Level 12

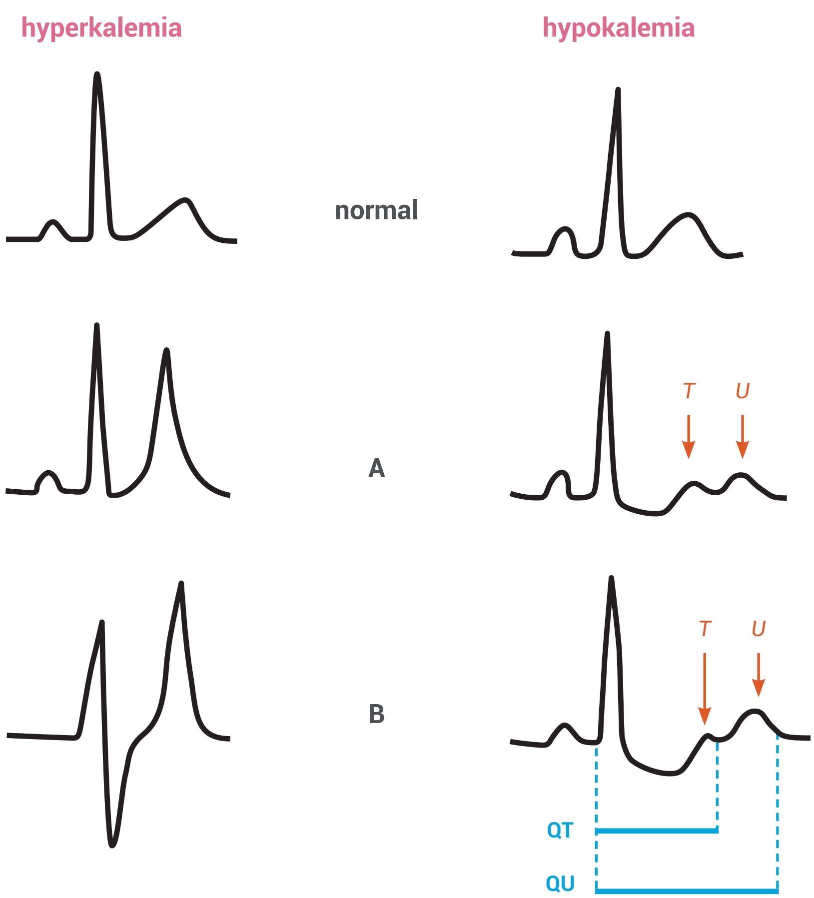
A short story about electrolytes and heart rate

The ECG can help you detect various kinds of electrolyte disturbances. Some of them are potentially life threatening.

Hyperkalemia and hypokalemia

Hyperkalemia (as seen in renal failure) is characterized by a **tall and "tented" T wave** (A in the illustration below). Sometimes the ECG can lead to a diagnosis of chronic renal failure even in patients who don't exhibit any symptoms yet. In more severe cases (B in the illustration), the **P wave gets lost** and the **QRS complex gets broader**.

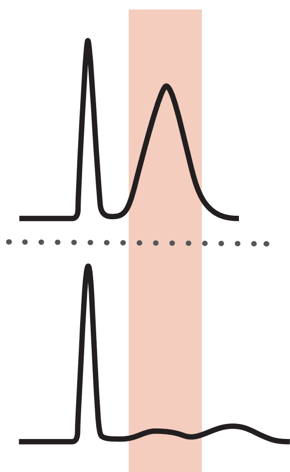
Remember that in vagotonia we can also see tall T waves. But these T waves are not as tall and sharp as the ones seen in hyperkalemia. Measurement of potassium levels will give you the answer.



ECG changes seen in hypokalemia are a sign of cellular potassium loss. They are seen even before blood levels start to drop. That's why ECG changes associated with hypokalemia correlate less well with potassium levels than changes associated with hyperkalemia.

The typical ECG changes seen in **hypokalemia** are **flattening of the T wave, appearance of a U wave**, and **ST depression**. A U wave is a second positive deflection that comes after the T wave. Note that hypokalemia does not lead to a prolongation of the QT interval. The QT interval starts at the beginning of the QRS complex and ends at the end of the T wave.

Don't confuse the QU interval with the QT interval!



