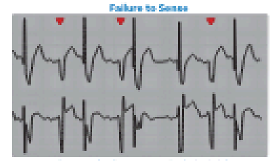
The electronic pacemaker and the patient's own cardiac rhythm occurs simultaneously producing a combination of a paced beat and an intrinsic beat.

Failure to Capture



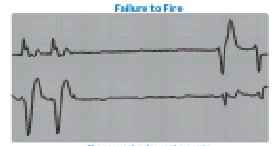
The pacemaker generates a pacemaker spike but does not cause an intrinsic beat (P wave or QRS).

Failure to Sense



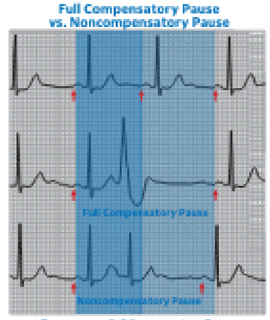
The pacemaker does not recognize the intrinsic beats and generates an unnecessary pacemaker spike.

Failure to Fire



The pacemaker does not generate a pacemaker spike when it is needed.

Full Compensatory Pause vs. Noncompensatory Pause



To measure a Full Compensatory Pause:

1. Mark off three normal cycles.
2. Place the first mark on the P wave of the normal cycle preceding the premature complex.
3. The third mark should fall exactly on the P wave following the premature complex to be called a compensatory pause.

ECG Artifact

Any waveform on the ECG that is not related to the patient's cardiac events

Calibration Pulses

Deliberate artifact caused to show the interpreter the relationship of the complexes with a known electrical stimulus (standardization procedure).

AC Interference (60 cycle)

Sixty even, regular spikes in a one-second interval caused by electrical current near the patient.

Muscle Tremor (Somatic)

Electrical interference caused by the patient's tensed muscles.

Wandering Baseline (Drift)

An undulating baseline with waveform present.

Arrhythmia Recognition (poster 2 of 2)

Normal ECG Standards for Children Age

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heart Rate (bpm)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PR Interval Lead II (seconds)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
QRS Duration Lead V5 (seconds)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The most common ECG rate, interval, and duration measurements are from the following publications: