Marquette® 12SL™ ECG Analysis Program

Physician's Guide

416791-004 Revision B

GE Medical Systems
Information Technologies

gemedical.com

NOTE: The information contained in this physician's guide refers specifically to 12SL version 17 through 20 unless otherwise noted. Due to continuing product innovation, specifications in this manual are subject to change without notice.

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Appendices

For your notes

1 Introduction

For your notes

Revision History

Each page of the document has the document part number followed by a revision letter at the bottom of the page. This letter identifies the document's update level. The latest letter of the alphabet corresponds to the most current revision of the document.

The revision history of this document is summarized in the table below.

Table 1. Revision History, PN 416791-004

Revision	Date	Comment
A	14 November 2000	Initial release of document.
B	31 January 2005	Document updated. Added "Serial Comparison," "12SL Version Identification," and "Screening Criteria." Removed "Statement of Validation & Accuracy".

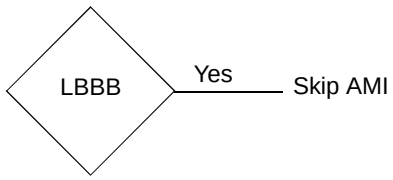
Purpose

The intent of this physicians' guide is to provide a logical approach to computerized ECG analysis. The information is first presented in a generalized format, followed by a more detailed one. Our primary objective is to present the Marquette 12SL ECG analysis program in a succinct manner for the novice user as well as a detailed display for the more advanced user.

The following "rules and examples" will facilitate the use of this guide:

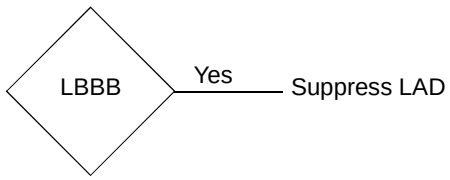
- Understanding the flow of the program is essential before the details of a specific criteria will make any sense.
- Drawings and/or logic symbols are included with the presentation of the criteria to help you understand how the program works.
- The flow of the program can be comprehended by viewing the drawings from top to bottom.
- The logic symbols are used to indicate tests that cause the program to proceed forward or to suppress statements that the program has already made. For example:

  Proceed forward...



OR

Suppress statements...



NOTE

The use of LBBB as opposed to "Left Bundle Branch Block" mnemonic abbreviations are used for brevity.

- Acronyms are generally located on the left side of the logic symbols.
- Most of the acronyms are obvious, but if they are not, consult the library tables in the appendixes.
- Diagnostic statements are made by the 12SL analysis program by utilizing a set of rules and thresholds (presented throughout this guide), which are applied to the measurements obtained from the 12-lead electrocardiogram.

- A concise overview will be presented at the beginning of most sections. Refer to the table of contents for a listing of each section.
- Detailed sections and ECG samples are located following the interpretive section.

The sections include our attempt in visually portraying the 12SL criteria. We hope you will find this to be a useful tool in understanding computerized ECG analysis.

Despite the fact that the Marquette 12SL analysis program has a high level of accuracy, it will occasionally not correctly interpret an ECG. The ECG tracing is significant only when interpreted in conjunction with clinical findings. Thus, it is critical that a physician utilizes his/her best clinical judgement when reviewing the ECG interpretation.

A Statement of Validation and Accuracy for the Marquette 12SL ECG analysis program is available upon request.

Overview

The first human electrocardiogram was taken over a hundred hears ago, and computerized electrocardiography has been in existence since the late 1950's.[1,2] In spite of its widespread use,[3] long history, and the voluminous amount of literature regarding the scientific aspects of this technology, there is little written that directly addresses the intent of computerized electrocardiography.

The pioneers of this technology had motivations which ranged from the esoteric goal of proving that a computer could mimic human activity to the basic requirement of efficiently recording artifact free tracings.[4] Some of the favorable developments which resulted from the evolution of this technology were hardly imagined at its inception. Consider, for example, work patterns at facilities which provide ECG services; they have been greatly streamlined.[5] Additionally, computerization has resulted in two practical advantages for the overreading physician. First, the computer can serve as an additional expert opinion. Second, cardiologists have found that it is possible for them to overread computer analyzed tracings in half the time required for conventional, non-analyzed ECGs.[6]

The computer, therefore, is not only used to efficiently record, store, transmit, and present the ECG; but it is also used to assist the physician in overreading an ECG. Consequently, developers inherit a certain responsibility. GE Healthcare has accepted this serious challenge.

It should be made clear that a computerized analysis is not a substitute for human interpretation. There are two reasons for this. First, statements of accuracy need to be viewed from a statistical perspective. Although accuracy levels may be high, outliers can and will exist. Second, a computer does not have the ability to include the entire clinical picture of the patient. A person with organic heart disease can exhibit an ECG within normal limits. Conversely, a normal individual can have an abnormal appearing ECG. The ECG, therefore, must always be reviewed in light of the surrounding clinical circumstances.[7]

References

1. Burch et. al., 1964. *A history of electrocardiography*. Year Book Medical Publishers. Chicago. Ill.
2. Pipberger et. al., 1975. *Computer methods in electrocardiography*. Annu. Rev. Biophys. Bioneng. 4:15-42
3. Drazen et. al., 1988. *Survey of computer-assisted electrocardiography in the United States*. J Electro. 21(suppl):98-104
4. Rowlandson, I., 1990. *Computerized electrocardiography: a historical perspective*. Ann. New York Academy of Science. 601:343-352
5. Sheffield et. al., 1987. *Electrocardiography and computerization: a winning combination*. Card. Prod. News. 47-51
6. Sheffield et. al., 1987. *Seminar on computer applications for the cardiologist, computer-aided electrocardiography*. JACC, 10(2):448-55
7. Goldman et. al., 1989. *Principles of clinical electrocardiography*. Appleton and Lange Publishers. Norwalk, Conn.

For your notes

2 Acquisition

For your notes

Patient Information

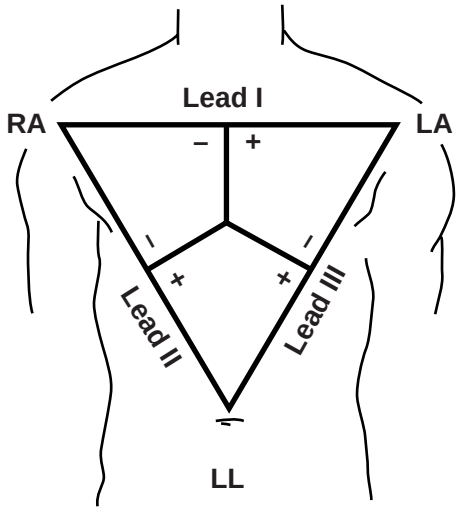
Entering patient information is the first step in taking a 12-lead ECG. Age is important because the Marquette 12SL analysis program contains age specific criteria. Age, in particular, is necessary for accurate pediatric analysis.

NOTE

This version of the 12SL analysis program contains gender-specific criteria therefore it is important to enter the age and sex of the patient in order to activate these performance enhancing criteria.

Simultaneous 12-Lead Acquisition

All 12 leads of the ECG are simultaneously acquired. Eight of the leads are acquired directly (I, II, and V1 through V6). The remaining four (III, aVR, aVL, and aVF) are derived via Einthoven's law.



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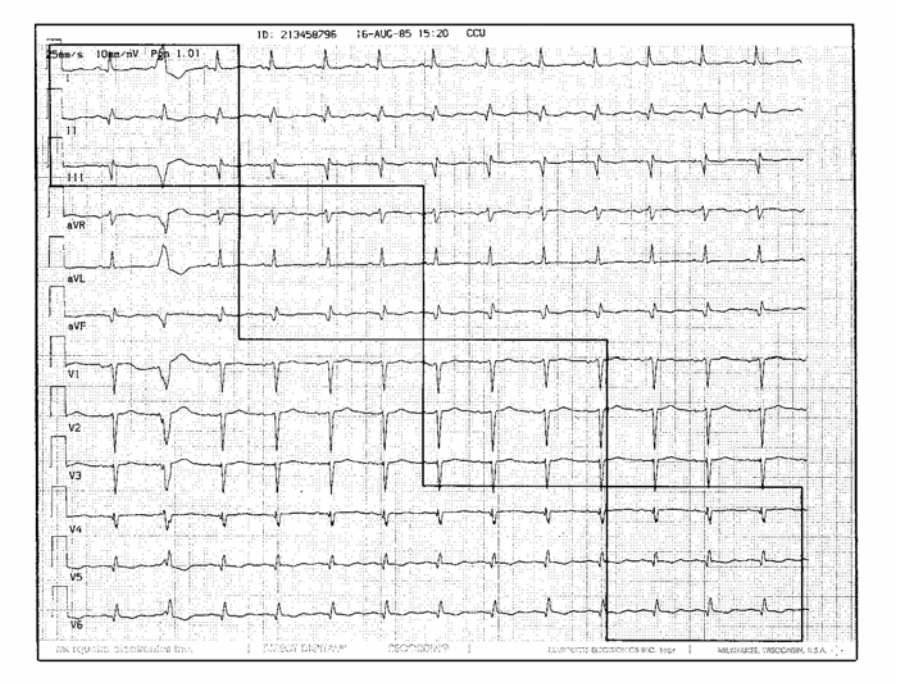
Because of the inherent relationship of the standard limb leads to each other, Einthoven stated that at any given instant during the cardiac cycle, the sum of the potentials of leads I and III equals the potential of lead II. (This complies with the American Heart Association recommendations.)

Most formats show only a portion of the 12-lead, 10-second data. An example of this is the standard 12-lead presentation which displays only 2.5 seconds from each of the 4 lead groups.

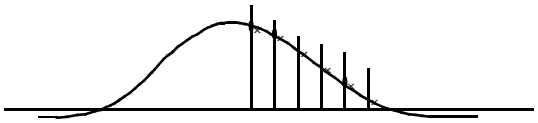


M1306-2

Regardless of the data that you see, the complete data is always acquired. This is used by the 12SL analysis program for precise waveform measurement. It also allows you to choose from a multiple set of formats for accurate rhythm and contour diagnosis.

Digitization/Sampling Rates

The incoming analog electrical signals are digitized. For resting electrocardiography, the device digitizes the analog potential into 4.88-µV units at a rate of 4 kHz. This fast sampling rate allows for superior reproduction of pacemaker artifact.



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The 12SL analysis program requires data that has been acquired at the rate of 500 samples per second as per AHA guidelines. This sampling rate represents a value every 0.05 mm on a chart that is moving with the standard speed of 25 mm/s. The device obtains this rate, from the data above, by averaging ten consecutive digital values together.

Eliminating Noise

To acquire cardiac waveforms accurately, we have taken great care to design our electrocardiographs to exclude noise from the 12SL data set. Our resting ECG analysis systems employ several noise excluding mechanisms.

Let us first discuss the noise that is generated by signals that originate outside the patient's body. That is, in addition to the small voltages that are generated by the heart, the ECG equipment is receiving signals that are coming from electrical equipment outside the body. These signals are called common mode signals because all of the leads on the body see these signals; it is common to all of them. A common mode signal can be many times greater than the ECG. Therefore, it is important to eliminate it.

The ability of the electrocardiograph to reject that signal, so that it does not appear in the ECG tracing, is called common mode rejection. Due to practical limitations, it is not possible to entirely eliminate the common mode signal, but we are able to reduce it. The amount of reduction is called the common mode rejection ratio.

Despite all of the methods used to reject common mode signals, power line interference — which is often referred to as 50/60-Hz "buzz"—will continue to be part of the acquired signal. This is because magnetic fields induce differential signals in the loops formed by the lead connections to the body. Since digitization takes place at the patient, the effective leadwire length is very short, thus these signals are minimized. Nevertheless, a line frequency filter is used for taking out any remaining 50/60-Hz buzz. This filter must know what the line frequency is; you can specify it in the setup options.

Besides reducing the noise due to electrical interference, we must also address the artifact that is caused by the patient. This artifact falls generally into two broad categories, low frequency and high frequency noise.

Below is an example of a low frequency wave. Notice that it does not change quickly. Low frequency noise typically results from patient respiration or the slowly changing potentials caused by the electrode-electrolyte-skin interface. This is often referred to as baseline sway which generally occurs at less than 1 Hz in the signal frequency spectrum. Good skin preparation and the use of quality electrodes will reduce the contribution from this source.

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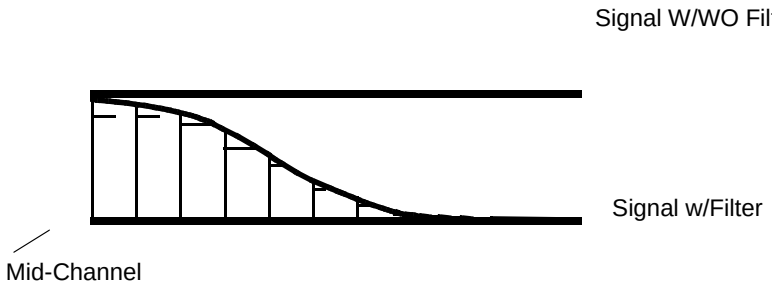
Low Frequency

Below is an example of a high frequency wave. It has sharp edges and it changes quickly. High frequency noise is usually caused by the activity of the skeletal muscles. If the patient relaxes, the artifact should be reduced.

M15264-15

High Frequency

A baseline filter is used to remove baseline sway. The filter works by subtracting a portion of the difference of the signal and the mid-channel potential. The longer the signal strays away from the middle, the greater the portion of the difference subtracted. The result of this processing is that it will remove baseline sway. However, a higher frequency waveform—such as that caused by a QRS—is not altered.



M15264-51

Pre-Acquisition

Pre-acquisition is another option. When pre-acquisition is selected, your device sends digitized ECG data to a buffer in its computer memory whenever there are incoming signals. When the buffer is full, new data constantly displaces the older data; it will always have the latest 10 seconds available for analysis. If the buffer is not full, the analysis program pauses until it is full. If pre-acquisition is not on, the device begins acquiring 10 seconds of data when you initiate 12-lead acquisition.

One particularly noteworthy advantage to pre-acquisition is that it allows you to capture a 12-lead ECG on a relatively infrequent event. For instance, if you observe an arrhythmia on the display, you have 10 seconds to capture a 12-lead ECG. With pre-acquisition on, the arrhythmic episode will be part of the 10 seconds of data in the buffer and will be analyzed.

Gain Setting

The standard gain, or sensitivity, setting is 10 mm/mV. The setting is indicated by the 1 mV high calibration pulse at the beginning of each trace. At the standard setting, the calibration pulse is 10 mm high. At one-half sensitivity, the pulse is 5 mm high.

NOTE

Adjusting the gain affects only output traces. Data for the 12SL analysis program are always measured at the standard 10-mm/mV setting.

References

1. H.V. Pipberger et al.,

   Recommendations for Standardization of Leads and of Specifications for Instruments in Electrocardiography and Vectorcardiography. American Heart Journal...

2. D.I. Tayler and R. Vincent,

   Artifactual ST segment abnormalities due to electrocardiograph design, Br.,H. Journal, 554: 121-128 (1985).

For your notes

3 Measurement

For your notes

Introduction

Following acquisition, the program measures the electrocardiogram. This process can be broken down into six basic steps:

1. **QRS detection** – Identifies and groups, by shape, the QRS complexes in the ECG record. (See "QRS Detection" on page 3-4 for more information.)
2. **Ventricular rate calculation** – The ventricular rate is determined by the number of QRS complexes detected. (See "Ventricular Rate Calculation" on page 3-8 for more information.)
3. **Median formation** – Beats of the same shape are combined into an accurate, representative cycle. Noise is dramatically reduced by this process. (See "Median Formation" on page 3-9 for more information.)
4. **Onsets/offsets and Intervals** – All 12 leads are used to demarcate the P, QRS, and T. (See "Onsets/Offsets and Intervals" on page 3-11 for more information.)
5. **Wave measurement** – The program generates a measurement matrix that identifies all the waves evident in each lead. (See "Wave Measurement" on page 3-12 for more information.)
6. **P wave detection** – The raw rhythm tracings are examined for P waves. (See "P Wave Detection" on page 3-15 for more information.)

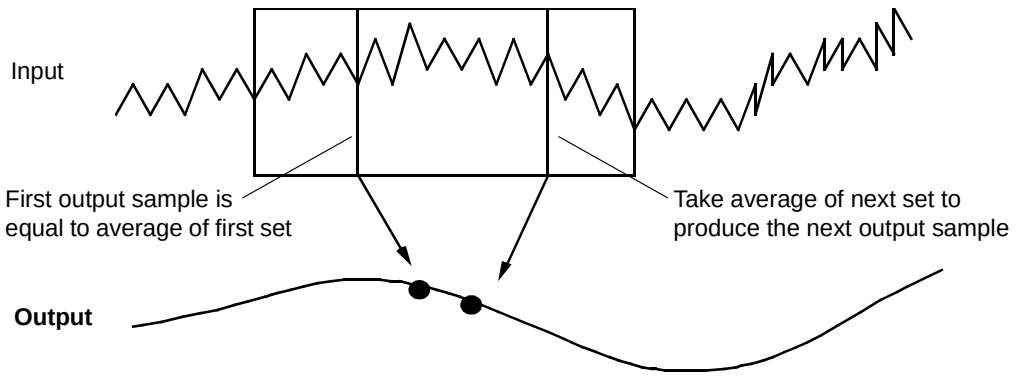
QRS Detection

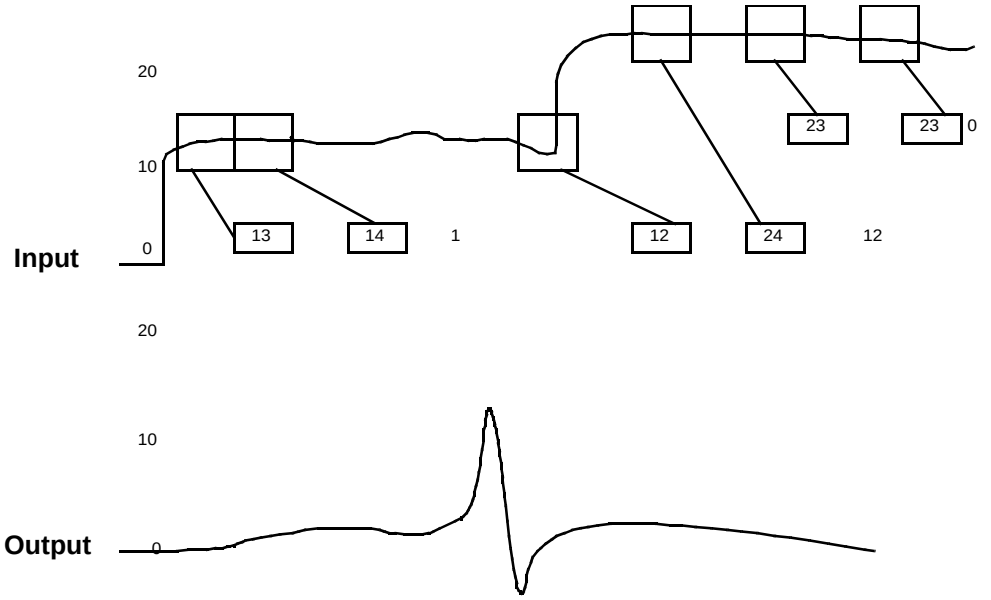
The first step in computerized ECG analysis is the identification of each QRS complex. This step is vital. If it is done incorrectly, all subsequent steps in the analysis will be in error. Since all 12 leads are available to the 12SL program, correct identification is maximized. Even when individual leads have low voltage complexes, the program can use all signals from all leads to properly identify each QRS.

