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Dr Cheentan Singh

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APPROACHING THE PAEDIATRIC ECG

Anna McCorquodale

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ECG interpretation

European Heart Journal (2001) 22, 702–711

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New normal limits for the paediatric electrocardiogram

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Table 2 Lead-independent ECG measurements for boys (upper row) and girls (lower row): median (2nd percentile, 98th percentile)

Lead	0-1 months	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	5-8 years	8-12 years	12-18 years
Heart rate beats min ⁻¹	105 (126, 92)	102 (126, 87)	104 (121, 90)	103 (120, 89)	103 (120, 89)	103 (120, 89)	103 (120, 89)	103 (120, 89)	103 (120, 89)
P axis (°)	58 (13, 99)	52 (10, 75)	49 (1, 79)	49 (1, 79)	49 (1, 79)	49 (1, 79)	49 (1, 79)	49 (1, 79)	49 (1, 79)
P duration (ms)	79 (64, 85)	79 (65, 91)	79 (65, 91)	79 (65, 91)	79 (65, 91)	79 (65, 91)	79 (65, 91)	79 (65, 91)	79 (65, 91)
P-R interval (ms)	99 (77, 126)	99 (77, 126)	99 (77, 126)	99 (77, 126)	99 (77, 126)	99 (77, 126)	99 (77, 126)	99 (77, 126)	99 (77, 126)
QRS axis (°)	10 (10, 12)	10 (10, 12)	10 (10, 12)	10 (10, 12)	10 (10, 12)	10 (10, 12)	10 (10, 12)	10 (10, 12)	10 (10, 12)
QRS duration (ms)	62 (50, 65)	62 (50, 65)	62 (50, 65)	62 (50, 65)	62 (50, 65)	62 (50, 65)	62 (50, 65)	62 (50, 65)	62 (50, 65)
QTc interval (ms)	419 (379, 462)	420 (380, 460)	421 (380, 460)	421 (380, 460)	421 (380, 460)	421 (380, 460)	421 (380, 460)	421 (380, 460)	421 (380, 460)

95% confidence intervals of the percentile estimates for boys and girls do not overlap.

*Normal distribution according to Shapiro-Wilk test, P < 0.05.

Table 3 P-wave amplitudes (mV) for boys (upper row) and girls (lower row): median (98th percentile)

Lead	0-1 months	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	5-8 years	8-12 years	12-18 years
II	0.14 (0.23)	0.16 (0.25)	0.15 (0.22)	0.14 (0.20)	0.14 (0.20)	0.14 (0.20)	0.14 (0.20)	0.14 (0.20)	0.14 (0.20)
V ₁	0.12 (0.22)	0.13 (0.23)	0.13 (0.23)	0.13 (0.23)	0.13 (0.23)	0.13 (0.23)	0.13 (0.23)	0.13 (0.23)	0.13 (0.23)
V ₅	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)

95% confidence intervals of the percentile estimates for boys and girls do not overlap.

Table 4 Q-wave amplitudes (mV) for boys (upper row) and girls (lower row): median (98th percentile)

Lead	0-1 months	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	5-8 years	8-12 years	12-18 years
II	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)
III	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)
aVF	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)
V ₁	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)
V ₅	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)	0.14 (0.23)

95% confidence intervals of the percentile estimates for boys and girls do not overlap.

Table 5 R-wave amplitudes (mV) for boys (upper row) and girls (lower row): median (98th percentile)

Lead	0-1 months	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	5-8 years	8-12 years	12-18 years
I	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
II	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
III	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
aVR	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
aVL	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
aVF	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
V ₁	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)
V ₅	0.10 (0.47)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)	0.11 (0.52)

95% confidence intervals of the percentile estimates for boys and girls do not overlap.



Making ECG interpretation in the Paediatric Emergency Department easier and safer by introduction of an ECG checklist



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Results

Between May and November 2018, 600 electrocardiograms were performed in paediatric ED. 48 electrocardiograms of patients known to cardiology services or discussed with the on-call team were excluded.

Of the remaining 552 electrocardiograms;

- 30 were identified by the emergency clinicians as abnormal
- 13 of these were considered normal by cardiology and discharged.
- The other 17 patients were allocated to cardiology outpatient clinic.
- 3 of these 17 required ongoing follow-up.

