

PART I

Timing Cycles and Troubleshooting Review

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SECTION 1

Calculating Rates and Intervals

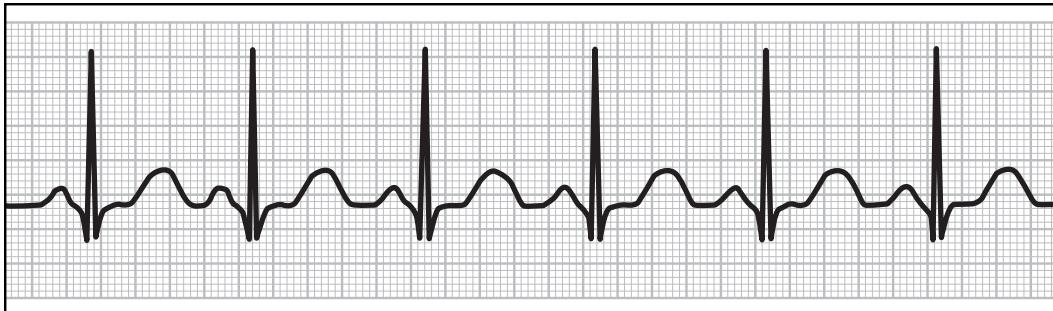


Figure 1.1

Few clinicians can escape their training without having to learn to read a basic ECG. The illustration above is a textbook-type ECG, a perfect example of an ECG that you would probably never see in real-life clinical practice. That's fine, since you should learn from textbooks and then apply your knowledge to the messier ECGs you'll come up with in the clinic.

A surface ECG is a graphic representation of electrical energy. The electricity that generates this tracing is obtained from the surface of the skin of the patient. It's amazing that the heart (about the size of a clenched fist) can generate enough electricity so that it can be picked up on the skin.

The smallest rounded bumps on the ECG are the P-waves, which graphically depict the atrial depolarization. This is followed closely by the largest waveform on the ECG, a pointed wave that goes both below and above the baseline. Called the QRS complex (also sometimes nicknamed an R-wave), this sharp, pointed waveform depicts the depolarization of the ventricles. It's much larger on the tracing because the ventricles are much larger than the atria and produce more electricity as they squeeze together to pump out blood. After a short pause is another rounded waveform known as the T-wave.

The T-wave represents the ventricular repolarization, that is, the time period where the ventricles go back to baseline, in other words, from depolarization to repolarization.

Standard ECG paper has a grid on it that can help you "eyeball" timing. The gridwork is made up of many tiny blocks that are 1 mm square. Each of these tiny boxes is 40 ms duration. Heavier lines are used to make larger squares of five boxes tall and five boxes wide. Each larger square has a duration of 200 ms. Five of these larger squares (200×5) equals 1000 ms or 1 sec.

By counting out the grids, you can get a fast approximation of the duration of a particular cardiac cycle or timing cycle. This is going to become increasingly important as we get into paced ECGs. With the heart, timing is everything!

Test your knowledge

- 1 Looking at this non-paced ECG, would you say that this patient has a regular or an irregular rhythm?
- 2 Using just this tracing, approximate how long (in ms) the duration is from one P-wave to the next P-wave.