Before the QRS detector can scan the signal data for something that resembles a QRS, it must first remove any pacemaker artifact. This is because pacemaker signals can be large in amplitude and they could fool the detector. The program identifies pacemaker artifact through two independent methods. Separately, the 12SL analysis program identifies pacemaker artifact in the ECG data by finding either large amplitude spikes (greater than 1000 µV) or lower amplitude spikes (greater than 250 µV) that pass further scrutiny, so as not to be deceived by muscle artifact. Regardless of how the spikes are detected, the 12SL program remembers their height and position and then removes them. When the program is finished, it replaces these spikes.

After the pacemaker spikes are removed, the QRS detector filters the data. It attenuates both low frequency and high frequency waves, leaving untouched the mid-band frequencies that are usually evident in the QRS. This may sound complicated but it is ultimately reduced to the adding and subtracting of samples. High frequencies are attenuated by adding samples together while low frequencies are attenuated by subtracting samples. See the examples below.

Eliminate high frequencies by adding





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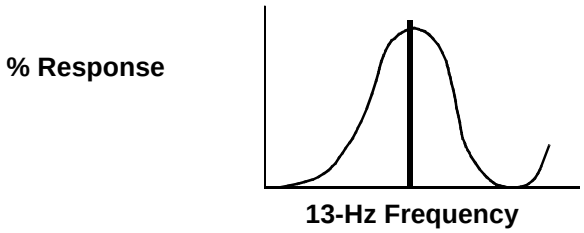
Eliminate low frequencies by subtracting

This filter makes the QRS detector more resilient in the presence of noise. It also decreases the probability of a false detection due to T waves. Below is a diagram of the frequency response of the QRS detector.



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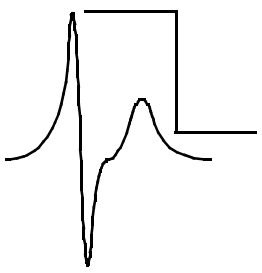
The output of this filter is summed across all 12 leads. Once the summed output crosses a specific threshold, a QRS is considered to be detected. In order to avoid the following T wave, the threshold is increased for a short period of time (200 ms).



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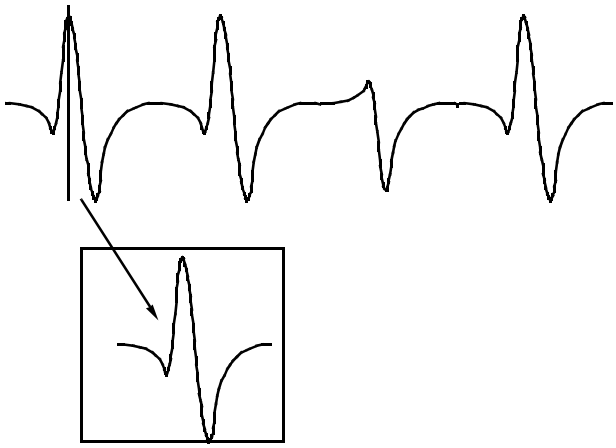
Once a QRS is detected, the 12SL analysis program makes a template of it for each lead.



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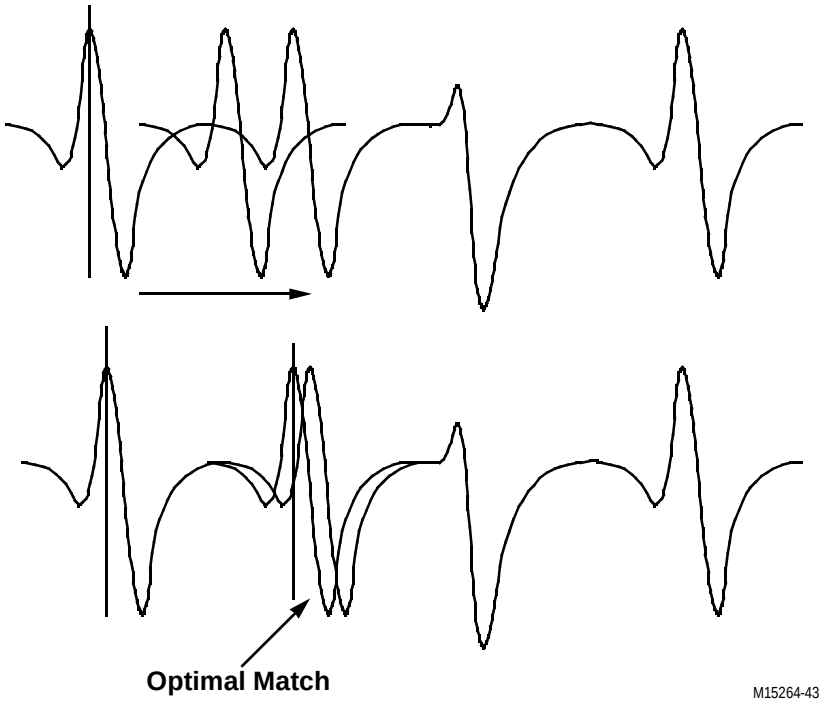
From this point on, the QRS detector looks for the same shape. If it finds a match, the program classifies it as another QRS detection. Furthermore, it slides the waveforms past one another looking for the optimal match. This sample time will be used later when we form a composite cycle.



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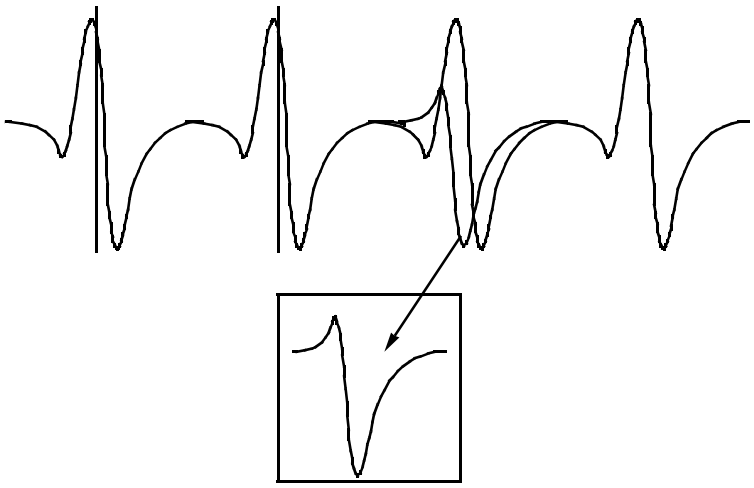
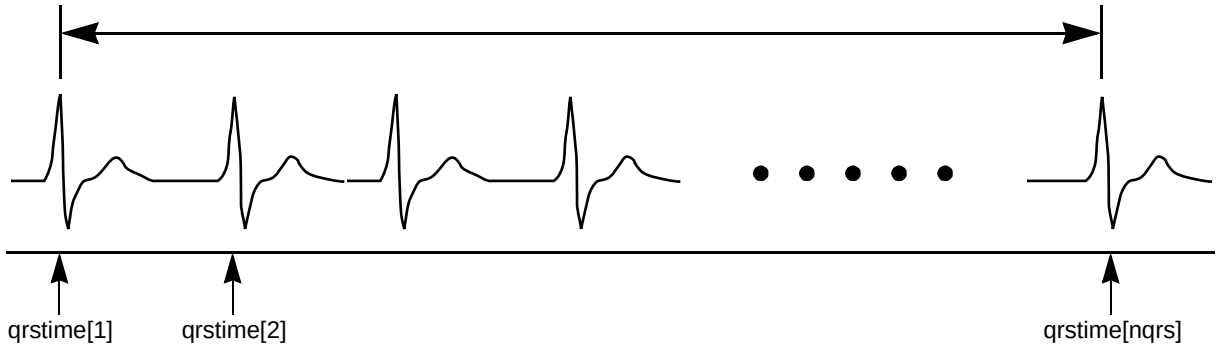
If the filter output exceeds thresholds, but there is no match, it is assumed that a different beat type has been detected and an additional set of lead templates is made for further matching tests.



In summary, the QRS detector uses a filter and template matching techniques to both detect and group, by shape, the QRS complexes which occur in the ECG record. The QRS detector also defines the points in the ECG record that can be used to align in time, with maximum correlation, the respective beats of a beat type.

Ventricular Rate Calculation

After all QRS complexes have been detected, the ventricular rate is computed by counting the number of beats detected and dividing by the time difference between the first and last beats.



$$\text{rate} = \frac{(\#\text{ of QRSs} - 1)\text{ beats}}{(\text{time difference between first and last QRSs})\text{ msec}} * 60000\text{ msec / min}$$

The number of R-R intervals (number of QRS complexes minus one) is divided by the time difference between the first and last beats, and the result is converted to units of beats per minute.

NOTE

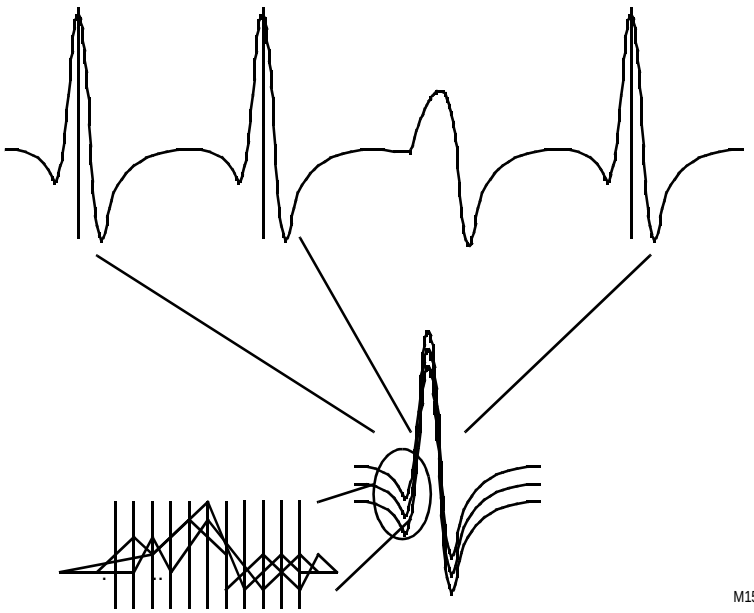
The interpretations of **Sinus bradycardia**, **Sinus rhythm**, and **Sinus tachycardia** are based on the atrial rate, not the ventricular rate. The atrial rate is determined from the P wave detections. Of course, the atrial rate will equal the ventricular rate for the majority of ECGs. In cases of 2nd or 3rd degree AV blocks, for example, the atrial rate may legitimately differ from the ventricular rate.

Median Formation

Before any further signal processing takes place, the program must determine which beat type will be used for the morphology measurements. The program uses the RR intervals and the location of any pacer spikes in order to decide which beat type has the highest level of origin in the conduction system. This selection is not dependent upon the number of beats per beat type. Rather, the beat type which is most informative for analysis is the one sought after and any beat type with three or more complexes can qualify.

The beat type that the computer considers to be most informative of normal conduction is often referred to as the "primary beat." Later in this guide you will see the rhythm criteria refer to "a normally shaped beat." This is a QRS complex with the same shape as the primary beat.

After a primary beat type has been chosen, each of its associated beats is used in generating a **representative (median) complex** for each lead. This is done using the sample times that were generated by the QRS detector. These times not only indicate the occurrence of a QRS, but they also indicate when the QRSs for a specific beat type are optimally matched. The representative complex is then generated with the median voltages from this aligned group of beats; that is, it is formed by taking, at each sample time, the middle voltage of the superimposed beats.



This process has several advantages. As opposed to other analysis programs, the alignment is done in all channels simultaneously. The problem of reconciling data from different lead groups is eliminated. Secondly, this technique is excellent for diminishing noise. A median is better than an average. It disregards the contributions that could be

made by outliers. The net result is the most artifact-free picture of the electromotive forces generated by the heart cycle.

Consider, for example, the set of five voltages given below. The median is defined as the value at which half of the samples are above this value and half of the samples are below this value. For this example, the median is 10 (two samples are greater than 10 and two samples are less than 10). On the other hand, the average is 26. The average was greatly biased by the outlier value of 100, whereas the outlier did not unduly bias the median.

Median

0	5	10	15	100	Median is 10

Average

0	5	10	15	100	Average is 26

Onsets/Offsets and Intervals

At this point, the median for the primary cycle has been established for each of the 12 leads. Since all leads were sampled synchronously, and time aligned synchronously, the median complexes are also synchronous. Since noise has been eliminated, the accuracy of the identification of wave onset/offset has been increased and the process simplified.

The onsets and offsets of the P, QRS, and T are found in a specific order. QRS onset is detected first. This is because it is the easiest to find; the slope change is usually very rapid and in great contrast to the other slopes in the median. This is followed by QRS offset and T offset. Next, the representative complex is searched for a P wave. A P wave will be found in the representative complex only if P waves are present and are synchronous with the QRS complexes. For example, junctional rhythms may not have a P wave and the P waves of Mobitz I (Wenckebach) second degree AV block will not have a constant PR interval and are asynchronous with QRS complexes. Finally, if a P wave is found, the onset and offset of the P wave are delineated.

The onsets and offsets are determined by an analysis of the simultaneous slopes in **all 12 leads**. Onsets are defined as the earliest deflection in any lead, and offsets are defined as the latest deflection in any lead. Thus, the **QRS duration** is measured from the earliest onset in any lead to the latest deflection in any lead. Similarly, the **QT interval** is measured from the earliest detection of depolarization in any lead to the latest detection of repolarization in any lead. The **PR interval** is measured from the earliest detection of atrial depolarization in any lead to the earliest detection of ventricular depolarization in any lead (the QRS onset). A PR interval is reported only if synchronous P waves are detected (i.e. P waves are detected and have a constant PR interval for each beat).

The QT interval is corrected for heart rate (QTc) using Bazett's formula[1]:

$$QTc = QT\sqrt{\frac{HR}{60}}$$

where HR is the ventricular rate in beats per minute, which is calculated as described previously in this chapter.

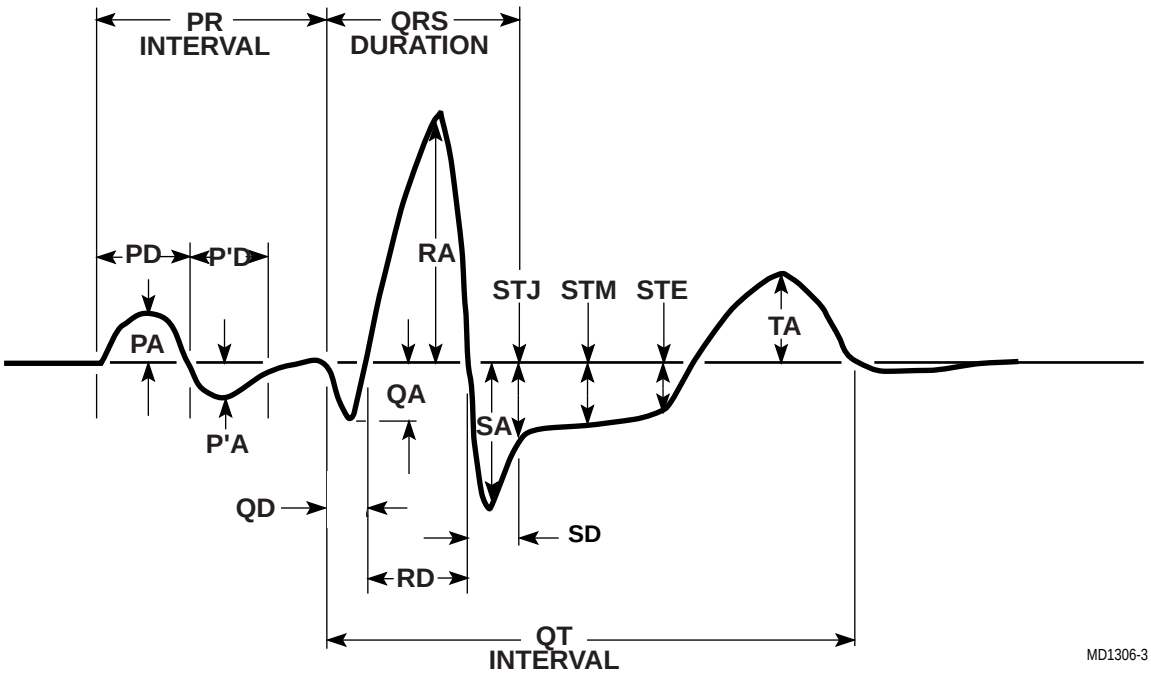
NOTE

By definition, the QTc will equal the QT interval for a heart rate of 60 beats per minute.

Wave Measurement

After the P, QRS, and T complexes have been demarcated in the median complex, the waves for each complex are identified. This is done separately for each lead. The program finds the points at which the signal crosses the baseline within each complex. If the crossing points define a wave that has an area greater than or equal to 160 µV • ms, the wave is considered to be significant. If the area is less than this value, the program considers the wave to be insignificant, and it will not label it as a separate wave.

The **measurement matrix** contains the amplitudes (with respect to QRS onset) and durations of all of these individual waves.



The median complex is shifted so that the voltage at the QRS onset is 0 by definition. All amplitudes and ST levels are voltages in µV with respect to the voltage at the QRS onset. The P, P', T, and T' amplitudes and the STJ, STM, and STE voltages may be positive or negative values, depending on whether the values are greater than or less than 0. However, because the Q, S, and S' waves are always defined as negative deflections, their amplitudes are represented as positive values with the implicit understanding that they are negative deflections.

STJ is defined as the ST level (with respect to QRS onset) at the QRS offset (commonly referred to as the “J point”). STM is the ST level at the QRS offset plus 1/16 of the average RR interval. STE is the ST level at the QRS offset plus 1/8 of the average RR interval.

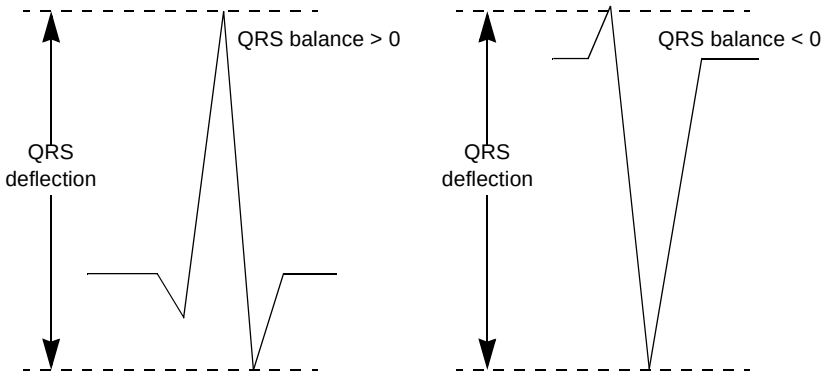
In addition to the individual wave durations and amplitudes defined on in the previous paragraph, the following quantities are also defined for each lead:

Maximum R amplitude = maximum of the R or R'
This is the maximum positive deflection.

