Cardiovascular Physiology
The electrocardiogram
Fall 2019-2020

Part 5-6

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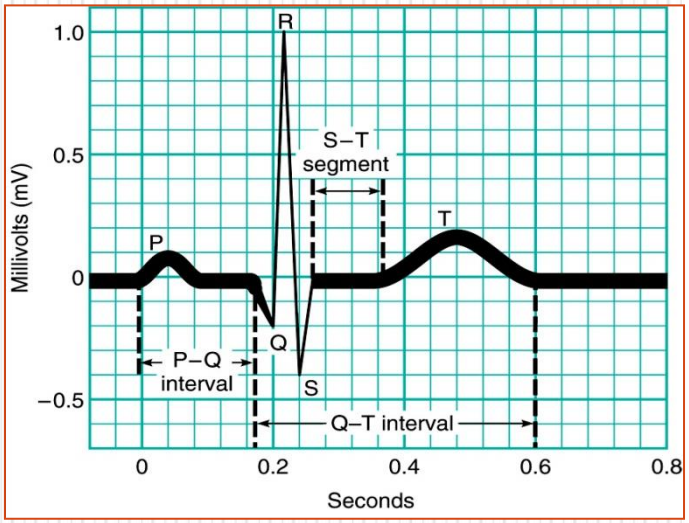


Outline

- Electrocardiography
- Electrocardiogram
- Correlation of ECG Waves and Atrial and Ventricular Systole

Electrocardiography

- As action potentials propagate through the heart, they generate electrical currents that can be detected at the surface of the body.
- Electrical activity is recorded by electrocardiogram (ECG or EKG).
- ECG is a composite record of action potentials produced by all the heart muscle fibers.
- The instrument used to record ECG is the electrocardiograph.

Electrocardiography

- In clinical practice, electrodes are positioned on the arms and legs (limb leads) and at six positions on the chest (chest leads) to record the ECG.

- The electrocardiograph amplifies the heart's electrical signals and produces 12 different tracings from different combinations of limb and chest leads.

- Each limb and chest electrode records slightly different electrical activity because of the difference in its position relative to the heart.

Electrocardiography

- By comparing tracings from different leads with one another and with normal records, it is possible to determine:

✓ if the conducting pathway is abnormal

✓ if the heart is enlarged

✓ if certain regions of the heart are damaged

✓ the cause of chest pain.

