

Physiology of the Normal ECG Waveform (Lead II)

Start of ECG waveform

A group of pacemaker cardiomyocytes in the right atrium (the Sino Atrial (SA) node) rely on slow Ca^{2+} channels on their surface to spontaneously reach depolarization threshold

Depolarizations occur at regular intervals of 60-100 beats per minute

Normal heart rate
Regular cardiac rhythm

Depolarization wave travels through the atria, contracting atrial myocytes (thus causing atrial contraction)

Depolarization moves towards Lead II, thus causing upward deflection on ECG. Atria has less myocytes → smaller depolarization → smaller upward deflection on ECG (Lead II)

Normal P Wave

SA node relays conduction to bundle of His, which delays the depolarization

Flat segment between P wave and QRS

Depolarization conducts down the ventricular septum via the bundle branches, towards the apex

Depolarization directed inferior and left (compared to patient's vertical axis), in the direction of Lead II → upward deflection on ECG (Lead II)

Normal R wave

At the apex, depolarization conducts up the Purkinje fibers within the ventricular walls, towards the base of the heart → ventricular contraction

Depolarization is now directed away from Lead II → downward deflection on ECG (Lead II)

Normal S wave

Normal QRS Complex

During ventricular contraction, repolarization starts in the atria → atrial relaxation

Electrical signal from atrial repolarization is too weak to stand out and is "buried" in the QRS

Absence of any ECG components representing atrial relaxation

As repolarization proceeds to ventricles, and down from the epicardium to the endocardium, with a net direction from the apex towards the base of the heart

Ventricular myocytes are contracted → no net movement of electrical charge

No ECG deflection occurs

Isoelectric ST segment (Interval between end of ventricular depolarization and beginning of repolarization)

The opposite charge (or polarization) is now moving away from the positive electrode of Lead II

An upward deflection in Lead II is produced, but is slower and smaller in amplitude compared to the QRS, which reflects the slower repolarization process

Normal T Wave

End of waveform

Lead number and orientation



Note:

- Q Waves: Small Q-waves can be seen in lead II and are non-pathologic as they represent the left to right depolarization of the ventricular septum. Larger Q waves are pathologic and are usually indicative of previous infarct/ischemia.
- Axis: For an explanation of how to tell the Axis from an ECG, please consult the relevant Calgary Guide slide on the subject.

Note: Normally, the apex of the heart points down and to the left of the body, in the direction of leads I, II, and aVF. Since QRS deflections on ECG reflect the direction of ventricular depolarization, an upward QRS deflection in these leads means the heart's apex is pointed in a normal direction (normal "axis").

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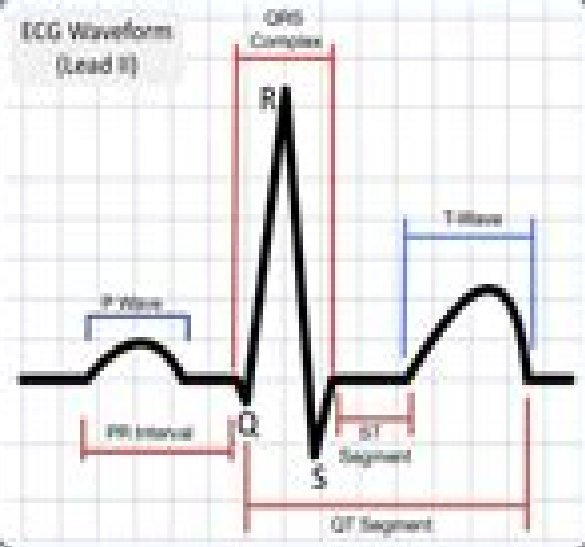
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* MD at time of publication

Regular intervals of P-waves followed by QRS complexes (60-100 P-waves/min, 60-100 QRS/min) = "normal sinus rhythm"

ECG Waveform (Lead II)



Note: for simplicity, we will only use Lead II to explain the direction of ECG deflections. However, the same principle applies to all leads:

- Depolarization moving towards the lead → upward deflection on ECG
- Depolarization moving away from the lead → downward deflection on ECG

PR Interval

Represents time between start of atrial depolarization to start of ventricular depolarization

SA node to atrial and AV node depolarization takes 120-200 milliseconds (ms)

Action potential conduction velocity is slowed at AV node

PR interval is 120-200 ms (normally)

Normally, each action potential travels through the AV node to the ventricular conducting system to cause ventricular depolarization

If abnormal conduction through AV node or down the ventricular septum

Heart Block

QRS Width

Represents time required for ventricular depolarization

Depolarization spreads along fast conduction pathways of bundle branches and Purkinje fibers

Rapid conduction results in ventricular depolarization in 60-120 ms

"Narrow" QRS <120 ms

QT Interval

Represents time required for ventricular depolarization and repolarization

Without the influence of factors including genetics, electrolyte abnormalities, or drugs, the QT segment is of a normal length

Normal adult QT interval <440ms in males and <460ms in females

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James A. Chambers



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,1984 Elsevier's Clinical Skills Manual, Medical-Surgical Nursing, 1SAE, e-Book Daisy Thomas,2020-09-03 Dr Daisy Thomas is currently working as Assistant Professor at Raj Kumari Amrit Kaur College of Nursing Lajpat Nagar New Delhi She has completed her Masters in Nursing with distinction from Delhi University and Doctorate in Nursing from IGNOU She has also held the position of Registrar Delhi Nursing Council from 2016 to 2019 She is an experienced nursing teacher of Medical Surgical Nursing and has been tutoring graduate and postgraduate students of Delhi University for the past three decades She is the research guide for postgraduate students of Delhi University She has been examiner for many universities of India and have presented papers at state and national level workshops and conferences She has several publications to her credit both as single author as well as co author and has published in national and international journals She has been the adaptation editor for the First South Asia edition of Potter Perry s Fundamentals of Nursing Fully compliant with the new syllabus prescribed by the Indian Nursing Council Content organized in sections and chapters text presented in points Steps of procedures are based on current and best practices Chapter content presented under heads like Overview Supplies Child and Family Education Assessment and Preparation Procedure Monitoring and Care Expected Outcomes and Documentation Content richly supported by figures and tables ideas related to the procedures available on the MedEnact website

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