Maximum S amplitude = maximum of the Q, S, or S'
This is the maximum negative deflection. (a positive value)

QRS balance = maximum R amplitude – maximum S amplitude
Will be positive if the QRS is predominately positive. Will be negative if the QRS is predominately negative.

QRS deflection = maximum R amplitude + maximum S amplitude
The maximum peak-to-peak deflection.

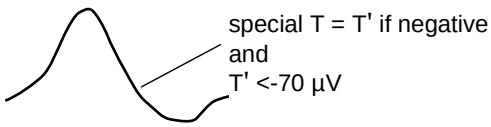


Minimum ST amplitude = minimum of STJ or STM

Special T amplitude = the minimum of either T amplitude or the T amplitude – STE
This value reflects the T amplitude without ST segment effects.

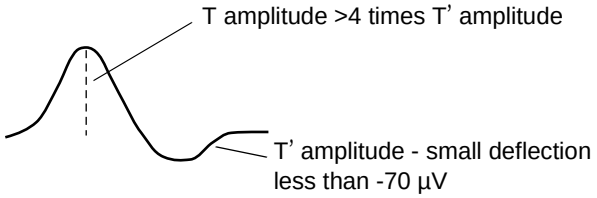
If the T' amplitude is negative, then the special T amplitude = T' amplitude

If T amplitude >-70 µV and T' amplitude is 4 times greater than the T amplitude and the T' amplitude is positive, the special T amplitude is = T' amplitude



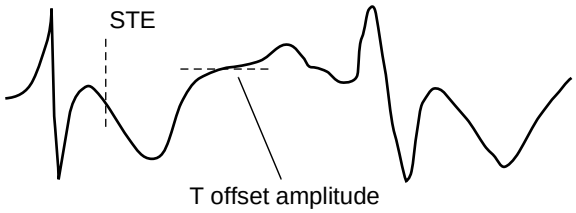
MD1306-14

There is an exception to this if the T' is a small deflection. Specifically, if the wave is less than 70 µV and the positive wave is at least 4 times bigger than the negative deflection, it ignores the small negative deflection.



MD1306-15

If T' = 0 and T amplitude is negative, then special T amplitude = minimum of either, minimum of T amplitude, or T amplitude – STE, or T amplitude – amplitude at T offset.



MD1306-16

P Wave Detection

In addition to P wave detection in the median complex, the raw rhythm data is also analyzed for atrial activity following the QRS detection and median formation. All leads are first examined for the greatest probability of proper P wave detection. One of leads I and II is selected and one precordial lead (V1 - V6) is selected. The QRST portion of the median complexes of the two selected leads are subtracted from the corresponding QRST locations in the rhythm data. Then, atrial waves (P, fibrillatory, or flutter waves) are detected from a composite signal of the two leads using a threshold based on the maximum values in the regions between the QRS complexes. Onsets and offsets of the detected atrial waves are delineated using a second threshold based on the baseline activity. Each detected atrial wave is assigned a confidence score based on how closely its measurements resemble those of the majority of the detected waves. Next, contextual analysis is applied to the measurements of the detected atrial waves, their confidence scores, and their temporal relations to each other and to QRS complexes. This is intended to exclude erroneously detected P waves and to perform a second search, using lower thresholds, for P waves that are suspected to be missing. For more information on P wave detection, see references 2 through 5 found on page 3-16.

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4 Diagnosis

For your notes

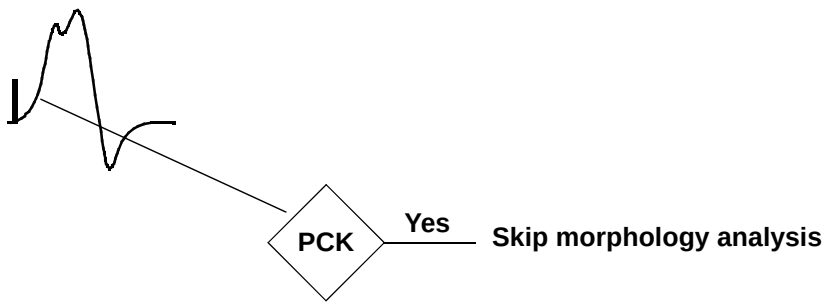
Introduction

The interpretive section determines which diagnostic statements will be made by the 12SL analysis program. The following sections present the rules and thresholds (i.e., the criteria) that are used by the program.

Keep the following items in mind as you use this manual:

- Understanding the flow of the program is essential before the details of a specific criteria will make any sense.
- Drawings and logic symbols are included with the presentation of the criteria. This should help you understand the flow of the program.
- The flow of the program can be comprehended by viewing the drawings from top to bottom and left to right.
- The logic symbols are used to indicate tests that cause the program to proceed forward or to suppress statements that the program has already made.
- Acronyms are generally located on the left side of the logic symbols.
- Most of the acronyms are obvious, but if they are not, consult the library tables in the appendices.
- Detailed sections and ECG samples are located following the presentation of the flow of the program.

The rhythm criteria is presented first since it is analyzed before the morphology of the waveforms. This sequence is required because information regarding the rhythm is needed for proper morphology interpretation.



A pediatric or an adult interpretation is available with the 12SL program; that is, if an age of less than 16 years is entered, the program employes pediatric as opposed to adult criteria. Age can also adjust thresholds within these two main bodies of criteria, as in the characterization of left ventricular hypertrophy. If age is not entered, the program enters a default adult age.

NOTE

This version of 12SL contains gender specific criteria therefore it is important to enter the age and sex of the patient in order to activate these performance enhancing criteria.

Age is used by the rhythm criteria but in very limited ways; for example, age is used to define normal sinus rates for pediatric ages. Therefore, the rhythm criteria for both pediatric and adult analysis is presented as a single unit.

Following the documentation of rhythm, the morphology criteria are presented. Morphology analysis cannot be presented as one set of criteria since pediatric analysis is not possible through simple adjustments of adult thresholds. A whole other approach is required. Therefore, the morphology criteria for pediatrics and adults are presented separately, with the adult criteria presented first.

Computer Interpretation/Development Process

The Marquette 12SL Program was introduced in 1980. All improvements to the program have been accomplished via a systematic, logical, and controlled methodology. A major aspect of this methodology benefits from the use of stored ECGs.

ECGs are stored in such a fashion that they can be re-analyzed by the 12SL Program.[1,2] In other words, the fidelity of the stored ECG is such that it can be used as if it was newly acquired. This allows us to access large volumes of stored ECGs for the purposes of either training or testing the program.

Any change to the program requires a great deal of research. This effort can be instigated by a variety of sources. The constant pursuit of clinically correlated databases can yield statistics that indicate whether a change should be considered. New criteria published in the literature can be evaluated and sometimes incorporated into the program. Consultations with cardiologists also stimulate investigations. This is especially true when they have stored ECGs whose interpretation has been verified by other, non-ECG data.

Before a change can be instituted, it must always be evaluated in relation to the current performance of the program. This validation process is facilitated by a set of research tools developed specifically for this purpose. These tools are then used in conjunction with our reanalysis capability. As an ECG is re-analyzed, a score pertaining to the item under investigation is stored and collated by the computer. Later, after many ECG records have been scored, the computer can generate statistics on the entire set of ECGs that it reanalyzed and scored. To determine ECGs that might be affected by a program change, the entire ECG set is reanalyzed twice: once with the change and once without. After this is done, the computer automatically calls out and plots any ECGs that scored differently between the two versions of the program. This work has resulted in an efficient set of research tools that allows an automatic determination of how a change might affect program performance on a large database.[3]

Given these sophisticated tools, the next issue relevant to the development process is the selection of an appropriate database. Appendix B contains a list of “gold standard” databases that Marquette has used in program validation. These databases are extremely valuable, because they are time consuming and expensive to obtain. Nevertheless, they are an essential ingredient. Without an objective yardstick, the program will not excel since the target for performance will be vaguely and inconsistently defined by the “consensus cardiologist”.[4]

It should also be noted that different databases are used during the development and validation process. This precludes us from developing a program that works beautifully on the training set but cannot be applied, with the same success, to other populations.[5,6]

During the training phase, we use a database that has been correlated with a “gold standard”. The choice of the “gold standard” depends upon

the problem being investigated. For criteria that references a particular patho-physiologic state (like myocardial infarction), we use a database that is correlated with other non-ECG evidence (like, cardiac catheterization, echocardiography, autopsy, cardiac enzymes, patient history, etc.). For measurements, or arrhythmia statements that can be confirmed by the ECG itself, we use the ECG in conjunction with expert opinion.

During the test phase, not only is an independent "gold standard" database used, but other databases are also used. This is prudent because "gold standard" databases have some limitations. Examples include the following:[7]

- The "gold standard" may not be representative of the disease in the clinical setting. For example, an ECG database which contains autopsy proven myocardial infarctions (MI) may not be indicative of what typical MI looks like since many patients survive a MI.
- "Gold standard" databases often contain only one, isolated disease. For example, a database may only contain MIs and normals. The program, however, must also operate in the presence of ischemia, LVH, drug effects, etc.
- There may be a systematic bias when selecting patients for a "gold standard" test. "CATH proven normals" often receive the test because they were symptomatic.
- A "gold standard" database may only contain extremes of normal versus abnormal. ECG analysis programs don't operate in a black and white world.
- And finally, a "gold standard" cannot be considered perfect: every test comes with its own inherent level of inaccuracy.

Given these aforementioned limitations, testing must go beyond the use of "gold standard" databases. The program must be tested with a wider spectrum of data. This is accomplished by measuring the program's performance on a large database (>150,000 ECGs). This process, which the computer can do in less than a few hours, presents the program with multiple diseases and varying degrees of abnormality. ECGs that changed their analysis results due to program modification can be further investigated with either confirmation from medical records and/or expert opinion.

Only after this retrospective testing is complete, can we finally incorporate the change into 12-lead ECG device and evaluate its performance at a clinical site. If this last test is successful, the change is incorporated into the program for general release.

References

1. Huffman, D.A., 1952. *A method for the construction of minimum redundancy codes*. Proc. Inst. Radio Eng.: 1098-1101
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For your notes

5 Rhythm Criteria

For your notes

Introduction

The rhythm criteria first determines the origin of the predominant rhythm in the 10 seconds of analyzed data. The program chooses from the following major categories:

- Electronic artificial pacing
- Atrial flutter
- Ectopic atrial rhythm
- Sinus rhythm
- Junctional rhythm
- Atrial fibrillation

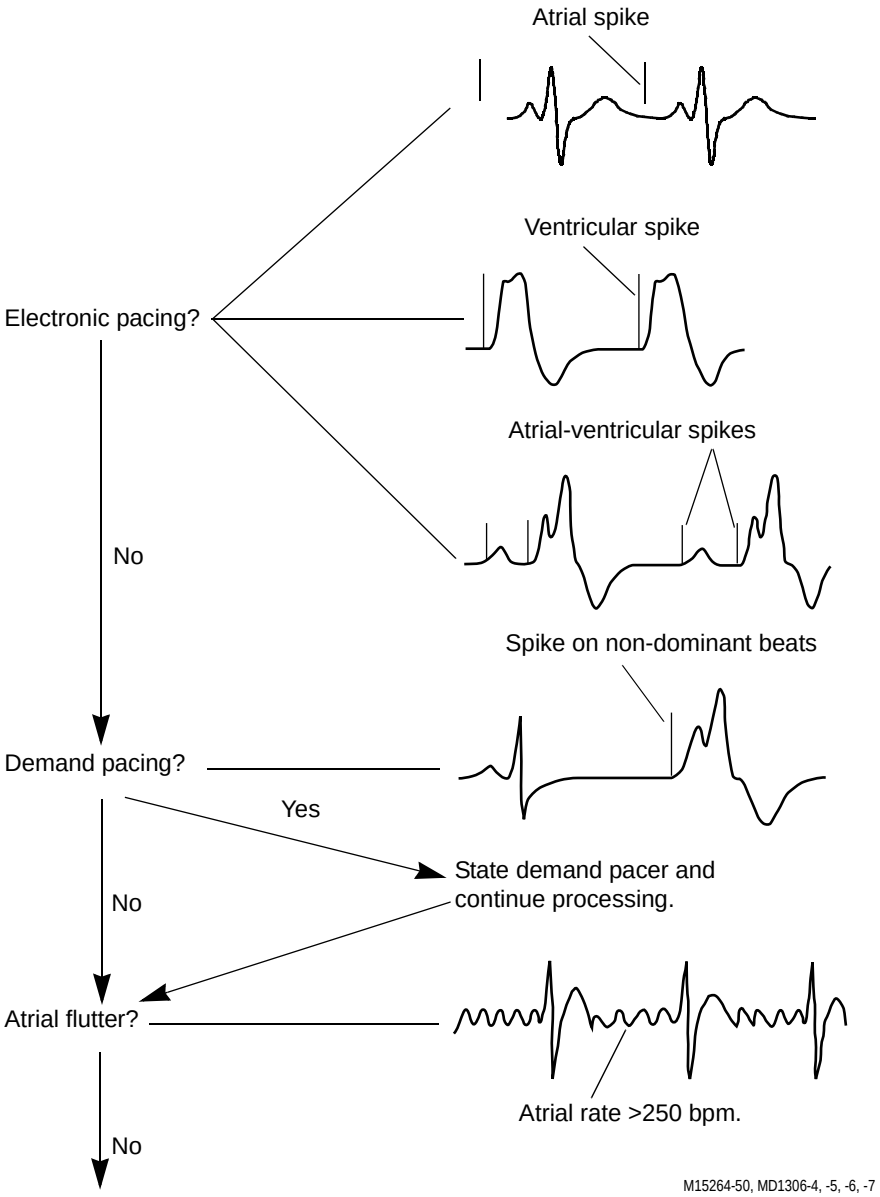
A set of statements exists for each of these categories; for example, sinus rhythm includes sinus tachycardia, normal sinus rhythm, sinus bradycardia, and marked sinus bradycardia.

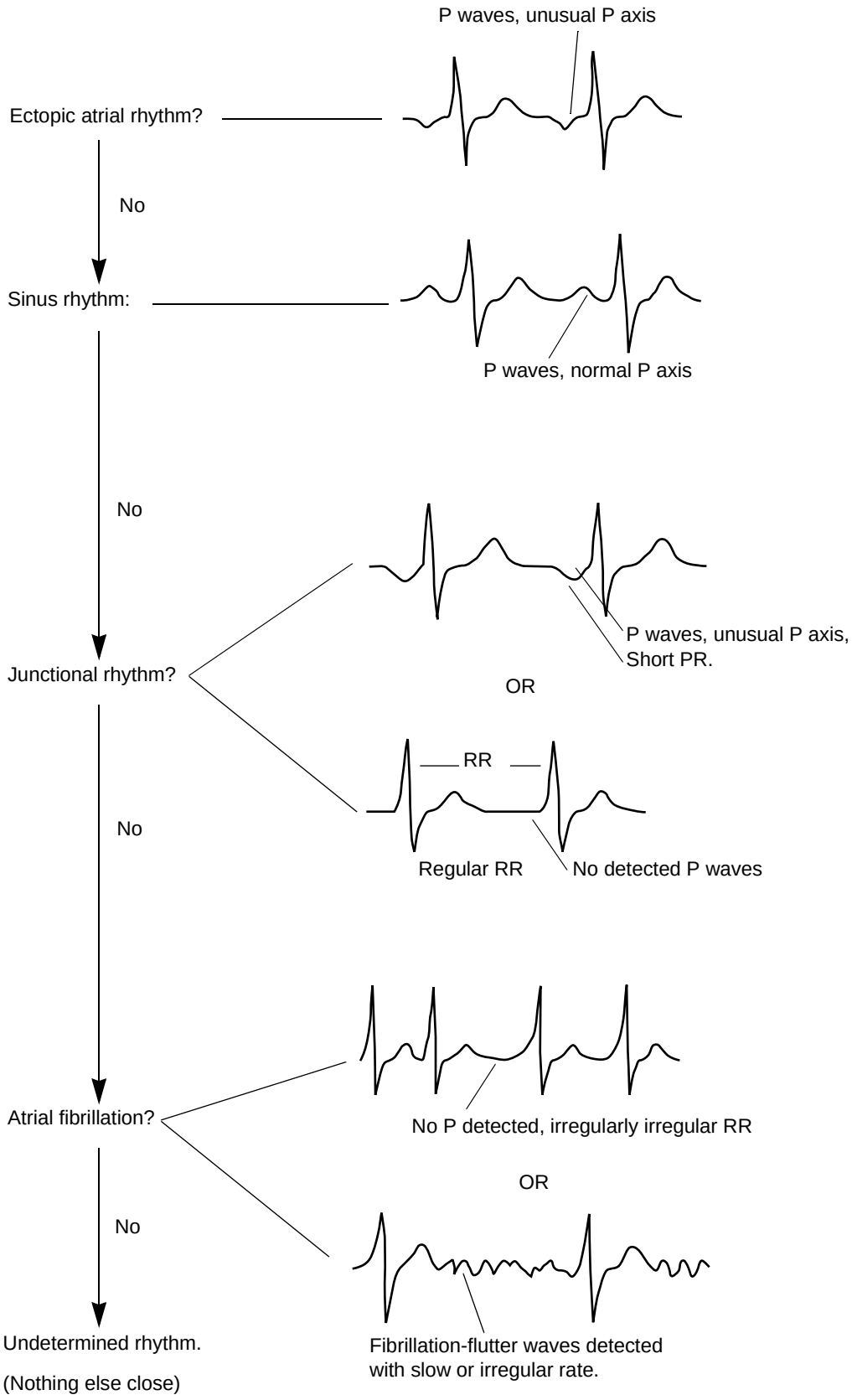
If the program is not able to choose a rhythm that is described by one of the above categories, it defaults to the undetermined rhythm category. This category includes such statements as wide QRS tachycardia and supraventricular tachycardia; these describe the overall rhythm, but refrain from defining the mechanism. If the rhythm cannot be labeled by these descriptive statements, the program states “Undetermined Rhythm.”

After the program states the predominant rhythm, several rhythm modifier statements can be appended for abnormalities of conduction and/or ectopy. Some of the modifier statements are only used for particular predominant rhythms. For example, the statement “with rapid ventricular response” is used only in conjunction with atrial fibrillation.

The following figure graphically portrays the criteria for selecting the predominant rhythm. Notice that if the program does not find a match in the first six categories, it defaults to the undetermined rhythm category.

Since the use of the rhythm modifiers are dependent upon the stated predominate rhythm, the document will first describe the criteria that is used for determining the predominant rhythm.


Atrial spike
Ventricular spike
Electronic pacing?
Atrial-ventricular spikes
No
Spike on non-dominant beats
Demand pacing?
Yes
State demand pacer and
continue processing.
No
Atrial flutter?
Atrial rate >250 bpm.
No
M15264-50, MD1306-4, -5, -6, -7



MD1306-8, -9, -10, -11, -12, -13

Criteria for Predominant Rhythms

There are seven categories of predominant rhythm statements.