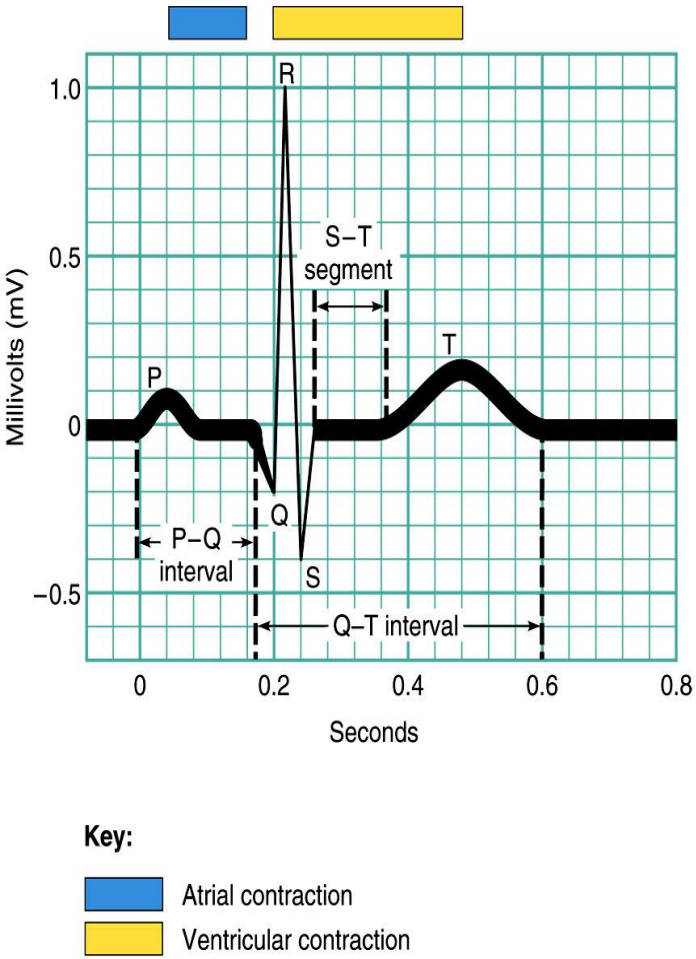


Figure 20.12 Tortora - PAP 12/e

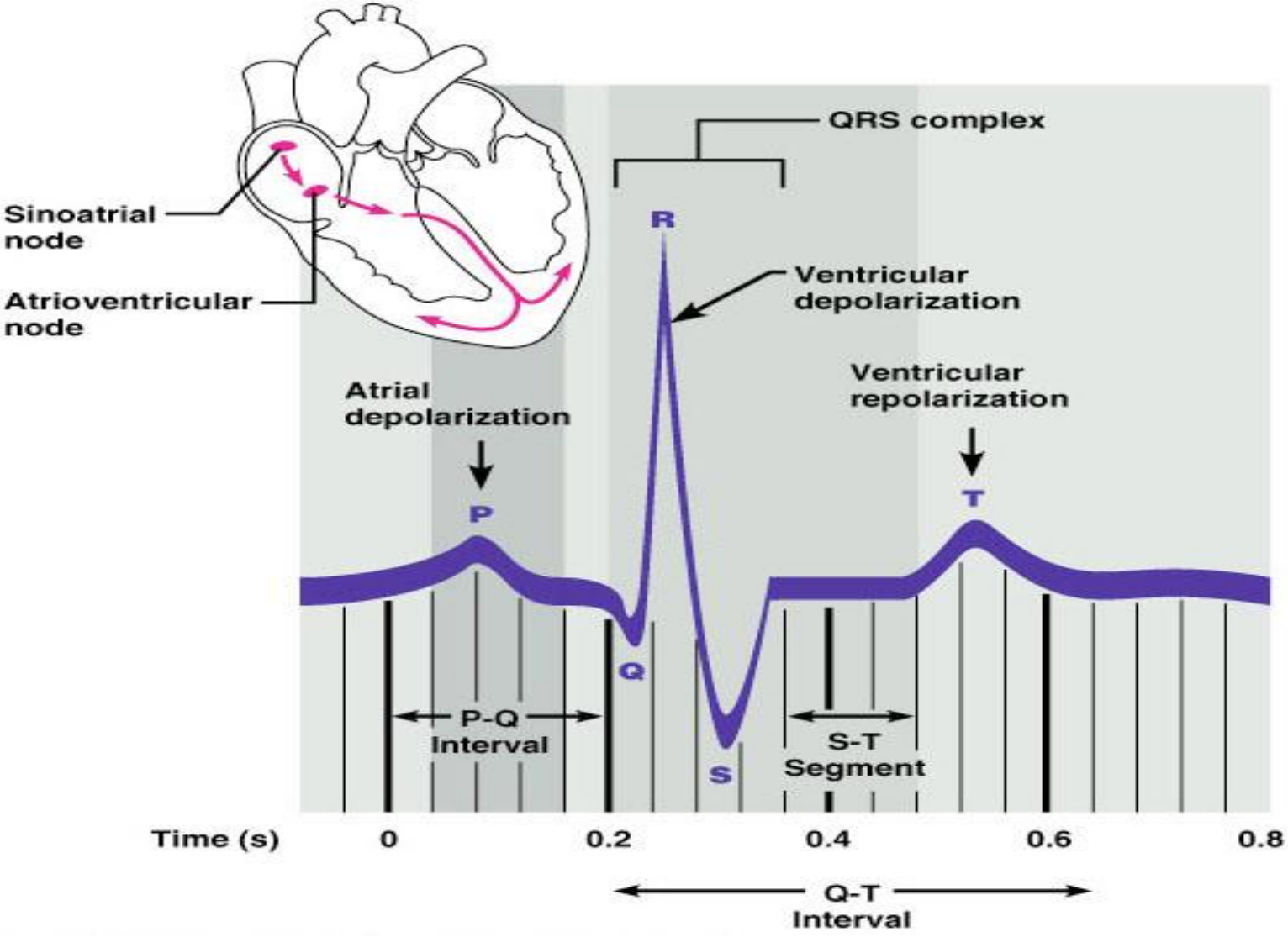
Electrocardiogram

- In a typical record, three clearly recognizable waves appear with each heartbeat:

1. P wave corresponds to depolarization of SA node and atrium
2. QRS complex corresponds to ventricular depolarization
3. T wave corresponds to ventricular repolarization

- Atrial repolarization record is masked by the larger QRS complex

Electrocardiography



P wave

- **P wave,** is a small upward deflection on the ECG.