Indications for ECG



- Syncope
- Chest Pain
- Seizure
- Ingestion
- Other
- Rhythm Concern
- Palpitations

Red Flags

Syncope

- Whist lying down / supine or sitting
- On swimming
- On exercise
- Family history of sudden explained death
- Family history of epilepsy

Prolonged QTc

- Syncope with QTc > 450ms
- Otherwise QTc > 460ms in both boys and girls

ECG checklist

Rate	Is the heart rate appropriate for the age of the child?	NO
	YES	
Rhythm	Is there a P-wave preceding every QRS complex?	NO
	YES	
P-waves	Is the P-wave amplitude less than 3 small boxes?	NO
	YES	
Axis	Is the QRS complex positive in leads I and aVF? <i>(In 12-lead it is normal to have right axis deviation - positive aVF but negative lead I)</i>	NO
	YES	
PR interval	Is the PR interval more than 2 small boxes but less than 4 small boxes? <i>(If more than 2 small boxes, check for presence of delta wave and QRS complex > 2 small boxes in lead)</i>	NO
	YES	
QRS interval	Are the QRS complexes less than 2 small boxes in size?	NO
	YES	
QT interval	Is the QTc less than 400ms? <i>(Corrected QT interval = QT / \sqrt{RR})</i>	NO
	YES	
Ventricular hypertrophy	Is the R wave smaller than the S wave in V1?	NO
	YES	
	Is there separation with no overlap between the R-wave of V6 and the S-wave of V2?	NO
	YES	
Q-waves	Are the Q-waves less than 4 boxes in all leads?	NO
	YES	
	Are the T-waves positive in V5, V6?	NO
	YES	
T-waves	In patients <8yrs old, is the T-wave negative in V2? <i>(A negative T-wave in children older than 8yrs can be normal)</i>	NO
	YES	
ST segment	If there is any ST segment elevation: Is the ST segment raised by less than 2 boxes?	NO
	YES	
<p>If all answers to above YES with NO RED FLAG features AND Patient fit for D/C then ECG Suitable for e-writing. (See below for process).</p>		

Patient Name: _____
 DOB: _____ Age: _____
 Hospital Number: _____ ECG Date: _____
 Presentation: _____

ECG
 Calibrated at 1mm:10mV? Paper at 25 mm/s?
 Lead position: right arm clockwise (R,Y,G,B) + V4R in all under-5s?

RATE
 Regular (300 / R-R interval): _____
 Irregular (6 x p number of complexes in rhythm strip): _____

RHYTHM
 Assess LEAD II. 1 small square = 0.04s therefore 1 big square = 0.2s

P wave before every QRS?
 ?SVT, ?Heart Block

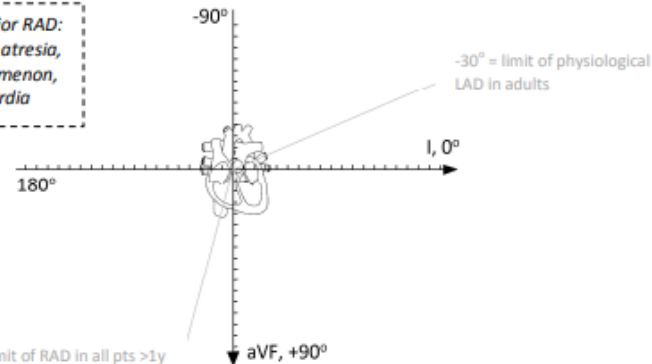
PR Interval		QRS Duration		QTc Interval	
< 2 y	0.08 – 0.16s	<2y = <0.08s	>16y = <0.12s	< 6 months	Variable
2y - 15y	0.09 – 0.18s	NB Lengthens with age: 'normal' can represent slight prolongation i.e. BBB		> 6 months	< 0.44s
>16 y	0.12 – 0.2s			QTc = QT/vpreceding R-R(s)	

AXIS
P wave axis (i.e. SAN location) normal?
 Normal = positive in I, III and aVF

QRS axis

NB RAD normal in <3/12, normalising to LAD by 1y & progressing to adult parameters by 8y.

Causes of superior RAD:
 AVSD, Tricuspid atresia, Ebstein's phenomenon, WPW, Dextrocardia



MORPHOLOGY

P wave (lead II)
 Normal amplitude < 3mm
 Normal duration: < 0.07s (infants) / < 0.09s (children)
 RED FLAG: tall (RA) and wide (or bifid, LA) = combined atrial hypertrophy

QRS complex
 Normal Variants:
 - RSR' in V1-V3 in neonates, persisting in 7% of under-5s
 - R wave dominance generally regresses by 4y
 RED FLAGS:
 - Delta Wave
 - Q waves in I and aVL
 - Deep Q waves (>5mm) inferolaterally
 - BBB (WiLLiaM MaRRoW)