1. Electronic artificial pacing
2. Atrial flutter
3. Ectopic atrial rhythm
4. Sinus rhythm
5. Junctional rhythm
6. Atrial fibrillation
7. Undetermined rhythm

Each of these categories is presented with its associated statements. Each statement is shown in its actual wording, followed by the statement acronym, and any specific criteria associated with that statement.

Electronic Artificial Pacing

This category requires that the predominant rhythm be artificially paced. Three statements are included in this category; they delineate the origin of the artificial pacing.

1. "Electronic Ventricular Pacemaker" — PCK
2. "Electronic Atrial Pacemaker" — APCK
3. "AV Sequential or Dual Chamber Electronic Pacemaker" —AVPCK

If artificial pacer spikes are detected before beats that are not the primary beats, then a demand pacemaker statement is issued.

Demand Pacemaker; Interpretation is Based on Intrinsic Rhythm

Acronym: **DPCK**

Requires

1. No pacer spikes preceding the primary beats, and
2. pacer spikes preceding the secondary beats.

Rhythm analysis continues after this statement is issued. Therefore, the predominant rhythm of the ECG is still chosen after a demand pacemaker is cited.

Atrial Flutter

Acronym: **FLUT**
The program must detect an atrial rate from 200 to 350 bpm (for pediatrics, requires atrial rate to be 300 to 350 bpm).

Ectopic Atrial Rhythm

This category is chosen if a P wave, with an abnormal axis, is found before the primary beats.

Specifically, this category requires:

1. Rigidly coupled P wave detected for primary beat, and
2. no flutter or second degree AV block, and
3. P axis less than -30 or greater than 120. (For pediatrics, P axis less than -20 or greater than 100.)

For adults the ectopic atrial rhythm statements are rate dependent.

Unusual P axis, possible ectopic atrial bradycardia

Acronym: **EABRAD**
Requires

1. Atrial rate less than 60 bpm.

Unusual P axis, possible ectopic atrial rhythm

Acronym: **EAR**
Requires

1. atrial rate from 60 to 100 bpm.

Unusual P axis, possible ectopic atrial tachycardia

Acronym: **EATACH**
Requires

1. Atrial rate greater than 100 bpm.

For pediatrics, the ectopic atrial rhythm statements are dependent on both rate and origin of impulse. If low right atrial rhythm is stated, the P axis is greater than 100 degrees. A left atrial rhythm is stated if the P axis is less than -20. Rate thresholds are age dependent. (Refer to Appendix C for pediatric ages.)

1. Low Right Atrial Bradycardia — **RABRAD**
2. Low Right Atrial Tachycardia — **RATACH**
3. Left Atrial Bradycardia — **LABRAD**
4. Left Atrial Tachycardia — **LATACH**
5. Low Right Atrial Rhythm — **RAR**
6. Left Atrial Rhythm — **LAR**

Sinus Rhythm

This category requires the program to detect P waves with a normal axis. Specifically, it requires.

1. Rigidly coupled P wave detected for primary beat, and
2. normal P axis.

   or

1. P waves detected at a regular rate and not associated with primary beat.

Sinus rhythm statements are rate dependent (refer to Appendix C for pediatric ages). “Marked Sinus Bradycardia” is stated for both adults and pediatrics at a rate below 50 bpm.

NOTE

The determination of sinus bradycardia, sinus rhythm, or sinus tachycardia is based on the **atrial** rate, not the **ventricular** rate. This is because it is the atrial rate that reflects the rate of the sinus node. While these two rates will be identical for the vast majority of sinus rhythms, they may differ in cases such as 2nd or 3rd degree AV block. For example, an ECG with complete heart block and an atrial (sinus) rate of 115 bpm and a ventricular rate of 55 beats per minute would be interpreted as “Sinus tachycardia with complete heart block” even though the ventricular response might normally be thought of as bradycardia.

Sinus bradycardia

Acronym: **SBRAD**
Requires atrial rate from 50 to 59 bpm.

Normal sinus rhythm

Acronym: **NSR**
Requires atrial rate from 60 to 100 bpm and no rhythm modifiers appended or only “with sinus arrhythmia” appended.

Sinus rhythm

Acronym: **SRTH**
Requires atrial rate from 60 to 100 bpm and any rhythm modifiers appended beyond “with sinus arrhythmia”.

Sinus tachycardia

Acronym: **STACH**
Requires atrial rate over 100 bpm.

Marked sinus bradycardia

Acronym: **MSBRAD**
Requires Atrial rate less than 50 bpm.

Junctional Rhythm

Two sets of criteria are used for this category. One set of criteria is applicable to those junctional rhythms that have a P wave which precedes the QRS. The other criteria is for when the P wave is submerged in the QRS or T.

If the P wave precedes the QRS, it must be ectopic in shape with a short PR interval. Pediatric patients exhibit shorter time intervals before the onset of ventricular activation. As a result, they rarely exhibit AV nodal rhythms with a short PR interval. Therefore, pediatric analysis leaves this rhythm categorized as ectopic atrial rhythm.

Specifically, if P waves are visible before the QRS then the criteria requires:

1. Rigidly coupled P wave detected for primary beats, and
2. no flutter or second degree AV block, and
3. PR interval less than 140 ms, and
4. P wave axis outside of -60 to 240 degrees, and
5. an adult age.

The statements for this criteria are rate dependent.

Unusual P axis and short PR, probable junctional bradycardia

Acronym: **JBRAD**
Requires ventricular rate less than 50 bpm.

Unusual P axis and short PR, probable junctional rhythm

Acronym: **JR**
Requires ventricular rate from 50 to 75 bpm.

Unusual P axis and short PR, probable junctional tachycardia

Acronym: **JTACH**
Requires:

1. Ventricular rate greater than 75 bpm.

If P waves are not visible, then the program requires a very regular, narrow QRS rhythm.

Specifically it requires:

1. No P waves found, and
2. a regular RR interval (that is, a range of RR intervals that is less than 10% of the average RR interval), and
3. a narrow primary beat (<120 ms for QRS duration, for pediatric ages refer to Appendix C), and
4. a ventricular rate less than 90 bpm.

Junctional rhythm statements are rate dependent. The rate thresholds are the same for both pediatric and adult analyses.

Junctional bradycardia

Acronym: **JUNBRAD**
Requires rate less than 45 bpm.

Junctional rhythm

Acronym: **JUNCT-R**
Requires rate from 45 to 65 bpm.

Accelerated

Acronym: **ACCEL**
This statement precedes **Junctional Rhythm** when the rate is greater than 65 bpm.

Atrial Fibrillation

If none of the other aforementioned categories has been chosen, the program tests for atrial fibrillation. Generally, the program looks for an irregular rhythm or fibrillatory waves in the presence of a slow heart rate. Specifically, it requires test 1 or test 2 to be true.

Test 1 requires:

- An irregularly irregular rhythm (range of RR intervals more than 15% of average RR interval and RR intervals not organized) and
- no regular atrial rhythm detected.

Test 2 requires:

- Atrial rate >400

Only one statement is generated for this category. The rhythm can be further defined by rhythm modifier statements. (Refer to next section.)

Atrial Fibrillation — AFIB

Atrial fibrillation occurs so rarely in pediatric individuals that the program requires an adult age for this diagnosis.

Undetermined Rhythm

This category is chosen if none of the other previously mentioned categories fits the description of the measurements extracted from the ECG.

Some descriptive statements can be issued from this category without specifying the mechanism.

Ideoventricular Rhythm

Acronym: **IVR**

Requires:

1. A slow ventricular rate (<= 40 bpm for adult and pediatric).
2. same as for **WQTACH**.
3. same as for **WQTACH**.

Wide QRS Rhythm

Acronym: **WQR**

Requires:

1. Ventricular rate between 40 and 120 bpm; refer to Appendix C for upper rate limit for pediatric.
2. same as for **IVR**.
3. same as for **IVR**.

Wide QRS tachycardia

Acronym: **WQTACH**
Requires:

1. A fast ventricular rate (>120 bpm; refer to Appendix C for pediatric).
2. same as for **IVR**.
3. same as for **IVR**.

Supraventricular tachycardia

Acronym: **SVT**
Requires:

1. A fast ventricular rate (>140 bpm; >220 bpm for pediatric).
2. A narrow QRS (QRS duration <120 ms; refer to Appendix C for pediatric).
3. A regular heart rate (that is, the range of RR intervals is less than 20% of the average RR interval).

Narrow QRS tachycardia

Acronym: **NQTACH**
Requires:

1. Pediatric age
2. Same criteria as described for supraventricular tachycardia, but allows rates below 220 bpm that are still above the fast heart rate for age.

Undetermined rhythm

If the criteria cannot be met for these descriptive statements, then the program will state **Undetermined rhythm** (acronym: **UR**).

Criteria for Rhythm Modifiers

The rhythm criteria first determines the predominant rhythm for the 10-second record. Rhythm modifiers are then appended for a complete interpretation of the rhythm.

After the predominant rhythm is stated, the program can append phrases that further defined the rhythm.

For a sinus rhythm, the program has a variety of rhythm modifiers to choose from. These can be classified into six groups.

Sinus Rhythm

1. Ectopy (Example: **Premature Ventricular Complexes**)
2. AV Block (Example: **With Complete Heart Block**)
3. PR Interval (Example: **With 1st Degree AV Block**)
4. Sinus Arrhythmia (Example: **With Marked Sinus Arrhythmia**)

Ectopy is the only group of sinus rhythm modifiers that is used by other predominant rhythms: namely, ectopic atrial rhythm, and junctional rhythm.

Ectopic Atrial Rhythm and Junctional Rhythm

1. Ectopy

Ectopy or conduction abnormalities are stated for the rhythms, but with phrases that are more appropriate for the non-sinus predominant rhythm.

For example, ectopy can occur with atrial fibrillation or flutter, but the origin of it is harder to define. That is why atrial fibrillation and atrial flutter have a tailored set of ectopy statements.

Atrial Fibrillation and Atrial Flutter

1. Ectopy (tailored for fibrillation/flutter), Example: **With Premature Ventricular or Aberrantly Conducted Complexes**

Similarly, AV block can occur with atrial fibrillation or atrial flutter, but it is more clearly expressed with a different set of modifiers.

Atrial Flutter — AV Block (tailored for flutter)

1. Example: **With 4:1 AV Conduction**

Atrial Fibrillation — AV Block (tailored for atrial fibrillation)

1. Example: **With Slow Ventricular Response**

Immediately following is an explanation of each of these groups, including specific criteria and statements.

Sinus Arrhythmia

This group is only used for sinus rhythms. It requires a rigidly coupled P wave detected for the primary beat and no premature supraventricular beats (normal shape but without P wave) or premature ectopic beats (shape other than primary beat).

Sinus arrhythmia is stated if the range of RR intervals exceeds a particular limit. The limits are much higher for the pediatric population which has much more sinus arrhythmia. Specifically:

with sinus arrhythmia

Acronym: **SAR**
Requires range of RR intervals 20 to 39% (greater than 40% for pediatrics) of average RR interval.

with marked sinus arrhythmia

Acronym: **MSAR**
Requires range of RR intervals 40% or greater of average RR interval (not used for pediatric ages).

First Degree AV Block — Long PR

Sinus rhythm and ectopic atrial rhythms use this category. This statement is made if the PR interval is long for age.

with 1st degree AV block

Acronym: **FAV**
Requires PR interval of 210 ms or longer (for pediatrics, it is the 98th percentile plus 20 ms; refer to Appendix C for pediatric).

Short PR

Sinus rhythm is required. Short PR is stated if the PR interval is short for age. Obviously, if **WPW** is detected (see contour criteria) this statement is suppressed.

with short PR

Acronym: **SPR**
Requires PR interval 110 ms or less (for pediatrics, it must be less than the 2nd percentile for age. Refer to Appendix C for pediatric).

Ectopy

This group of modifiers can be used by the program if sinus rhythm, ectopic atrial rhythm, or junctional rhythm is stated.

The ectopy group can be further subdivided. It contains statements that pertain to premature beats, fusion beats, or escape beats.

Modifiers that are associated with premature beats are always preceded by a phrase that indicates how often the beats occur. Specifically:

with occasional

Acronym: **OCC**
Requires 1 or 2 beats.

with frequent

Acronym: **FREQ**
Requires greater than 2 beats.

NOTE
If ectopic shaped beats appear as at least one consecutive pair, then not only is the frequency of the beats commented on, but the consecutive nature of the beats is also indicated.

, and consecutive

Acronym: **CSEC**
Requires:

1. At least one pair of beats, and
2. these beats
   - are separated by less than 600 ms for rates lower than 85 bpm, or
   - are at least 100 ms premature for rates over 85 bpm.

Listed below are the various premature beat modifier statements that follow the aforementioned prefixes.

Premature supraventricular complexes

Acronym: **PSVC**
Requires:

1. No AV block, Mobitz I or II, and
2. no AV dissociation, and
3. at least one QRS that is premature, normally shaped, and
4. no P wave found before this QRS.

Premature atrial complexes

Acronym: **PAC**
Requires:

1. No AV block, Mobitz I or II, and
2. no AV dissociation, and
3. at least one QRS that is premature, normally shaped, and
4. one or more P waves found preceding this QRS, and
5. one of the following:
   - no rigidly coupled P for this beat and more than one preceding P, or
   - an organized bimodal or trimodal distribution of RR intervals.

Premature ventricular complexes

Acronym: **PVC**
Requires:

1. At least one QRS that is premature, ectopic shaped, and
2. has a QRS duration greater than 120 ms (for pediatrics, wide for age; refer to Appendix C), and
3. no fusion beats detected.

Premature ventricular and fusion complexes

Acronym: **PVCF**
Requires:

1. At least one QRS that is premature, ectopic shaped, and
2. has a QRS duration greater than 120 ms (for pediatrics, wide for age; refer to Appendix C), and
3. at least one fusion beat.

Premature ectopic complexes

Acronym: **PEC**
Requires:

1. At least one QRS that is premature, ectopic shaped, and
2. no PVCs.

A suffix can also be added to these statements if a pattern of bigeminy is evident.

in a pattern of bigeminy

Acronym: **BIGEM**
Requires:

1. A strict 10-second pattern of alternating premature and not premature beats, and
2. one of the following:
   - at least one QRS that is premature, ectopic shaped, or
   - at least one premature atrial or supraventricular beat.

Statements that specifically deal with fusion beats or escape beats are not conjugated with the phrase “With Occasional” etc. Listed below are these statements.

with junctional escape complexes

Acronym: **JESC**
Requires:

1. No AV block, Mobitz I or II, and
2. at least one beat that follows an RR interval which is longer than 1.4 times the longer of the previous RR or the median RR, and
3. no P wave preceding that beat, and
4. follows a normally shaped beat.

with ventricular escape complexes

Acronym: **VESC**
Requires:

1. At least one beat that is ectopic shaped, and
2. has a QRS duration greater than 120 ms, (for pediatrics, wide for age; refer to Appendix C) and
3. follows an RR interval of more than 1200 ms, and
4. follows a normally shaped beat.

with fusion or intermittent ventricular pre-excitation (WPW)

Acronym: **ALTWPW**
Requires:

1. Fusion beats, and
2. no premature ectopic shaped beats, and
3. delta waves in three or more leads of the fusion beat.

A fusion beat requires:

1. A QRS that is not premature but ectopic shaped, and
2. not the first QRS of the 10-second strip, and
3. within 100 ms of the expected RR interval.

with retrograde conduction

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **RETC**
Requires:

1. Junctional bradycardia, junctional rhythm, or accelerated junctional rhythm stated, and
2. no AV dissociation or complete heart block, and
3. regular atrial rhythm detected, and
4. number of P waves detected < number of QRSs plus 5, and
5. short RP interval

AV Block

Either sinus rhythm or ectopic atrial rhythm is required as the predominant rhythm before any of these modifiers can be used. This section lists the statements that express 2nd and 3rd degree AV block.

with 2nd degree AV block (Mobitz I)

Acronym: **MBZI**
Requires:

1. At least one beat that follows an RR interval which is longer than 1.4 times the longer of the previous RR or the median RR, and
2. no rigidly coupled P wave for this beat, and
3. two P waves preceding that beat, and
4. PR interval for this beat is shorter than average, and
5. this beat follows a normally shaped beat.

with 2nd degree AV block (Mobitz II)

Acronym: **MBZII**
Requires:

1. Two or more P waves preceding a beat, and
2. that beat follows a normally shaped beat, and
3. that beat follows an RR interval which is longer than one of the following:
   - 2.2 times the longer of the previous RR or the median RR, or
   - 1.8 times the longer of the previous RR or the median RR and there is a rigidly coupled P wave for this beat.

with 2:1 AV conduction

For MBZI and MBZII

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **W2T1**
Requires:

1. Synchronous blocked P wave identified in the median complex in addition to synchronous conducted P wave, or
2. Pattern of blocked P, conducted P, blocked P, conducted P detected somewhere in the rhythm analysis.

with 2nd degree AV block

Acronym: **SAV**
Requires:

1. Rigidly coupled P wave detected for primary beats, and
2. atrial rate less than 200 bpm, and
3. the atrial rate is less than 10 bpm different than twice the ventricular rate.

with 2:1 AV conduction

For SAV
Acronym: **W2T1**
Requires:

1. Synchronous blocked P wave identified in the median complex in addition to synchronous conducted P wave, or
2. Pattern of blocked P, conducted P, blocked P, conducted P detected somewhere in the rhythm analysis, or
3. Atrial rate is within 5 bpm of 2 times the ventricular rate.

with 3:1 AV conduction

For SAV
Acronym: **W3T1**
Requires: Atrial rate is within 10 bpm of 3 times the ventricular rate.

with 4:1 AV conduction

For SAV
Acronym: **W4T1**
Requires atrial rate is within 15 bpm of 4 times the ventricular rate.

with complete heart block

Acronym: **CHB**
Requires:

1. No AV Block (Mobitz I or II), and
2. regular atrial rhythm detected, and
3. no rigidly coupled P wave detected for primary beats, and
4. range of RR intervals less than 3% of average RR interval, and
5. atrial rate more than 6 bpm faster than ventricular rate, and
6. one of the following:
   - PR variance greater than 200 ms, or
   - atrial rate more than 25 bpm faster than ventricular rate.

with AV dissociation

Acronym: **AVDIS**
Requires:

1. No AV Block (Mobitz I or II), and
2. no flutter, and
3. regular atrial rhythm detected, and
4. no rigidly coupled P wave detected for primary beats, and
5. one of the following:
   - atrial rate more than 25 bpm faster than ventricular rate, or
   - PR variance greater than 200 ms.

NOTE

If “with complete heart block” or “with AV dissociation” is stated, then additional statements regarding the ventricular activity will follow. The presence of an atrioventricular dyssynchrony requires that both the atrial and the ventricular activity be specified. The ventricular activity will be stated as one of the otherwise predominant rhythm statements of: “Junctional rhythm”, “Junctional bradycardia”, “Ideoventricular rhythm”, “Wide QRS rhythm”, or “Wide QRS tachycardia”.