- The P wave represents **atrial depolarization, which** spreads from the **SA node** through **contractile fibers in both atria**.

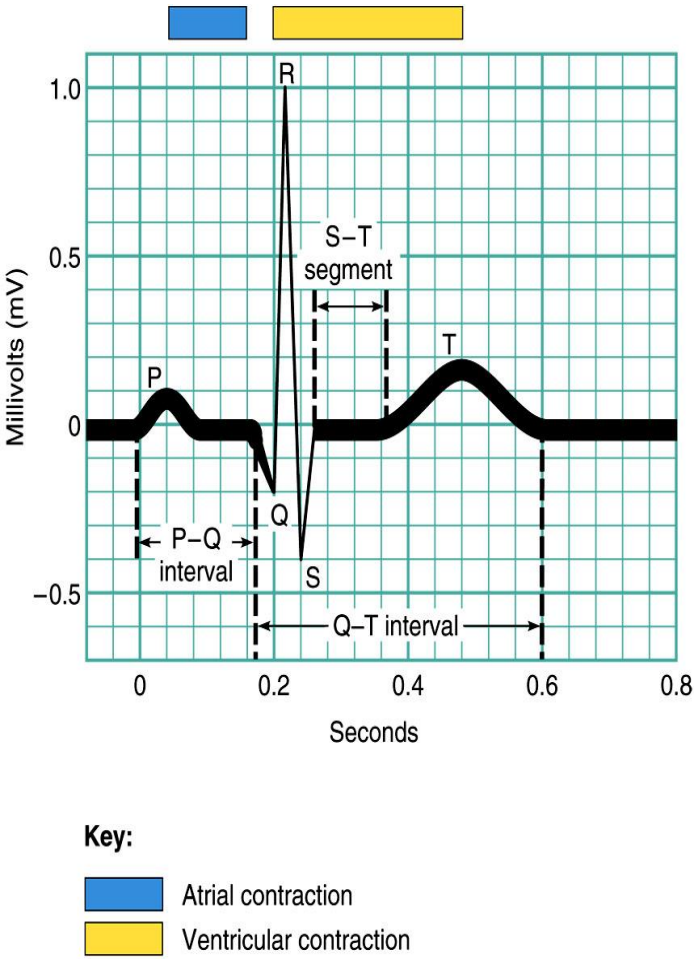


Figure 20.12 Tortora - PAP 12/e

QRS complex

- The second wave, called the **QRS complex**, begins as a downward deflection, continues as a large, upright, triangular wave, and ends as a downward wave.

- The QRS complex represents **rapid ventricular depolarization**, as the action potential spreads through **ventricular contractile fibers.**