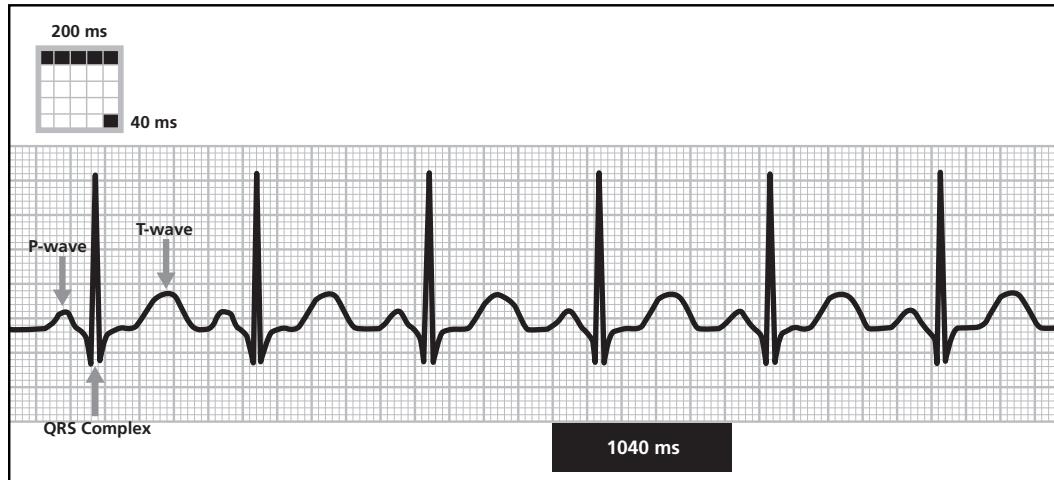


Figure 1.2

This rhythm is regular. Once your eye gets trained to reading ECGs, it is easy to look at a rhythm and appreciate something that is regular or irregular. What makes this rhythm regular, however, is not that the QRS amplitudes are the same or the T-waves have the same morphology (shape). (Those things matter, but for different reasons that we'll get into later on.) The regularity of this rhythm refers to its even timing. Notice that the complexes all have the same duration. It doesn't matter whether you measure from P-wave to P-wave, R-wave to R-wave, or T-wave to T-wave, you'll see the same results. In fact, if you go to the very last complex on the strip, and then added some blank grid paper, you would know enough to draw in where the next P-wave and QRS complex would fall.

In this tracing, we can see that the distance between one P-wave and the next consecutive P-wave is about 1040 ms. That's based on 4 big squares ($4 \times 200 = 800$) plus 6 little boxes ($6 \times 40 = 240$). You could also measure QRS to QRS or any other complexes. The trick is to measure from the one waveform to the next consecutive waveform *of that type*.

When clinicians talk about heart rate, we generally use terms like "70 beats per minute" or "82 bpm" or we might say a patient's heart rate is 120/min. In fact, pacemakers almost always program rate in

terms of pulses per minute (ppm) even though this information is not obvious on the ECG. While we humans tend to prefer beats per minute as a way to express rate, pacemakers (and ECG machines) use durations or intervals. That is, this strip does tell us the rate in the form of an interval value (1040 ms). But what rate is that?

Clinicians who work with pacemakers have to be able to convert intervals to rates and vice versa. There are conversion tables that do this and many pacemaker programmers will assist you as well. However, it can also be done with some basic arithmetic or a simple calculator. If one cardiac cycle (i.e., one beat) took 1040 ms, how many beats would occur in a minute? First, we know that 1 minute = 60 seconds or 60,000 ms (60×1000). By dividing 1040 (the interval duration) into 60,000 ms (1 minute), you arrive at the rate (57.69 beats a minute, which you would probably state as 58 bpm).

The formula works backward, too. For instance, if you know that a patient's heart rate is right around 80 bpm, you could expect to see a cardiac cycle interval duration on the ECG of about 750 ms (80 divided by 60,000). That's three big boxes on the ECG paper and almost four little boxes ($3 \times 200 = 600$ and $4 \times 40 = 160$).

The nuts and bolts of rates and intervals

- A regular rhythm refers to the timing of the events on the ECG (not necessarily the consistency of waveform shapes).
- Grid paper on an ECG can help you rapidly approximate intervals. Each tiny box is worth 40 ms, the heavier-lined squares count as 200 ms.
- When calculating the interval of a cardiac cycle, measure from one type of event (P-wave or QRS complex or T-wave) to the next consecutive such event.
- Devices tend to “think” in intervals, people tend to think in rates, but they are really just two different ways of expressing the same thing. Convert rate to interval by dividing 60,000 by the rate; convert interval to rate by dividing 60,000 by the interval. For example, 60 ppm converts to a pacing interval of 1000 ms.