Irregular Rhythm

Ectopic atrial rhythm and junctional rhythm use this category. It is analogous to the sinus arrhythmia category for sinus rhythms. If the program did not detect any ectopy and if the rhythm is irregular, the program will describe the condition with the following statements.

For adult ages, it will append:

with undetermined rhythm irregularity

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **IRREG**
Requires range of RR intervals greater than 20% of average RR interval.

For pediatric ages, it will precede the predominant rhythm statement with:

irregular

Acronym: **IRR**
Requires range of RR intervals greater than 20% of average RR interval.

AV Block (for Flutter)

AV block for atrial flutter is described by this group of modifiers.

with variable AV block

Acronym: **VAVB**
Requires range of RR intervals is 10% or more of average RR interval.

with 2:1 AV conduction

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **W2T1**

Requires:

1. Range of RR intervals less than 10% of average RR interval, and
2. atrial rate is within 10 bpm of 2 times the ventricular rate.

with 3:1 AV conduction

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **W3T1**
Requires:

1. Range of RR intervals less than 10% of average RR interval, and
2. atrial rate is within 10 bpm of 3 times the ventricular rate.

with 4:1 AV conduction

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **W4T1**
Requires:

1. Range of RR intervals less than 10% of average RR interval, and
2. atrial rate is within 10 bpm of 4 times the ventricular rate.

with 5:1 AV conduction

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **W5T1**
Requires:

1. Range of RR intervals less than 10% of average RR interval, and
2. atrial rate is within 10 bpm of 5 times the ventricular rate.

If the ventricular rate is regular (that is, the range of RR intervals is less than 10% of the average RR interval) and the atrial rate is not within some multiple of the ventricular rate, then the program will suggest a competing junctional pacemaker.

with a competing junctional pacemaker

Acronym: **CJP**
Requires:

1. Range of RR intervals less than 10% of average RR interval, and
2. atrial rate is not within 10 bpm of some multiple of the ventricular rate, and
3. no electronic pacer spikes detected.

Ectopy (for Flutter/Fibrillation)

In the presence of atrial fibrillation or atrial flutter it is difficult to define the origin of ectopic shaped beats. The following statement is used for this purpose.

with premature ventricular or aberrantly conducted complexes

Acronym: **ABER**
Requires Test 1 or Test 2 to be true.

Test 1 requires:

1. Flutter, and
2. range of RR intervals is 10% or more of average RR interval, and
3. one or more premature ectopic shaped beats.

Test 2 requires:

1. Atrial fibrillation, and
2. one or more premature ectopic shaped beats.

AV Block (for Fibrillation)

The following statements are used to indicate the degree of AV block in the presence of atrial fibrillation.

with rapid ventricular response

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **RVR**
Requires ventricular rate higher than 100 bpm.

with slow ventricular response

NOTE
This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **SVR**
Requires ventricular rate lower than 60 bpm.

with a competing junctional pacemaker

NOTE

This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acronym: **CJP**
Requires:

1. No electronic pacer spikes detected, and
2. one of the following:
   - range of RR intervals less than 5% of average RR, or
   - the 3 longest RR intervals are longer than 800 ms and within 40 ms of each other.

6 Adult Contour Criteria

For your notes

Overview

The morphology interpretation consists of two separate bodies of criteria: one for adults, the other for pediatrics. If an adult age is entered (16 years or older) or if no age is entered, an adult analysis is performed.

The 12SL analysis program has adult age and gender-specific contour criteria. These criteria are invoked if an adult age is entered and if the patient's sex is entered. If age and sex are not entered, 12SL returns to conventional criteria.

The categories of abnormalities that the program always examines for are listed in the following table. This outline is expanded upon in succeeding figures which describe, in very simplistic terms, the basic flow and logic of the program. Note that the order of the steps is important since information obtained from tests, performed earlier in the sequence, are applied to subsequent tests.

Following the presentation of the basic flow of the program are more detailed explanations of each step. This includes specific thresholds, sample tracings, and additional figures. This section will address those questions regarding particular criteria, as opposed to revealing the overall approach used by the program to interpret the morphology.

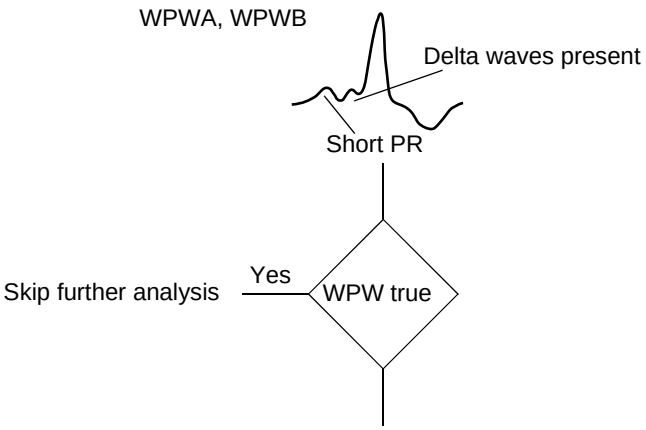
Refer to Chapter 3 for definitions of the wave measurements used in this chapter.

Table 1. Adult Contour Criteria Summary

Major Category	Subcategory	Acronyms/Statements
Wolff-Parkinson-White		WPWA WPWB
Atrial Hypertrophy		RAE, Right Atrial Enlargement LAE, Left Atrial Enlargement BAE, Biatrial Enlargement
QRS Abnormalities	Low Voltage QRS Pulmonary Disease Pattern QRS Axis Conduction Abnormalities Ventricular Hypertrophy	LOWV PULD RAD, Right Axis Deviation LAD, Left Axis Deviation RSAD, Right Superior Axis Deviation RBBB, Right Bundle Branch Block LBBB, Left Bundle Branch Block IRBBB, Incomplete Right Bundle Branch Block ILBBB, Incomplete Left Bundle Branch Block RSR, RSR Pattern In V1 IVCB, Intraventricular Conduction Block IVCD, Intraventricular Conduction Delay AFB, Left Anterior Fascicular Block PFB, Left Posterior Fascicular Block LVH, Left Ventricular Hypertrophy RVH, Right Ventricular Hypertrophy BIVH, Biventricular Hypertrophy RVE+, Plus Right Ventricular Hypertrophy QRSW, With QRS Widening

Table 1. Adult Contour Criteria Summary (Continued)		
Major Category	**Subcategory**	**Acronyms/Statements**
QRS Abnormalities (continued)	Infarction	MI, Myocardial Infarction AMI, Anterior SMI, Septal LMI, Lateral IMI, Inferior PXT, With Posterior Extension
ST Abnormalities—QRS Related	ST + T abnormality with Ventricular Hypertrophy Dating Infarcts	2ST, With Repolarization Abnormality AC, Possibly Acute AU, Age Undetermined
ST Elevation Abnormalities	Epicardial Injury Pericarditis Early Repolarization Undefined ST Elevation Nonspecific	INJ, Injury SINJ, Septal AINJ, Anterior LINJ, Lateral IINJ, Inferior PCARD, Acute Pericarditis REPOL, Early Repolarization STEL, ST Elevation Consider Early Repolarization, Injury or Acute Pericarditis NST, Nonspecific ST Abnormality
ST Depression Abnormalities	Subendocardial Injury Undefined ST Depression Digitalis Effect Junctional ST Depression Nonspecific	SBINJ, Subendocardial Injury SSBINJ, Septal ASBINJ, Anterior LSBINJ, Lateral ISBINJ, Inferior STDEP, ST Depression, Consider Subendocardial Injury or Digitalis Effect PDIG, Probably Digitalis Effect STDIG, ST Abnormality, Possible Digitalis Effect JST, Junctional ST Depression Probably Abnormal JSTN, Junctional ST Depression, Probably Normal NST, Nonspecific ST Abnormality
T Wave Abnormalities	Ischemia Nonspecific QRS-T Angle QT Interval	T Ischemia AT, Anterior IT, Inferior LT, Lateral MT, Marked Ischemia MAT, Anterior MIT, Inferior MLT, Lateral NT, Nonspecific T Wave Abnormality AQRST, Abnormal QRS-T Angle, Consider Primary T Wave Abnormality LNGQT, Prolonged QT

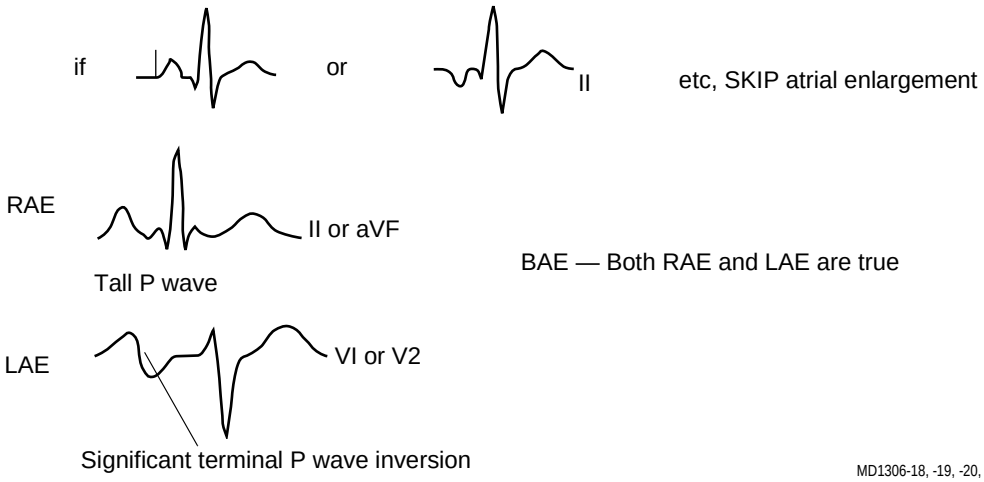
Wolff-Parkinson-White



MD1306-17

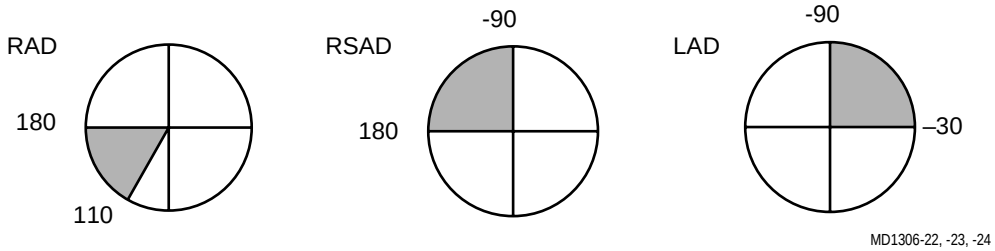
Atrial Enlargement

Skip the test if it is not a sinus rhythm.



MD1306-18, -19, -20, -21

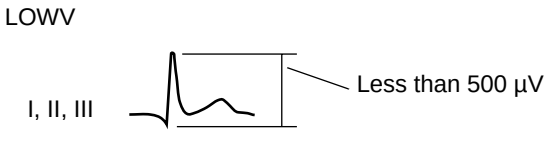
QRS Axis



MD1306-22, -23, -24

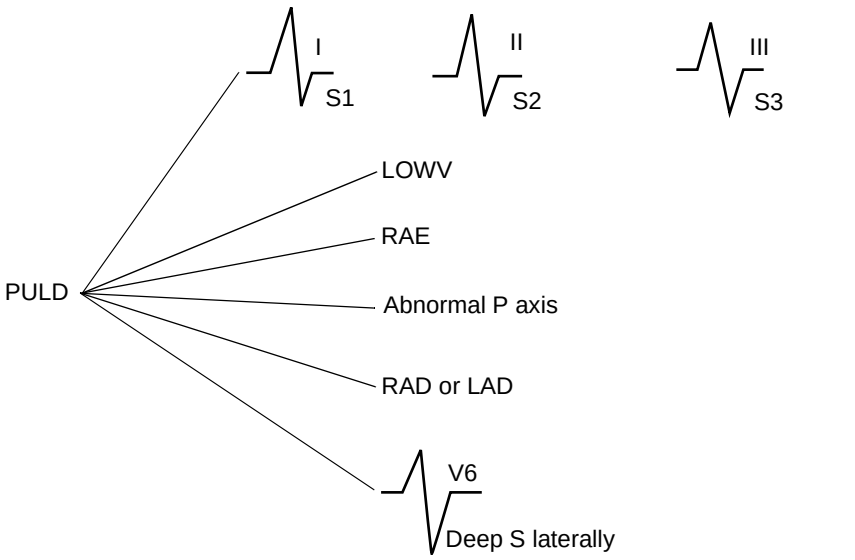
Low Voltage QRS

Standard requirement of limb leads less than 500 µV. However, if horizontal plane exhibits low voltage and the limb lead have voltage close to the standard requirement, state **low voltage QRS**.

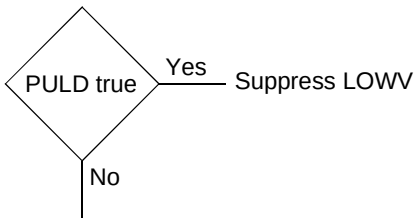


Pulmonary Disease Pattern

PULD — check for several attributes, states if at least a few are present.

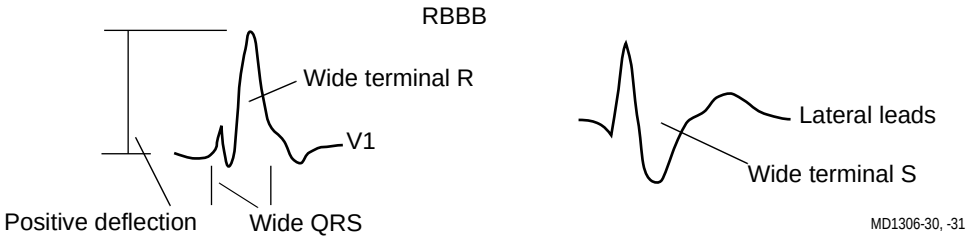


If **PULD** is true, do not redundantly state **LOWV**.



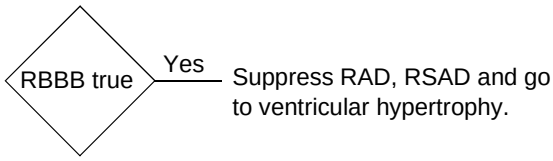
Conduction Abnormalities

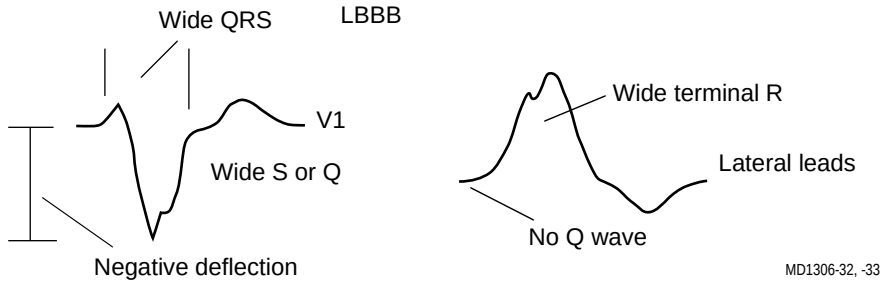
Major Blocks



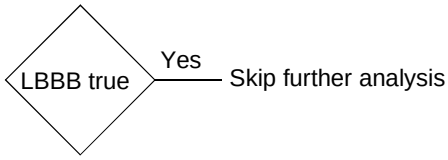
If **RBBB** is true, suppress **RAD** and **RSAD**.

If **RBBB** is true, skip further conduction tests and go to ventricular hypertrophy tests.

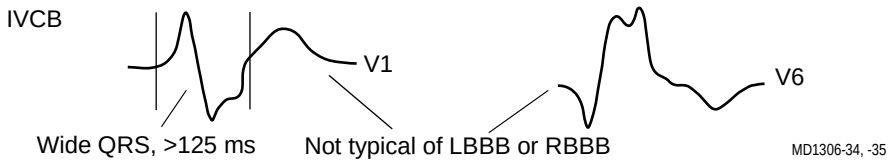




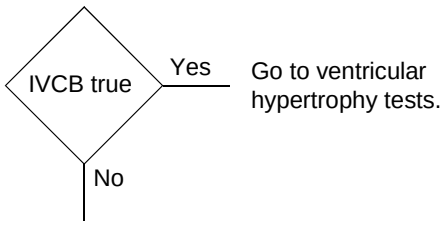
If **LBBB** is true, skip further analysis.



If QRS is wide and not **RBBB** or **LBBB**, state **IVCB**.



If **IVCB** is true, go to ventricular hypertrophy tests. If not true, test for incomplete blocks.

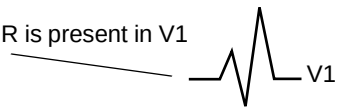


Incomplete Blocks

IRBBB
Same as RBBB, less stringent duration requirement.

ILBBB
Same as LBBB, less stringent duration requirement.

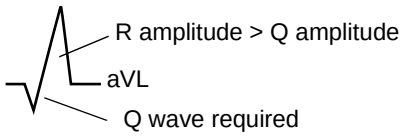
RSR
If not IRBBB and terminal R is present in V1

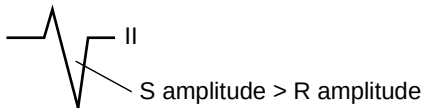


MD1306-36

Hemiblocks

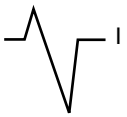
AFB

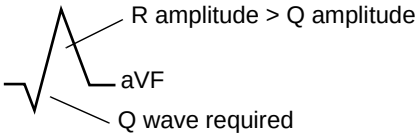




–QRS axis < = -45

PFB



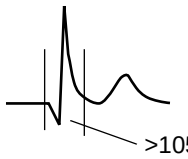


–QRS axis >110 and <180
–age >30 years required
–PULD cannot be true

MD1306-37, -38, -39, -40

If **AFB** is true, suppress **ILBBB** and **LAD**.
If **PFB** is true, suppress **RAD**.
If **RBBB** is also true, append **BIFB**.

IVCD
If no conduction abnormality is stated and QRS duration is greater than 105 ms, state **IVCD**.