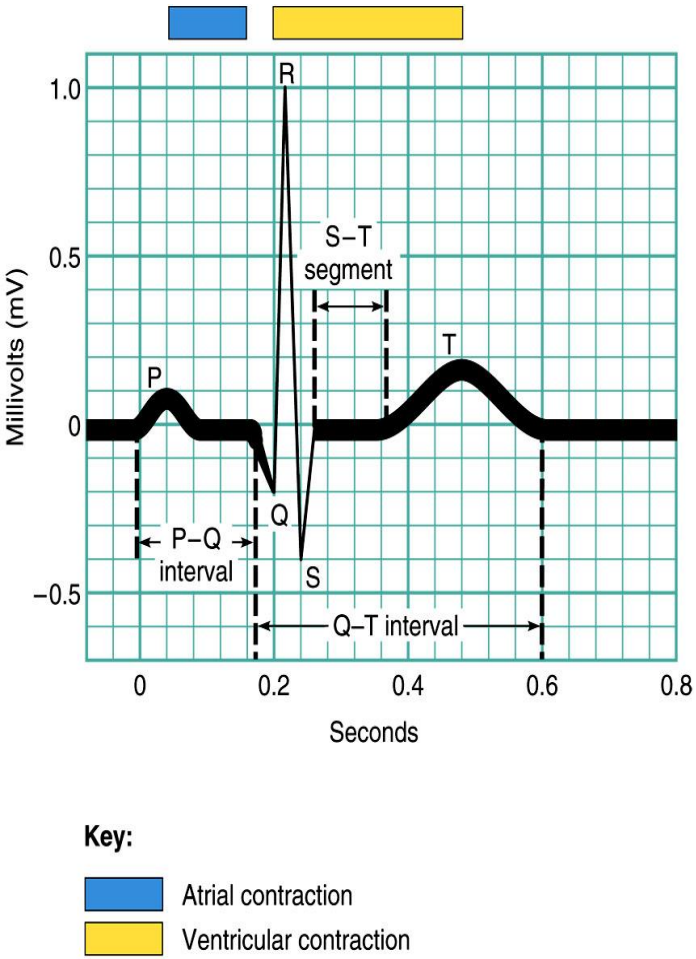


Figure 20.12 Tortora - PAP 12/e

T wave

- The **T wave** is a dome-shaped upward deflection.
- It indicates **ventricular repolarization** and occurs just as the **ventricles are starting to relax**.
- The T wave is **smaller** and **wider** than the QRS complex because **repolarization** occurs more **slowly** than depolarization.
- During the plateau period of steady depolarization, the ECG tracing is flat.

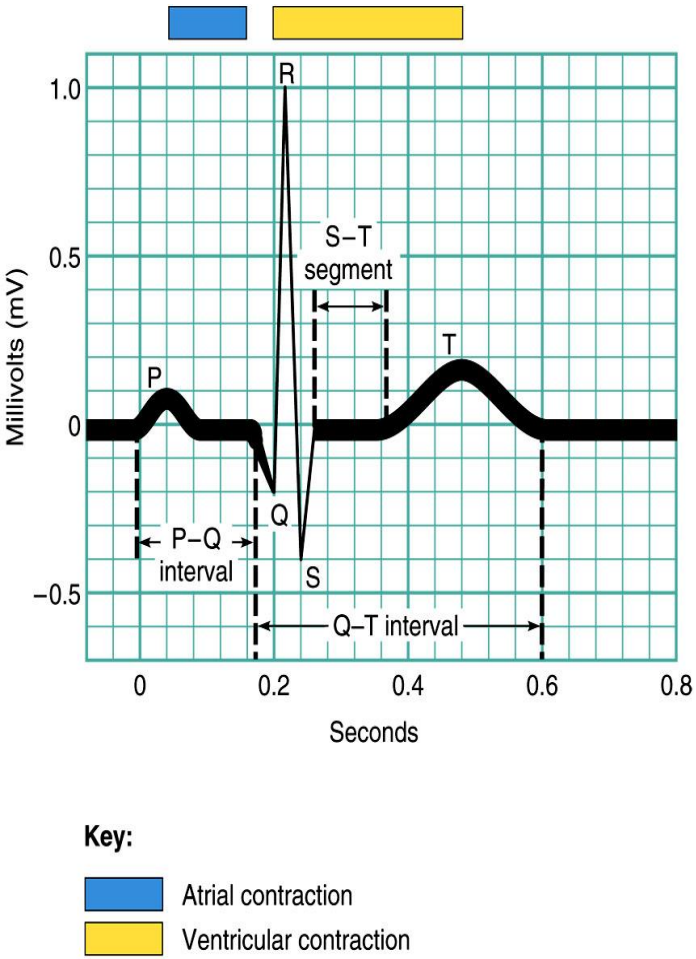


Figure 20.12 Tortora - PAP 12/e

ECG intervals

- Analysis of an ECG also involves measuring the time spans between waves, which are called **intervals or segments*.***