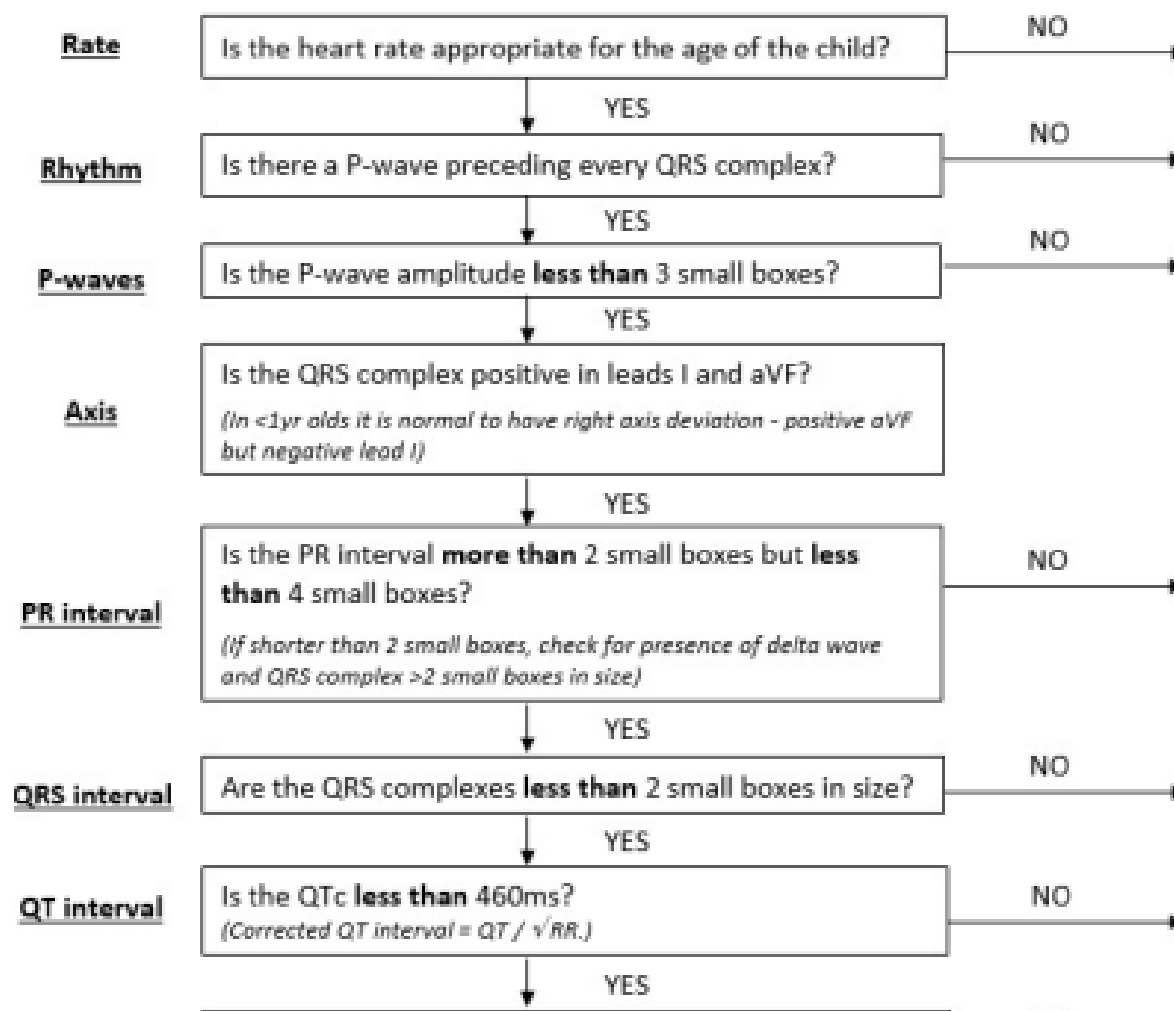


ST segment
 Normal variant: Upsloping ST depression
 RED FLAGS:
 1) Down-sloping ST
 2) Horizontal ST depression > 0.08s