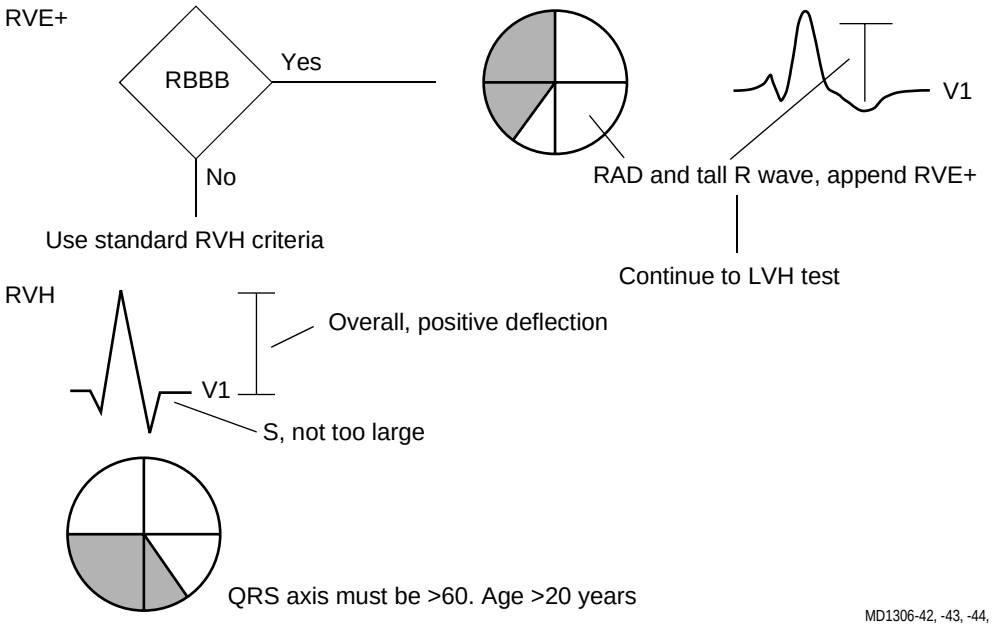


MD1306-41

Ventricular Hypertrophies

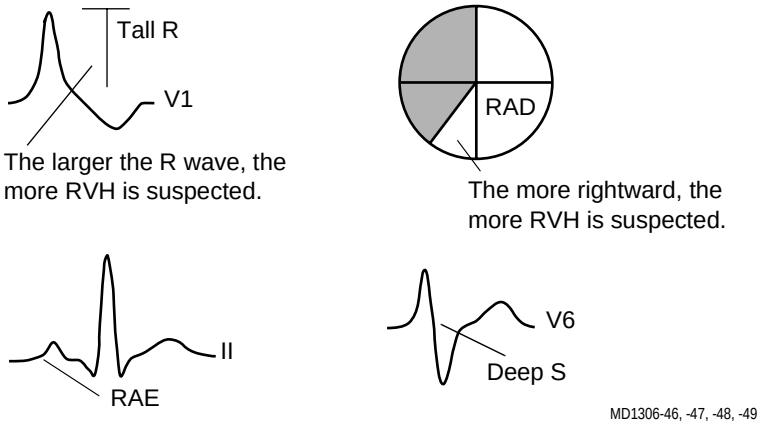
Right Ventricular Hypertrophy

If **RBBB** is true, use a separate set of criteria for **RVH**.



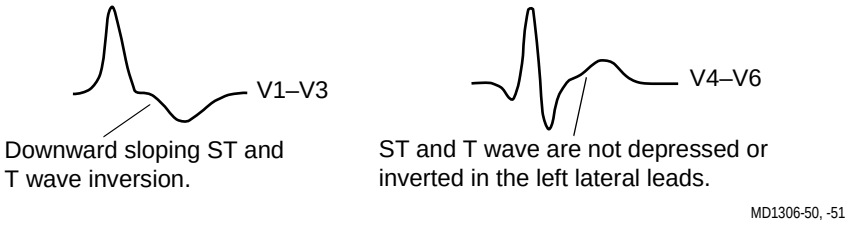
MD1306-42, -43, -44, -45

If these conditions exist, the program looks for other characteristics. If at least a few of these exist, it states **RVH**.



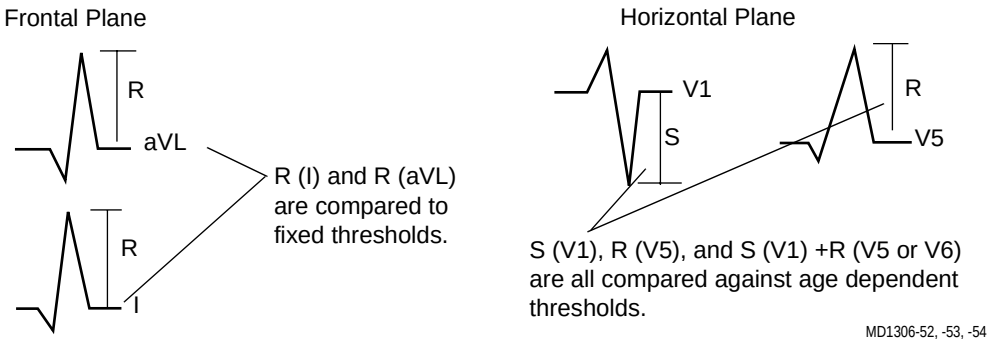
RVH-2ST

If the program finds a repolarization abnormality that is also indicative of RVH, it will upgrade any RVH call to **right ventricular hypertrophy with repolarization abnormality**.



Left Ventricular Hypertrophy

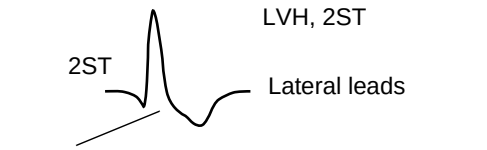
First evaluate voltage.



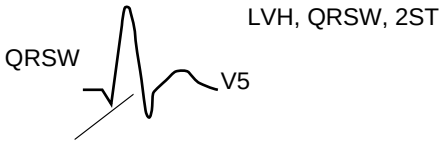
If just over threshold, the program states **minimal voltage criteria for left ventricular hypertrophy, may be normal variant**. Larger voltages, which exceed the thresholds by several hundred microvolts, are defined by the program as **moderate voltage criteria** or **voltage criteria for left ventricular hypertrophy**.

The program states left ventricular hypertrophy without the phase **voltage criteria for** which the program finds additional indications of

hypertrophy, namely: repolarization changes, increased ventricular activation time, or left atrial hyptertrophy.



Depressed, downward sloping ST segment.
If true, append 2ST and upgrade to LVH

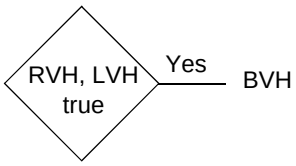


MD1306-55, -56

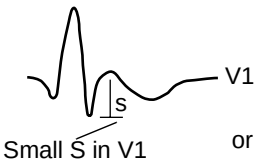
Wide, prolonged activation. If true, append QRSW and upgrade to LVH. Suppress IVCD, IRBBB, ILBBB, and IUVCB.

Biventricular Hypertrophy

If both **RVH** and **LVH** are true, then state **BVH**.

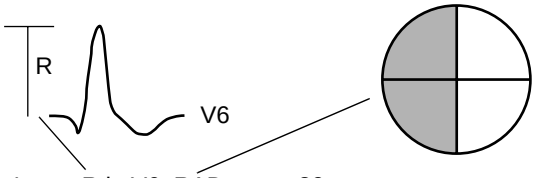


It is also possible to call **BIVH** based upon other tests.



Small S in V1
Large R in V6

or



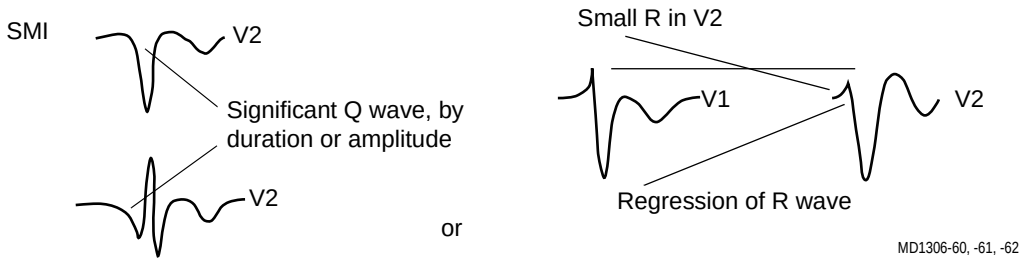
Large R in V6, RAD, age >30 years

MD1306-57, -58, -59

If **BIVH** is stated, the program will not also state **LVH** and/or **RVH**.

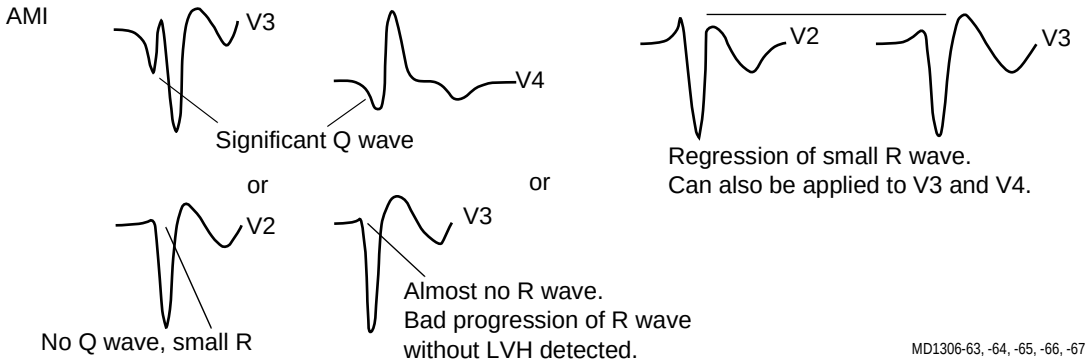
Infarction

Septal Myocardial Infarction



Degree of confidence is based on repolarization. If the ST is elevated, with terminal or complete T wave in version, SMI is stated without qualification, otherwise it is preceded by **cannot rule out**.

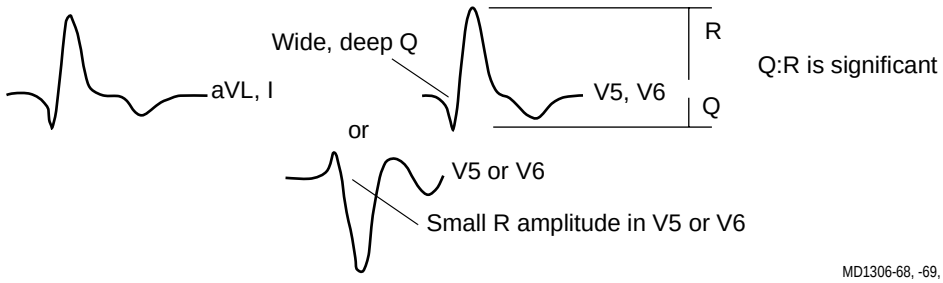
Anterior Myocardial Infarction



Narrow and shallow Q waves will be qualified as **cannot rule out** or **possible**.

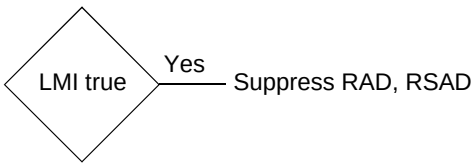
Lateral Myocardial Infarction

LMI
At least two lateral leads have wide and deep Q waves that have significant Q:R ratios.

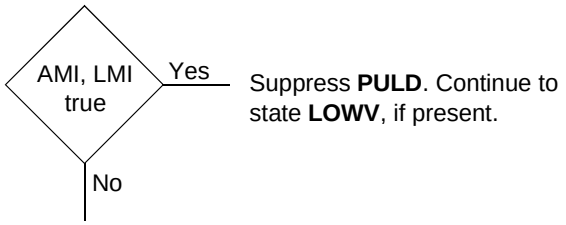


If the criteria detected significant Q waves, it states an unqualified **LMI**, otherwise it would prefix **possible**.

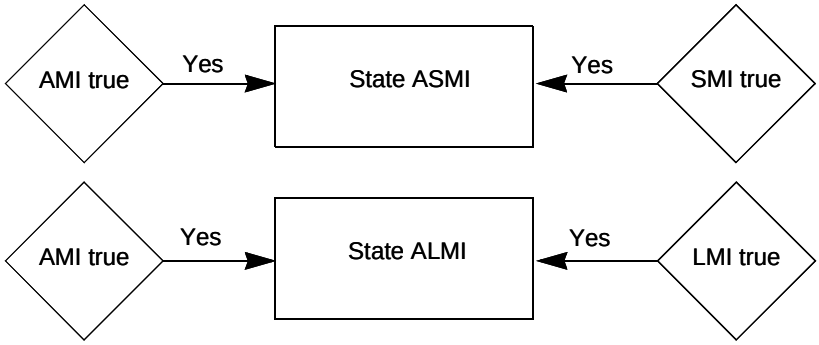
If **LMI** is true, suppress statements concerning right axis deviation (**RAD**, **RSAD**).



If **AMI** or **LMI** is true, the program will suppress **PULD**.

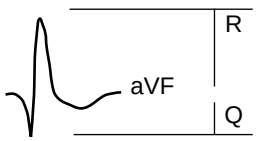


At this point the program will issue conjunctions of the different MIs it detected in the horizontal plane. For example:



Inferior Myocardial Infarction

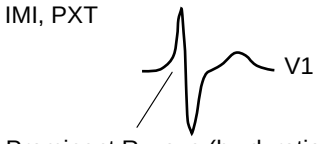
Acronym: **IMI**
Significant Q:R ratio is the main component of this test.



MD1306-71

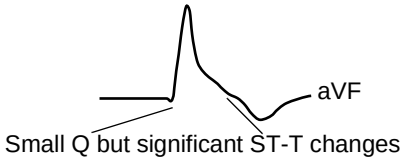
The significance of the Q:R ratio is evaluated in conjunction with other parameters, namely: Q amplitude, Q duration, QRS axis, and presence of Q in lead II.

If the **IMI** is true, then inspect posterior involvement.



MD1306-72

The qualification of the infarct is based upon the QRS and repolarization. Small Qs in aVF will be qualified as **cannot rule out** or **possible** unless there are ST-T changes commensurate with infarction.

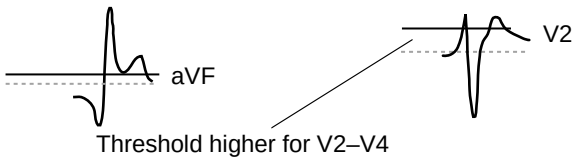


MD1306-73

ST Elevation Abnormalities

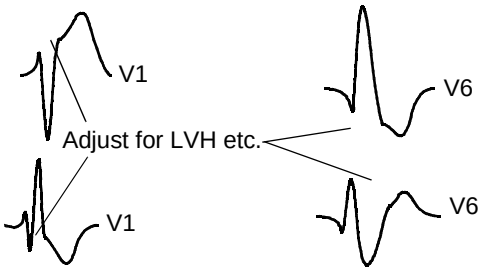
Epicardial Injury

All leads are inspected for ST elevation. Anteroseptal leads are tested with a higher threshold than the other leads.



M15264-52, -53

The thresholds are also adjusted for repolarization abnormalities that can occur with **LVH** and/or conduction abnormalities.

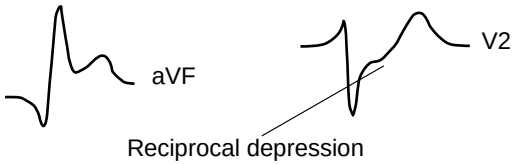


M15264-54, -55, -56, -57

If any lead is over threshold, the program then applies several additional tests. As the ST:T ratio gets larger, the program considers the character of the **STT** to be more like injury.

M15264-58, -59

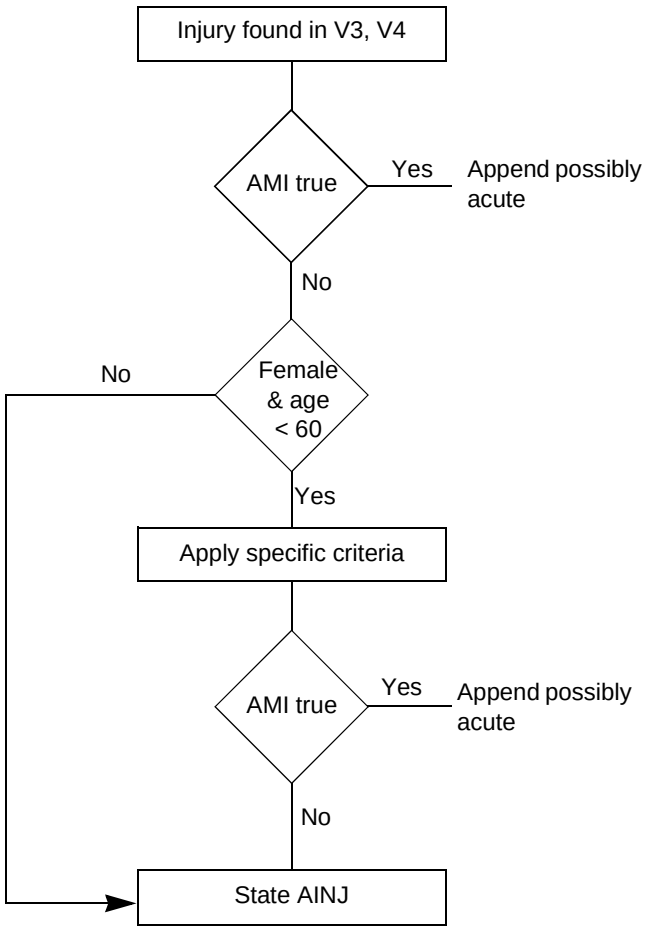
All of the leads are analyzed for reciprocal depression. If it is present, the ST elevation is considered to be more like injury.



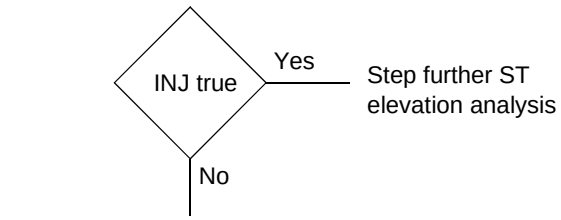
MD1306-74, -75

These three items: degree of ST elevation, ST:T ratio, and reciprocal changes are used for stating injury.

Injury is stated for those lead groups where it is most pronounced. if an MI has already been cited for that lead group, then the program does not state injury, it qualifies the MI as acute.



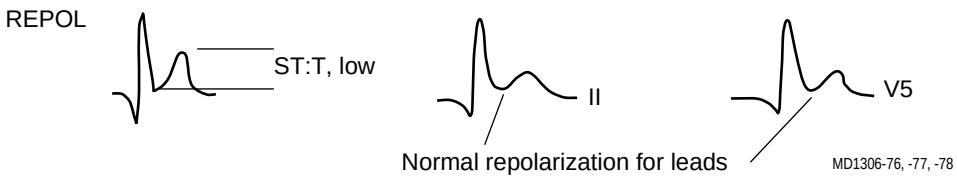
If injury has been stated, do no further analysis of ST elevation abnormalities.



The program has three choices:
(1) pericarditis,
(2) early repolarization, or
(3) unknown origin.

Early Repolarization

Early repolarization is stated if the ST:T ratio is low and the repolarization character appears normal (that is, T waves are upright in appropriate leads and ST aligned with T).



Acute Pericarditis

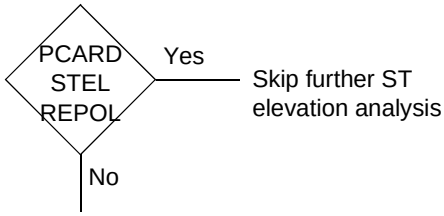
Pericarditis has similar criteria to early repolarization except more ST elevation is required.

ST Elevation, Mechanism Unknown

If pericarditis or early repolarization cannot be stated, the program identifies the ST elevation and suggests the three aforementioned mechanisms.