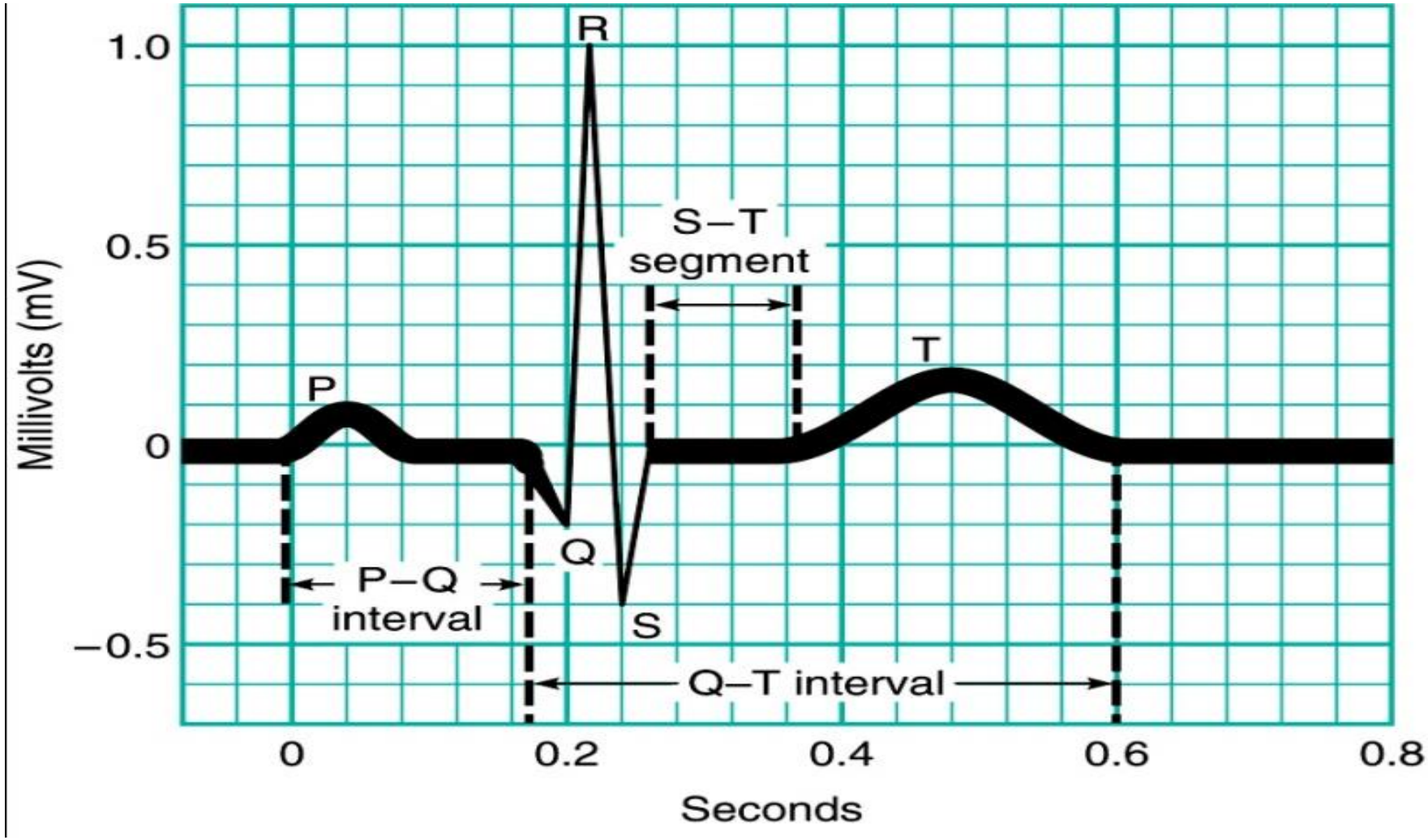
- The **P–Q interval** is the time from the beginning of the P wave to the beginning of the QRS complex.

- It represents the conduction time from the beginning of atrial excitation to the beginning of ventricular excitation.

- Is the time required for the action potential to travel through the atria, atrioventricular node, and the remaining fibers of the conduction system.

- As the action potential is forced to detour around scar tissue caused by disorders such as coronary artery disease and rheumatic fever, the P–Q interval lengthens.

ECG intervals



ECG intervals

- The **S–T segment** begins at the end of the S wave and ends at the beginning of the T wave.

- Represents the time when the ventricular contractile fibers are depolarized during the plateau phase of the action potential.

- The S–T segment is elevated (above the baseline) in acute myocardial infarction and depressed (below the baseline) when the heart muscle receives insufficient oxygen.