Hyperkalemia
tall T wave

Hypokalemia
small T wave

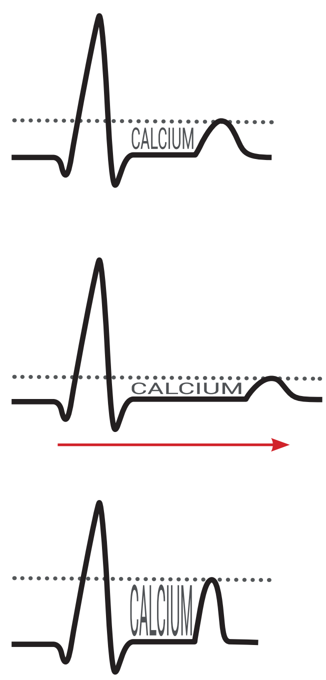
So remember:

- Hyperkalemia = tall T
- Hypokalemia = small T

Hypocalcemia and hypercalcemia

In hypercalcemia, the QT interval can be shortened, whereas in hypocalcemia, the QT interval can be prolonged.

And how will you know whether a patient's QT interval is normal or not? Well, the normal QT time varies with heart rate. **When heart rate is fast, the QT time shortens. When heart rate is slow, QT time becomes longer.** So there's no single normal value.



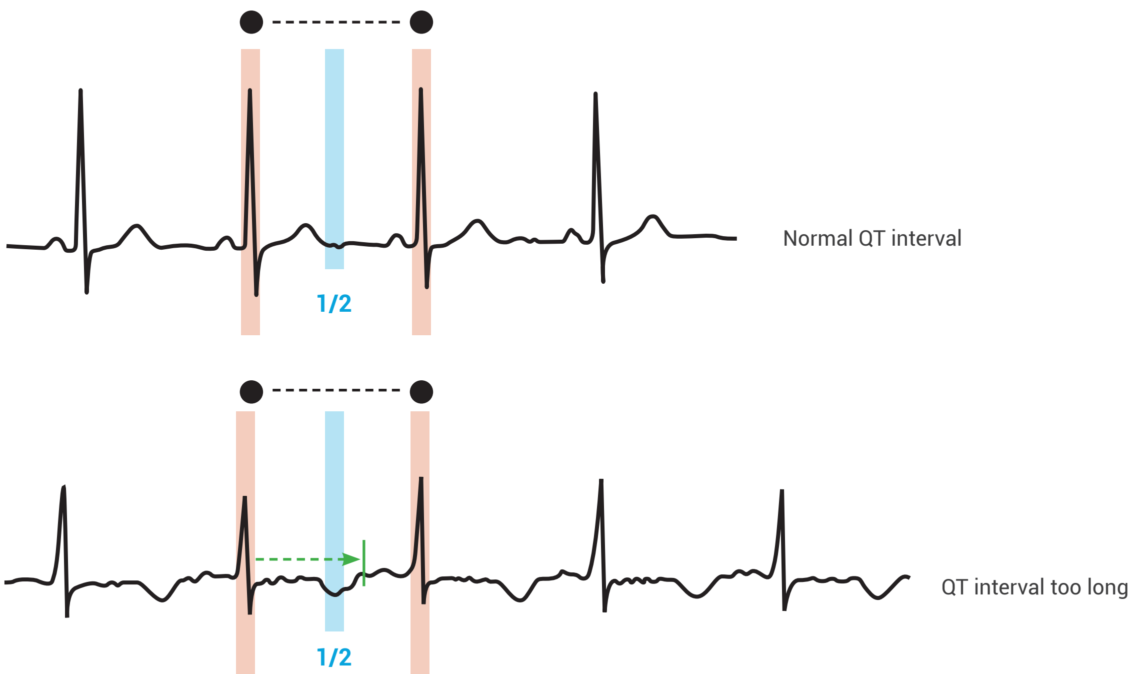
Normal

Hypocalcemia

Hypercalcemia

So how can you know whether your patient's QT interval is normal or not? There are two approaches that you should know for now:

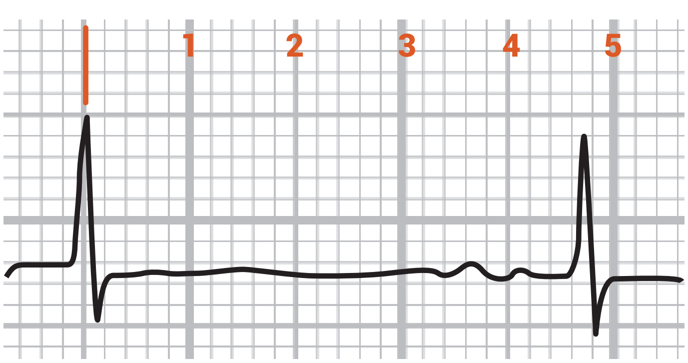
1. Most ECG machines will calculate the QTc time for you. That's the corrected QT interval normalized for a heart rate of 60 beats/min. The QTc is prolonged if it's >0.44 seconds in men and >0.46 seconds in women.
2. And the quick and dirty method goes like this:



Take an RR interval and "cut" it in half. If the T wave ends in the first half of the RR interval (as in the top example), the QT interval is normal. If the T wave ends in the second half of the RR interval (as in the lower example), the QT time is prolonged. If the QT interval is prolonged, you should then calculate the QTc to verify your suspicion.

Heart rate quick tip

An easy way to assess heart rate is to divide 300 by the number of big boxes between two QRS complexes:



The distance from one QRS complex to the next is between 4 and 5 boxes in length. 300/4 would be 75 beats/min; 300/5 would be 60 beats/min. So the heart rate is between 75 and 60 (probably around 65 beats/min).

You should now add the evaluation of heart rate, T waves, U waves, and the QT interval into your cookbook approach!

Question	Answer	Diagnosis
1. Rhythm	[coming later]	[coming later]
2. Heart rate	Estimate heart rate: 300/number of large boxes between two QRS complexes	heart rate in beats per min
3. P waves	a) Large P-wave amplitude (>2.5 mm in II, III, or aVF)	right atrial enlargement
	b) Prolonged negative part of P wave in V1 (1 mm) and P wave with 2 peaks in II, P-wave duration >0.12 s	left atrial enlargement
4. PR interval	a) >0.2 s (if PR interval constant for all beats and each P wave is followed by a QRS complex)	I° AV block
	b) <0.12 s and QRS complex normal	LGL syndrome
	c) <0.12 s and visible delta wave	WPW syndrome
5. QRS axis	Determine the axis according to leads I, II, and aVF	normal axis left axis deviation right axis deviation northwest axis
6. QRS duration	a) ≥0.12 s (always think of WPW syndrome as a differential)	complete bundle branch block
	b) >0.1 s and <0.12 s with typical bundle branch block appearance (notching)	incomplete bundle branch block
7. Rotation	Rotation is defined according to the heart's transition zone. Normally the transition zone is located at V4, which means that right ventricular myocardium is located at V1–V3 and left ventricular myocardium is at V5–V6.	transition zone at V5–V6: clockwise rotation transition zone at V1–V3: counterclockwise rotation NOTE: don't evaluate rotation in the setting of myocardial infarction, WPW syndrome, or bundle branch block
8. QRS amplitude	a) QRS amplitude <0.5 mV in all standard leads	low voltage
	b) Positive criteria for left ventricular hypertrophy	left ventricular hypertrophy
	c) Positive criteria for right ventricular hypertrophy	right ventricular hypertrophy
9. QRS infarction signs	abnormal Q waves, QS waves, missing R-wave progression	myocardial infarction; localization according to affected leads

10. ST–T segment

10. ST–T segment	tall T wave	ST depression	ST depression	ST elevation		negative T	
QRS normal	→						hyperkalemia, vagotonia
QRS normal		→					probably ischemia (DD: digitalis)
QRS normal			→				nonspecific repo–larization abnor–mality
QRS normal				→			acute ischemia, perimyocarditis, variant angina
QRS normal					→		STEMI/ perimyocarditis in resolution
QRS normal						→	STEMI subacute, NSTEMI, perimyocarditis
QRS with Q wave				→	→	→	STEMI acute, STEMI in resolution, STEMI subacute
QRS: left ventricular hypertrophy			→				left ventricular hypertrophy with abnormal repolarization
QRS: right ventricular hypertrophy, bundle branch block, or WPW syndrome			→				In these situations an ST–segment deviation is almost always present and cannot be interpre–ted in and of itself. It has to be left out in the ECG report

11. QT duration, T–U waves

11. QT duration, T–U waves		
a)	QT shortening	hypercalcemia
b)	QT prolongation	hypocalcemia
c)	tall and peaked T wave	hyperkalemia
d)	U wave, ST depression, T–wave flattening, or a combination of these	hypokalemia