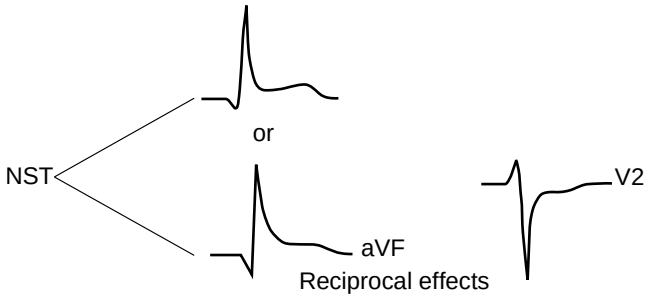
Acronym: **STEL**
ST elevation, consider early repolarization, pericarditis, or injury

If **PCARD**, **REPOL**, or **STEL** is stated, skip further ST elevation analysis.



Nonspecific ST Abnormalities

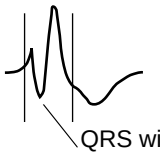
Nonspecific ST elevation abnormality is detected using the same methods as outlined above. The difference is that the threshold for elevation is twice as sensitive. Furthermore, the program only states the elevation as a nonspecific abnormality if it has characteristics that meet the criteria outlined for injury.



MD1306-79, -80, -81

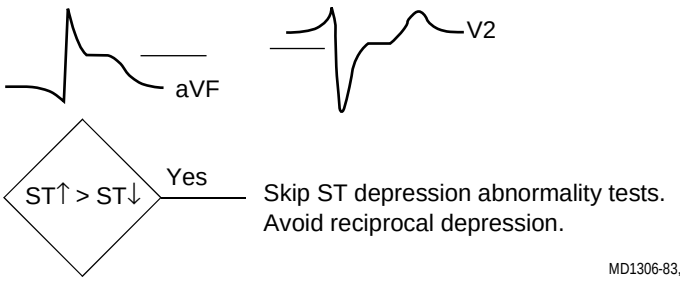
ST Depression Abnormalities

If the QRS is wide, do not test for ST depression abnormalities.



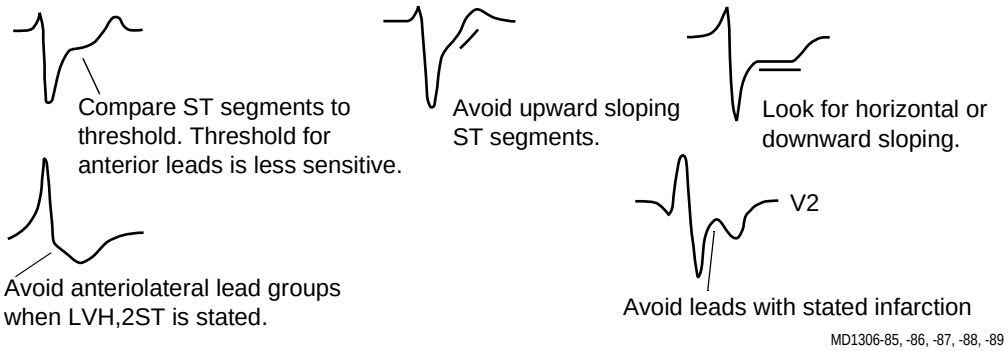
MD1306-82

If injury has been called and the ST elevation is larger than the depression, do not test for any ST depression abnormality.

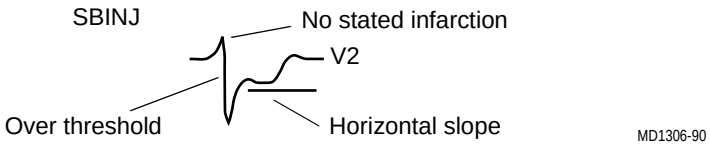


MD1306-83, -84

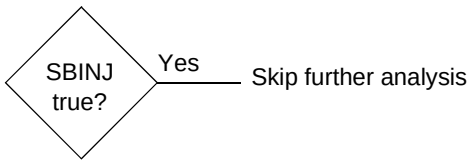
Subendocardial Injury



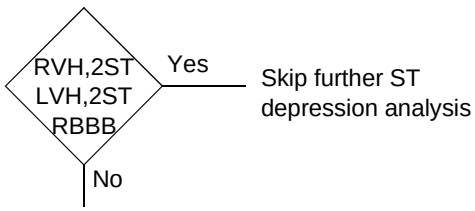
If all of these items are true, call **subendocardial injury**.



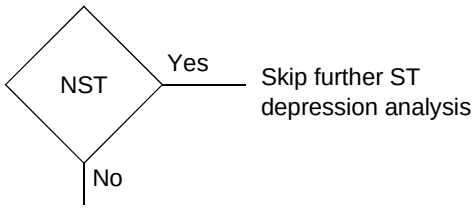
If subendocardial injury is true, skip further analysis.



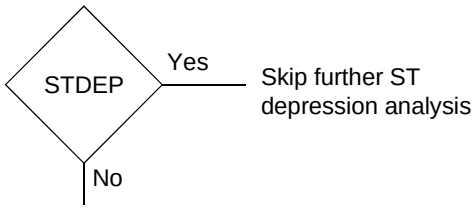
If any repolarization abnormality has been stated, in association with hypertrophy, do no further ST depression analysis. Also, avoid RBBB.



If a nonspecific ST elevation abnormality has already been found from ST elevation, test ST depression analysis.

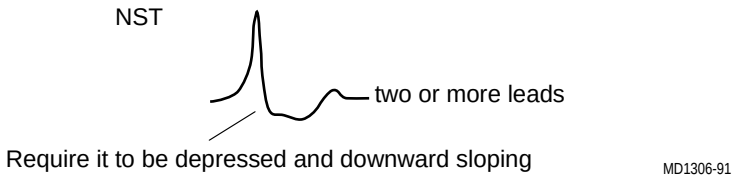


Now analyze ST segments as was done for **SUBNJ**, only with more sensitivity. If true, state **ST depression, consider subendocardial injury or digitalis effect** (**STDEP**). Also skip further ST depression analysis.

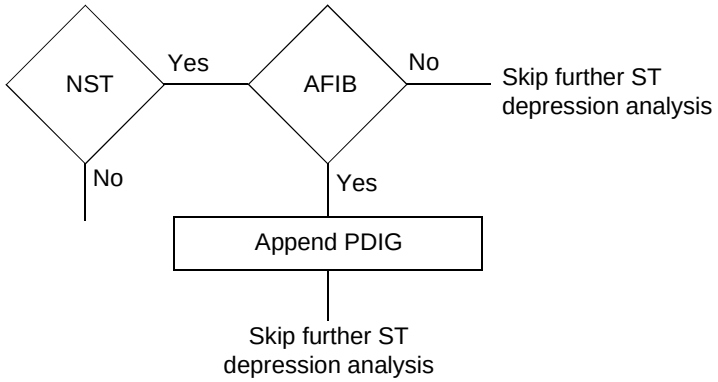


Nonspecific ST Abnormality

Again, analyze the ST segment with even more sensitivity.

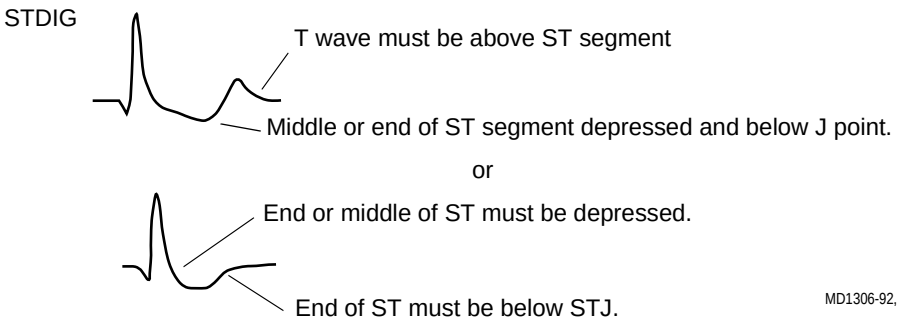


If this occurs in at least two leads, state **NST**. If **AFIB** is present, append **PRDIG**.

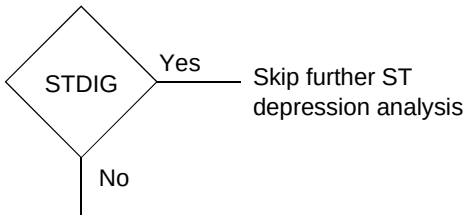


Digitalis Effect

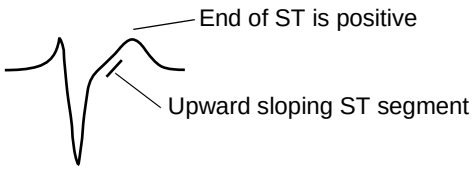
Now inspect for digitalis effect.



If digitalis is stated, do no further ST depression analysis

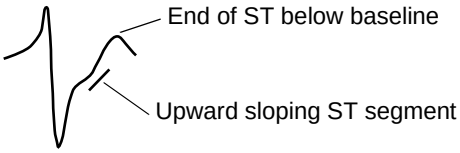


Junctional ST Depression



MD1306-94

If true, state: **Junctional ST depression, probably normal**.



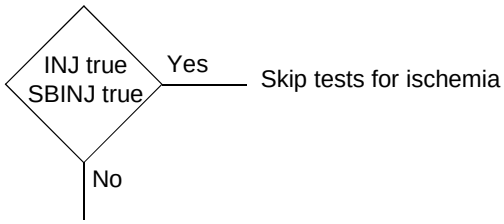
MD1306-95

If true, state: **Junctional ST depression, probably abnormal**.

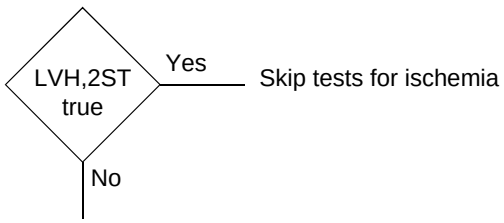
T Wave Abnormalities

Ischemia

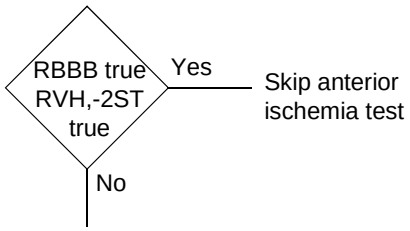
If any injury statement has been made, do not test for ischemia.



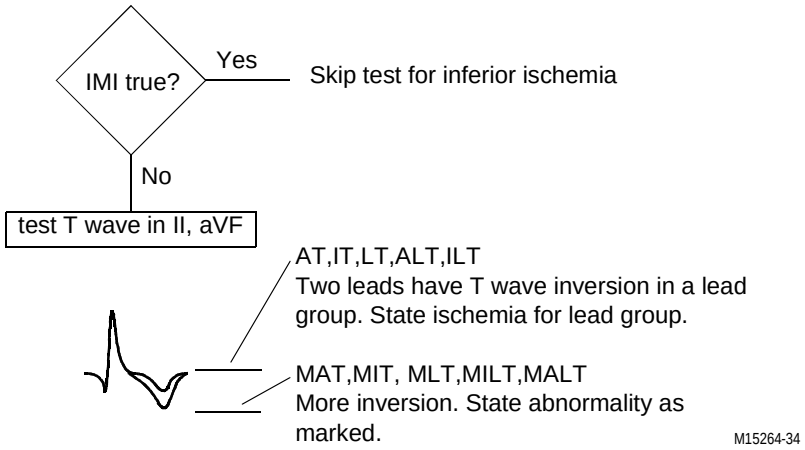
Likewise, if **LVH with repolarization abnormality** is stated, do not test for ischemia.



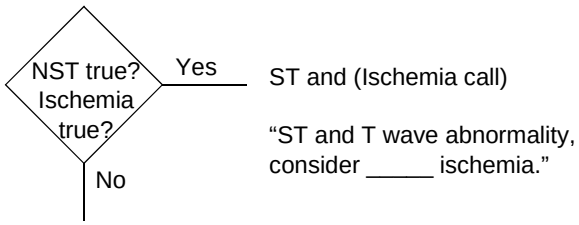
Additional restrictions are applied to anterior leads in order to avoid calling anterior ischemia in the presence of **RBBB** or **RVH,-2ST**.



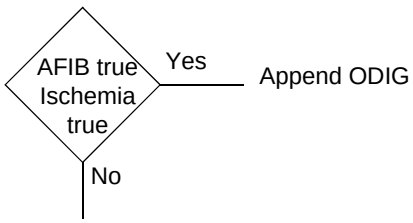
T wave abnormalities are also not tested in lead groups where infarction is stated.



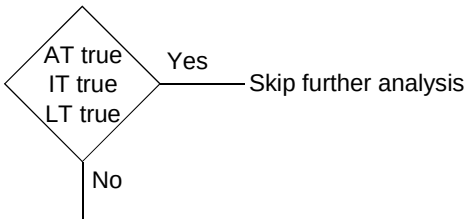
If ischemia is stated and a nonspecific ST abnormality was previously detected, make one statement as opposed to two.



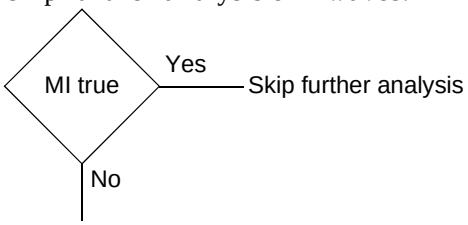
If atrial fibrillation is present, append **or digitalis effect**.



If ischemia is called, skip further analysis of T waves.

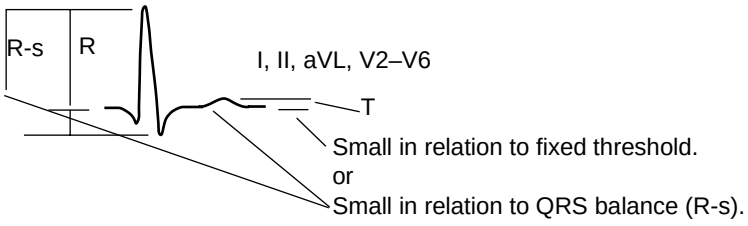


If infarction is present, skip further analysis of T waves.



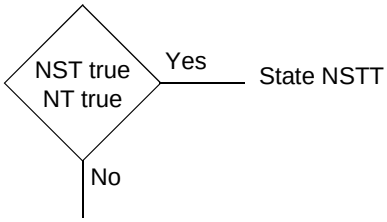
Nonspecific T Wave Abnormality

Acronym: **NT**
Small T waves or shallow T wave inversion are found in at least two leads.

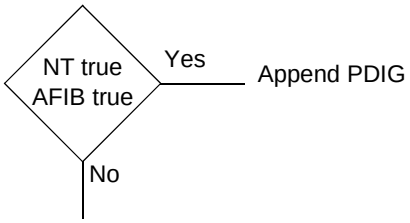


MD1306-96

If a nonspecific ST abnormality is found in conjunction with NT, then make one statement as opposed to two.



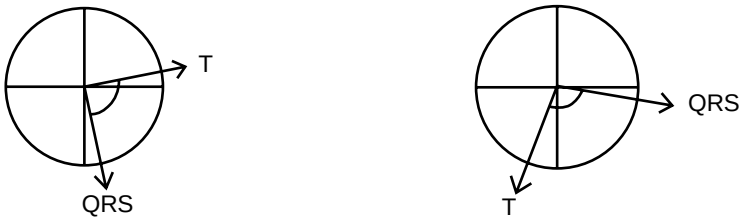
If atrial fibrillation is present, append **probably digitalis effect**.



Abnormal QRS-T Angle

Acronym: **AQRST**

Do not test for abnormal QRS-T angle if any other T wave abnormality has already been stated.

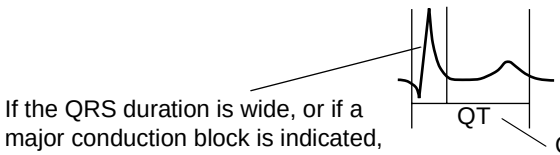


Abnormal T axis
and
Abnormally large QRS-T angle

MD1306-97, -98

Prolonged QT

QT interval is corrected for rate using Bazett's formula. (See "Onsets/ Offsets and Intervals" on page 3-11 for more information about Bazett's formula.) As the ventricular rate increases, the corrected QT increases.



If the QRS duration is wide, or if a major conduction block is indicated, skip prolonged QT analysis

QT interval is measured across all 12 leads from earliest onset to latest offset.

LNGQT

If QTc >460 ms and rate <100 bpm, stage LNGQT.

MD1306-99

Details

Suspect Arm Lead Electrode Reversal

Stop test if ventricular pacemaker.
Statement is made if:

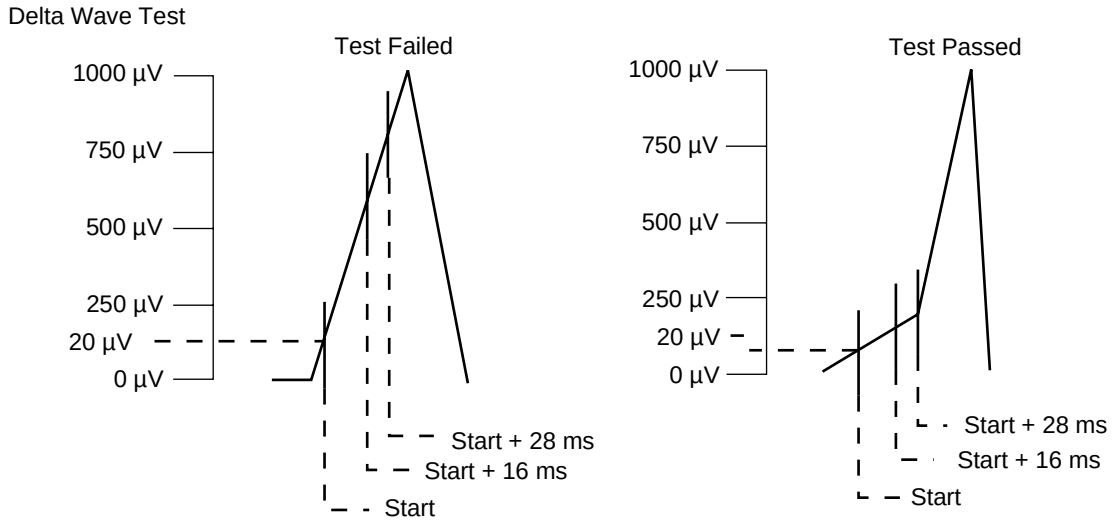
either		QRS axis is between 90 and 270 degrees
	and	P axis is between 90 and 210 degrees
or		QRS axis is between 130 and 270 degrees
	and	P axis is not measurable
	and	Q amplitude >R amplitude in lead I

Then say **suspect arm lead reversal**

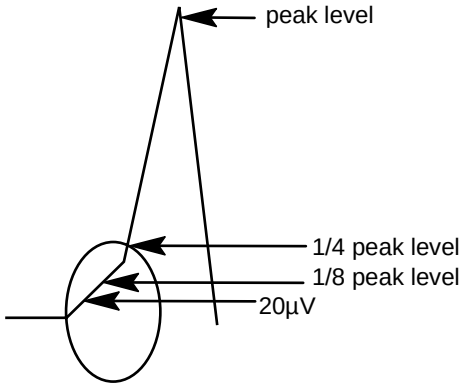
WPW

Skip test WPW if:

	Atrial flutter or atrial fibrillation is present
or	No P wave is present



Key Delta Wave Durations



Key Delta Wave Amplitudes

MD1306-100, -101, -102

Statement is made if:

		Delta wave is present in three or more of 12 leads
and		PR interval is not = 0
and		P axis is >-30 degrees and <120 degrees
and		P amplitude + P' amplitude in lead aVF >–50 µV
and	either	QRS area is positive in lead V1 and PR interval ≤180 ms
	or	QRS area is positive in lead V2 and PR interval ≤160 ms
	or	QRS area is negative in lead V1 and PR interval ≤140 ms

If QRS area is positive (R amplitude >80% of the total deflection) in lead V1, then say: **Ventricular pre-excitation, WPW pattern type A**

If QRS area is negative (S amplitude >80% of the total deflection) in lead V1, then say: **Ventricular pre-excitation, WPW pattern type B**

If not, say: **Wolff-Parkinson-White**

If test **WPW** passed, then suppress **with short PR**.