ECG intervals

- The **Q–T interval** extends from the start of the QRS complex to the end of the T wave.
- It is the time from the beginning of ventricular depolarization to the end of ventricular repolarization.
- The Q–T interval may be lengthened by myocardial damage, myocardial ischemia (decreased blood flow), or conduction abnormalities

Correlation of ECG Waves and Atrial and Ventricular Systole

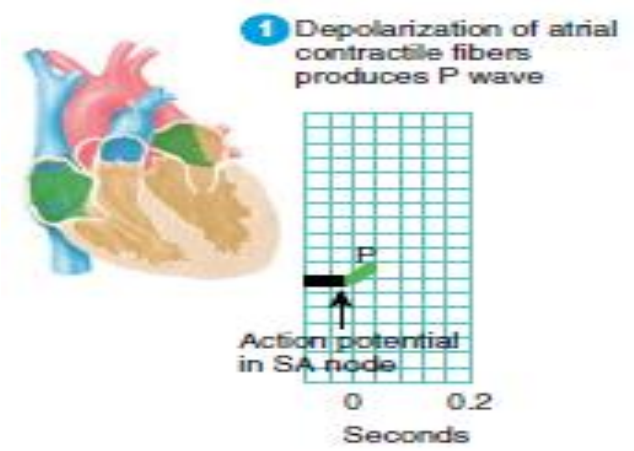
- The atria and ventricles **depolarize** and then contract at **different times** because the conduction system routes cardiac action potentials along a specific pathway.

- The term **systole** refers to the phase of contraction; while the phase of relaxation is **diastole**.

- The ECG waves predict the timing of atrial and ventricular systole and diastole.

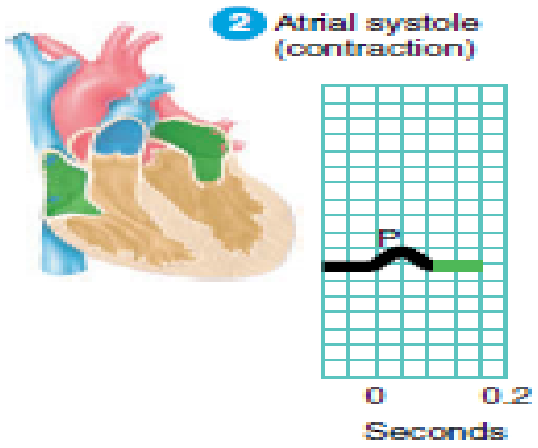
Correlation of ECG Waves and Atrial and Ventricular Systole

- At a heart rate of 75 beats per minute, the timing is as follows:



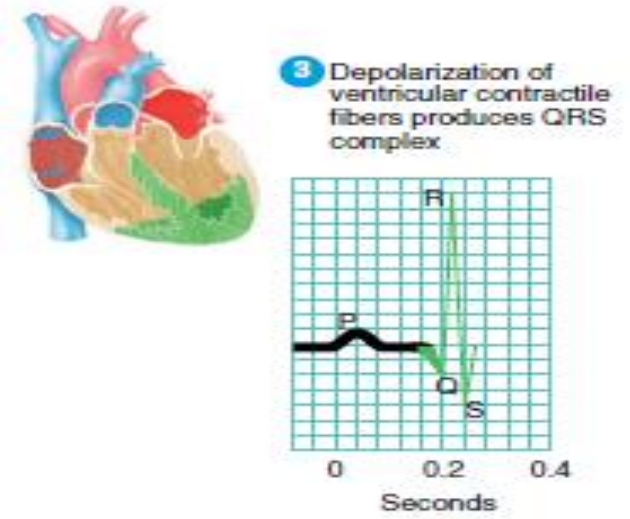
- 1) A cardiac action potential arises in the **SA node**. It propagates throughout the atrial contractile fibers and down to the AV node in about 0.03 sec. As the **atrial contractile fibers depolarize** the **P wave** appears in the ECG.

- 2) After the P wave begins, conduction of the action potential delayed by 0.1-sec at the AV node because the fibers there have much smaller diameters and fewer gap junctions. The resulting delay gives the atria time to contract **(atrial systole).**



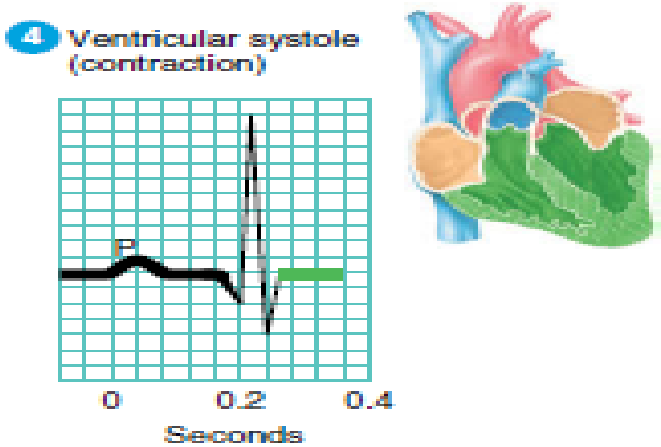
Correlation of ECG Waves and Atrial and Ventricular Systole