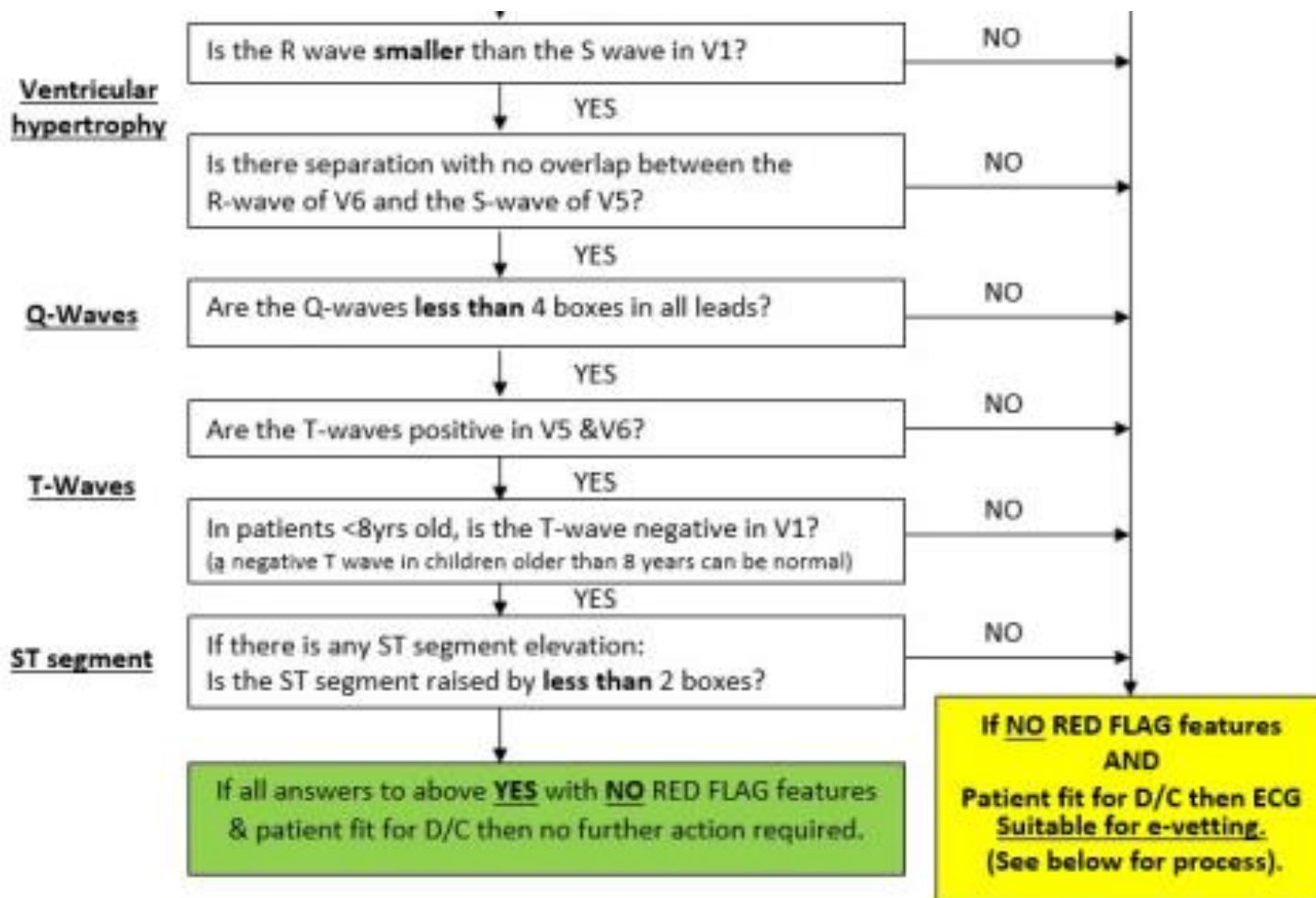


T wave
 'Juvenile pattern': Inverted T waves in V1-V4 are physiological after 48hrs of age, persisting in V1 until 8y and often into adolescence.
 RED FLAGS: Tall (>2/3 R wave), peaked // Flat // Deeply inverted

ECG checklist



continued.....



Paediatric ECG Interpretation

Anna McCorquodale

CHECK CALIBRATION

Lead position matches machine diagram
Vertical 10mm/mV
Horizontal 25mm/sec



1 Rate Calculation

Regular - $300 / (\text{no. large squares between R-R})$
Note if **irregular**

2 Rhythm

Assess in rhythm strip (lead II),

1 small square = 0.04 sec

Normal sinus rhythm:

- P wave before each QRS
- Normal P wave morphology
- Normal P wave axis (upright II, III, aVF)
- Normal PR interval
- Appropriate rate for age

3 QRS Axis

Use vector addition plotting arrows along **lead I** (positive to right) and **aVF** (positive downwards)

0-90° normal 1-8 years. Mild LAD (-30°) normal puberty- adulthood. RAD 90-180° normal <1 year

4 P Wave

Amplitude <3mm
<2 year 0.08-0.16
2-15 years 0.08-0.2
>15 years 0.12-0.2

Tall - **P pulmonale** - RA dilatation
Bifid & wide - **P mitrale** - LA dilatation

5 ST Segment

ST should be isoelectric

6 QTc

$QTc = QT / \sqrt{\text{preceeding RR}}$
0-6m - variable - max 0.46 secs
>6m - < 0.45 secs



7 QRS Complex

Duration increases with age and bradycardia
Max duration usually 0.12 secs during childhood
Bundle branch block - prolonged QRS duration and interruption in flow of R/S waves
Partial BBB (i.e. without QRS prolongation) normal finding

In BBB look for the pattern:



Then look at complex height across the chest leads:

Tall complexes V1-V3 - ?RVH

Tall V4-V6 complexes - ?LVH

8 T Wave

Physiological inversion V1-V3 after birth
Return to upright in reverse order during childhood, persisting inversion of V1 normal variant

Check if very tall/peaked, broad and flat, abnormally inverted or bifid
U wave normal if bradycardic, should be same orientation as T wave