- 3) Then action potential propagates rapidly again after entering the AV bundle. About 0.2 sec after onset of the P wave, it has propagated through the bundle branches, Purkinje fibers, and the **entire ventricular myocardium depolarize.** This will produce the **QRS complex**.
- At the same time, **atrial repolarization** is occurring, but it is **not usually evident** in an ECG because the larger QRS complex masks it.

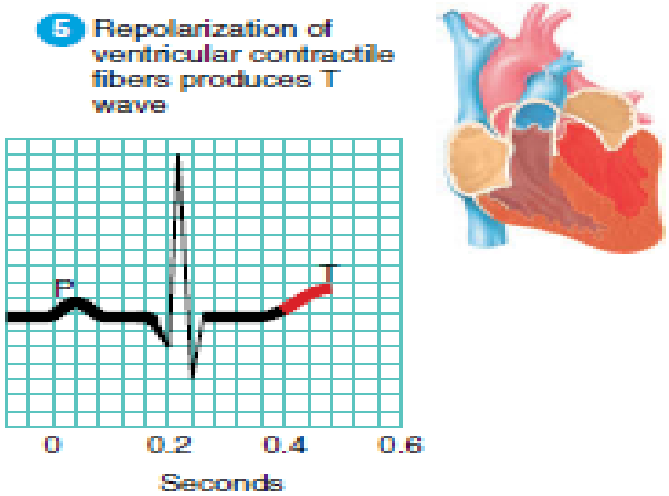


Correlation of ECG Waves and Atrial and Ventricular Systole

- 4) Contraction of ventricular contractile fibers (**ventricular systole**) begins shortly after the QRS complex appears and continues during the **S–T segment**. As contraction proceeds, blood is squeezed upward toward the semilunar valves.



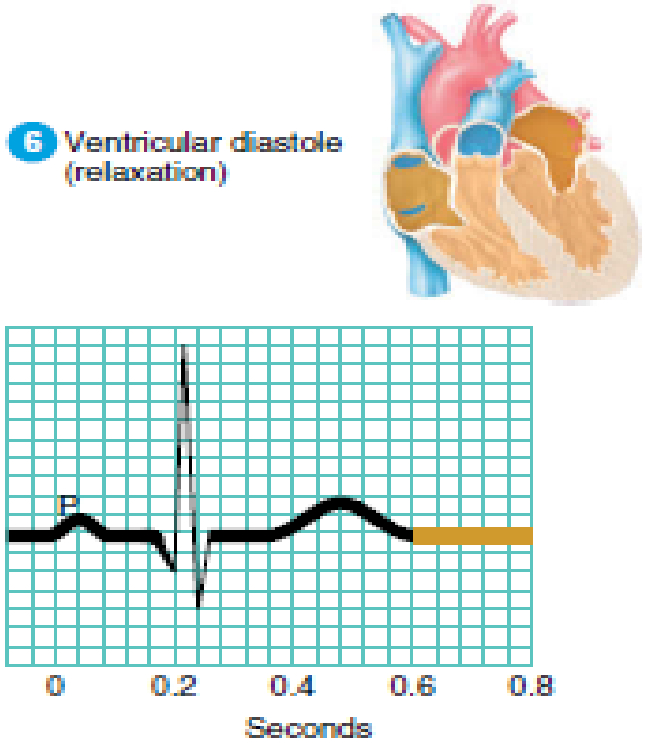
- 5) **Repolarization** of ventricular contractile fibers produces the **T wave** in the ECG about 0.4 sec after the onset of the P wave.



Correlation of ECG Waves and Atrial and Ventricular Systole

- 6) Shortly after the T wave begins, the ventricles start to relax (**ventricular diastole**). By 0.6 sec, ventricular repolarization is complete and ventricular contractile fibers are relaxed.

- During the next 0.2 sec, contractile fibers in both the atria and ventricles are relaxed. At 0.8 sec, the P wave appears again in the ECG, the atria begin to contract, and the cycle repeats.




Thank You