Atrial Enlargement

Skip all atrial enlargement tests if:

	Test **WPW** passed
or	Ventricular rate >150 bpm
or	PR interval = 0
or	No sinus rhythm or atrial pacemaker present
or	P axis is <0 degrees or >100 degrees

Right Atrial Enlargement

Statement is made if:

P wave amplitude >250 µV in any lead: II, III, aVF, V1, or V2

Then say **right atrial enlargement**

Left Atrial Enlargement

Statement is made if in lead V1 or V2, P or P':
Amplitude <-100 µV
and Duration ≥60 ms
and Amplitude area ≥4000 µV times ms (one small box)

Then say: **possible left atrial enlargement***

If test for possible LAE passed
and P or P' amplitude <-200 µV in lead V1 or V2

Then say **left atrial enlargement**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Biatrial Enlargement

Statement is made if:
Test left atrial enlargement passed
and Test right atrial enlargement passed

Then say **biatrial enlargement**

Frontal Plane Axis Deviation

Skip all frontal plane axis deviation tests if:
Test **WPW** passed

Left Axis Deviation

Statement is made if:
QRS axis between -30 and -89 degrees

Then say **left axis deviation**

Right Axis Deviation

Statement is made if:
QRS axis between 90 and 109 degrees

Then say **rightward axis***

If:
QRS axis between 110 and 180 degrees

Then say **right axis deviation** *

If:
QRS axis between 181 and 269 degrees

Then say **right superior axis deviation** *

* These statements will not appear if screening criteria is turned on. See Appendix F for more information.

Indetermined Axis

Statement is made if:
R amplitude minus S amplitude ≤50 µV or ≤10% of the total QRS deflection in leads I, II, and III

Then say **indeterminate axis**

Low Voltage and Lung Disease

Skip test low voltage and lung disease if:
Test WPW passed
or QRS duration >120 ms

Low Voltage

Statement is made if:
QRS deflection <1000 µV in all leads
or QRS deflection <500 µV in all frontal leads
Then say **low voltage QRS**

Pulmonary Disease

Statement is made by point scoring technique

	Test S1, S2, and S3 pattern used		1 point
	Test passed if:		
		R amplitude < (4 x S amplitude) in any two of leads I, II, and III	
	and	S amplitude >200 µV with no R' in leads I, II, and III	
	and	No R' wave is present in leads I, II, and III	
or		S amplitude >200 µV in leads I, II, and III	
	and	No R' wave present in leads I, II, and III	
	and	S amplitude in lead I >300 µV	
	and	S amplitude in lead II >400 µV	
	and	S amplitude in lead III >700 µV	
	QRS deflection <500 µV in all frontal leads		1 point
	P axis >80 degrees and <270 degrees		1 point
	QRS axis ≤–30 or >90 degrees or indetermined axis passed		1 point
	R amplitude in lead V5 <S amplitude in lead V5		
or	R amplitude in lead V6 <S amplitude in lead V6		1 point

If cumulative points are ≥3 points, then say **pulmonary disease pattern***

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Conduction Defects

Skip all tests for conduction defect if:
Test **WPW** passed

RSR' or QR Pattern

Statement is made if in lead V1:
either Q wave is >0 ms
and R wave amplitude >20 ms
R wave amplitude -STJ >200 µV
and No S wave is present
or R' wave duration >20 ms
and R' wave amplitude -STJ >200 µV
and No S' wave is present

Then say **RSR' or QR pattern in V1 suggests possible right**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Incomplete Right Bundle Branch Block

Statement is made if:
QRS duration is between 91 and 120 ms
and S wave duration >40 ms in any two of leads I, aVL, V4, V5, and V6
and In lead V1 or V2
either R wave duration $\geq$30 ms
and R wave amplitude >100 µV
No S wave is present
or R' wave duration $\geq$30 ms
and R' wave amplitude >100 µV
and No S' wave is present

Then say **incomplete right bundle branch block***

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Incomplete Right Bundle Plus Right Ventricular Hypertrophy

Statement is made if:

Test for **IRBBB** passed and
and R or R' amplitude >1000 µV in lead V1
and QRS axis >110 degrees

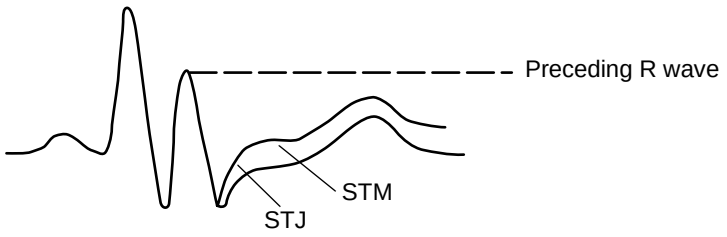
Then say **incomplete right bundle branch block plus right ventricular hypertrophy**
and Suppress **RVH**

Right Bundle Branch Block

Statement is made if:

Test 1:

QRS duration ≥120 ms
and In any two of leads I, aVL, V4, V5, and V6, S wave duration >40 ms
and QRS area in lead V1 is positive
and either No terminal S wave is present in lead V1
or S amplitude + minimum STJ or STM <100 µV and <R amplitude in lead V1
or S amplitude + minimum STJ or STM-to-R amplitude ratio <30% in lead V1
or S amplitude + minimum STJ or STM-to-R amplitude ratio <50% in lead V1
and either QRS >130 ms
or QRS axis <100 degrees



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or, if

Test 2:

QRS duration ≥108 ms
and QRS area is positive in lead V1
and R or R' duration >60 ms in lead V1
and In any three of leads I, aVL, V4, V5, and V6: S wave duration >60 ms

or, if

Test 3:

QRS duration >130 ms
and QRS area is positive in lead V2
and In two or more of leads I, aVL, V4, V5, and V6: S duration >40 ms
and R or R' wave present in lead V1 and no terminal S wave

Then say **right bundle branch block**

If test **RBBB** passed, then suppress all right axis deviation.

RBBB Plus Right Ventricular Hypertrophy

Statement is made if:

Test right bundle branch block passed
and either R or R' amplitude >1500 µV in lead V1
and QRS axis >110 degrees

Then say **right bundle branch block, plus right ventricular hypertrophy** *
and suppress **right ventricular hypertrophy**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Incomplete Left Bundle Branch Block

Statement is made if:

QRS duration $\geq$105 and $\leq$120 ms
and In leads V1 and V2, QRS amplitude is negative
and In leads V1 and V2, Q or S wave duration $\geq$80 ms
and In any two of leads I, V5, and V6, no Q wave is present
and In any two of leads I, aVL, V5, and V6, R duration >60 ms

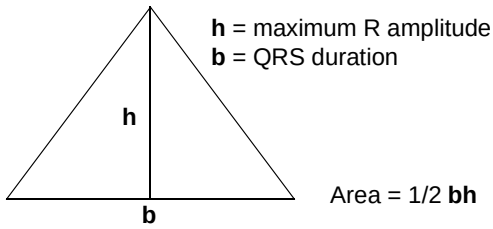
Then say **incomplete left bundle branch block**

Left Bundle Branch Block

Statement is made if:

QRS duration > 120 ms

and QRS area >1/4 of (QRS duration x maximum R amplitude) in lead I or V6. That is, the area of lead I or V6 is at least half the area of a right triangle with height **h** and base **b**.



and QRS balance is negative in leads V1 and V2

and In leads V1 and V2, Q or S duration ≥80 ms

and In any two of leads I, V5, and V6, no Q wave is present

and In any one of lead I, V5, or V6, R duration + R' duration ≥100 ms

and either QRS duration ≥160 ms

or QRS duration ≥140 ms

and Over leads I, aVL, and V6, the sum of R duration and R' duration totals >240 ms

or QRS duration >120 ms

and Over leads I, aVL, and V6, the sum of R duration and R' duration totals >240 ms

and QRS area >1/2.5 times (QRS duration x maximum R wave amplitude) in any two of leads I, aVL, and V6

Then say **left bundle branch block**

If test **LBBB** passed, then suppress **left anterior fascicular block** and **left posterior fascicular block**.

* If **LBBB** not stated, but QRS balance is negative in lead V1, QRS duration >140 ms, and **RBBB** test did not pass, then remember this ECG has passed as complete **LBBB** for internal logic purposes. This is not printed on the analysis report, but the ECG will be treated as complete **LBBB** in the analysis program logic.

Left Anterior Fascicular Block

Statement is made if:

QRS axis is <-45 degrees and no indeterminate axis present
and R amplitude >Q amplitude in leads I and aVL
and Any Q wave is present in lead I
and either S or S' is of greater amplitude than both R and R' in lead II

Then say **left anterior fascicular block**

If test **left anterior fascicular block** passed, then suppress all **left axis deviation** and **ILBBB**.

Left Posterior Fascicular Block

Statement is made if age >30 years:
and Test S1, S2, and S3 pattern failed
and Test pulmonary disease failed
and QRS axis between 110 and 180 degrees
and Indetermined axis not present
and R amplitude >Q amplitude in leads III and aVF
and Any Q wave is present in leads III and aVF

Then say **left posterior fascicular block**

If test **left posterior fascicular block** passed, then suppress all right axis deviation.

Bifascicular Block

Statement is made if:

Test **RBBB** passed
and Test left anterior fascicular block passed
or Test **RBBB** passed
and Test left posterior fascicular block passed

Then say **bifascicular block**

Nonspecific Intraventricular Conduction Delay

Statement is made if:
QRS duration is ≥118 ms and ≤124 ms
and Tests **RBBB** and complete **LBBB** failed
and Tests **IRBBB**, **ILBBB**, fascicular blocks, and **RSR** failed

Then say **nonspecific intraventricular conduction delay** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Nonspecific Intraventricular Conduction Block

Statement is made if:
QRS duration ≥125 ms
and Test **RBBB** and **LBBB** failed

Then say **nonspecific intraventricular conduction block**

If test nonspecific intraventricular conduction block passed, then suppress **left anterior fascicular block**, **left posterior fascicular block**, and **RSR** or **QR pattern**.

Ventricular Hypertrophy

Right Ventricular Hypertrophy

Skip test right ventricular hypertrophy if:

	Test **WPW** passed	
or	Test **RBBB** passed	
or	QRS is negative in lead V1	
or	S amplitude >1000 µV in lead V1	
or	QRS axis <60 degrees	

Statement is made by point scoring technique:

either	R or R' amplitude >500 µV in lead V1	
	Add one point for every 500 µV increment up to 1500 µV	1 point
	QRS amplitude is negative and S amplitude >500 µV in lead V5 or V6	1 point
	QRS amplitude is negative and S amplitude >500 µV in lead V5 or V6	1 point
	QRS amplitude is negative and S amplitude >500 µV in lead V5 or V6	1 point
	Test **right atrial enlargement** passed	1 point
	Patient is ≥30 years old	1 point
	Add one point for every 10 degrees increment up to maximum of 110 degrees	1 point
	Test S1, S2, and S3 pattern passed	1 point

If cumulative **RVH** points are ≥ 3 points, then say **possible right ventricular hypertrophy** *

If cumulative RVH points are ≥ 5 points, then say **right ventricular hypertrophy**

Suppress **RAD**, **LPFB**, **LOWV**, **RSR**, and **IVCD**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

RVH with Repolarization Abnormality

Statement is made if:

Test possible **RVH** passed
and QRS duration ≤120 ms
and In all leads V1, V2, and V3
either STJ > STM or STJ > STE
or STM or STE or T amplitude ≤-100 µV
and In no more than one lead of leads V4, V5, and V6
STM or STE or T amplitude <-100 µV

Then say **right ventricular hypertrophy with repolarization abnormality**

Left Ventricular Hypertrophy

Skip test if:

Test **WPW** passed
or **LBBB** was stated

Statement is made by point scoring technique.

Some amplitude indices are based on the patient's age. All values are in µV. A value of XXX indicates that any test using that index will not pass.

Table 2. Patient's Age

Index	under 20	20 to 29	30 to 39	over 39
Lead V1	XXX	3000	2400	2400
Lead V5	XXX	3000	2600	2600
Lead (V1/V5, and V6)	XXX	4500	4000	3500

Test for any age if:

R or R' amplitude >1100 µV in lead aVL	1 point
Add one point per 100 µV excess	

Test for specific age:

S or S' > (lead V1 index) in lead V1	1 point
Add one point per 200 µV excess	
R or R' amplitude > (lead V5 index) in lead V5	1 point
Add one point per 200 µV excess	
The greater of S and S' amplitude in lead V1 + the greater of R and R' amplitude in lead V5 or V6 > (leads V1/V5, and V6 index)	1 point
Add one point per 300 µV excess	

If cumulative **LVH** points ≥ 1, then suppress **low voltage**

If cumulative LVH points ≥ 1, say **minimal voltage criteria for LVH, may be normal variant** *

If cumulative LVH points are ≥ 3, then say **moderate voltage criteria for LVH, may be normal variant** *

If cumulative LVH points are ≥ 5, then say **voltage criteria for left ventricular hypertrophy**

If cumulative **LVH** points are ≥ 1 and **left atrial enlargement** passes, then say **left ventricular hypertrophy**

Skip tests with QRS widening and with repolarization abnormality if **LVH** points are 0.

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

With QRS Widening

Statement is made if:

Cumulative **LVH** points ≥ 1

and QRS duration ≥ 115 ms

Then say **left ventricular hypertrophy with QRS widening**

If test **QRS widening** passed, then suppress **IRBBB**, **IVCD**, **IVCB**, and **ILBBB**.

With Repolarization Abnormality

Statement is made if any of leads I, aVL, V4, V5, or V6 have:
STJ > STM or STJ > STE
and STE <-50 µV
and R amplitude ≥1100 µV
and Test **atrial fibrillation** failed
and LVH point logic ≥1

Then say **LVH with repolarization abnormality**

LVH with QRS Widening and Repolarization Abnormality

Statement is made if:
Test QRS widening test and repolarization abnormality passed

Then say **LVH with QRS widening and repolarization abnormality**

Biventricular Hypertrophy

Skip test of **biventricular hypertrophy** if:
Test **WPW** passed
or If test **RBBB** passed

Statement is made if:
Test **RVH** passed and cumulative **LVH** points were ≥1
or Patient's age ≥30 years
and QRS axis ≥90 degrees
and R or R' amplitude ≥2600 µV in lead V5 or V6
or Q, S, and S' amplitudes <500 µV in lead V1
and R or R' amplitude >2600 µV in lead V6
Then say **biventricular hypertrophy**

Suppress all **LVH** and **RVH** statements

If test QRS widening passed, then append **with QRS widening**

If test repolarization passed, then append **with repolarization abnormality**

If test QRS widening and test repolarization passed, then say **with QRS widening and repolarization abnormality**

Infarction

Anterior Infarction Tests

Skip tests if WPW passed or LBBB stated:

Test 1

Q duration in lead V3 >30 ms and Q amplitude is ≥75 µV

Test 2

Q duration in lead V4 >Q threshold duration and
Q amplitude ≥75 µV

Establish Q duration threshold via the following criteria:

If QRS duration <120 ms

and R amplitude in lead V4 >1200 µV, then for every 100 µV over 1200 µV (from lead V4 R amplitude) add 1 ms to the default lead V4 Q duration of 30 ms up to maximum of 40 ms

or If QRS duration ≥120 ms

and If R amplitude in lead V4 >800 µV, then Q duration threshold in lead V4 = 35 ms

and If RS in lead V1 is present

and R duration in lead V1 >35 ms, then lead V4 duration threshold = R duration in lead V1 + 3 ms up to a maximum of 45 ms

Test 3

Q amplitude in lead V3 ≥100 µV

and QRS balance is negative in lead V3

Test 4

Q amplitude in lead V4 ≥100 µV

and QRS balance is negative in lead V4

Test 5

Q duration in leads V2 and V3 >20 ms

and Q amplitude in leads V2 and V3 >200 µV

Skip tests 6 and 7 if the QRS deflection (maximum R amplitude + maximum S amplitude) in lead V3 ≤50 µV.

Test 6

LVH is not passed and balance in leads V1 and V2 is negative

and Maximum R or R' in lead V3 <200 µV

and Maximum R amplitude in lead V3 + 25 µV ≤R amplitude in lead V2

and Q + R + S duration in lead V3 ≤50 ms

or LVH not passed and balance in leads V1 and V2 is negative

and R amplitude in lead V3 <200 µV

and R amplitude in lead V3 + 25 µV ≤R in lead V2
and Q + R + S duration in lead V3 ≥50 ms

Test 7

LVH is not passed and QRS duration ≤120 ms and Q amplitude in lead V2 is 0 µV
and Maximum R or R' amplitude in lead V3 <100 µV
and Q + R + S duration in lead V3 ≤50 ms
or **LVH** does not pass and QRS duration ≤120 ms and Q amplitude in lead V2 is 0 µV
and R amplitude in lead V3 <100 µV
and Q + R + S duration in lead V3 ≥50 ms

SKIP TEST 8 IF THE QRS DEFLECTION (maximum R amplitude + maximum S amplitude) in lead V4 <50 µV.

Test 8

Q + R + S duration ≤50 ms
and No **LVH** passed
and QRS balance in leads V1 and V2 is negative.
and Maximum R amplitude in lead V4 + 25 µV ≤R amplitude in lead V3
or Q + R + S duration in lead V4 ≥50 ms
and R amplitude in lead V4 <200 µV
and R amplitude in lead V4 + 25 µV ≤R amplitude in lead V3
and No **LVH** passed
and Balance in leads V1 and V2 is negative

Cannot Rule Out Anterior Infarction

If any **AMI** tests passed, then say **cannot rule out anterior infarction***

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Possible Anterior Infarction

Statement is made if:
Any of **AMI** tests passed
and Low voltage did not pass and IVCB did not pass
and In lead V3 the R duration <30 ms, the Q duration = 0 ms, and the S duration >40 ms or In lead V3 the Q duration >30 ms
and In lead V4 the R duration <45 ms, the Q duration = 0 ms, and the S duration >40 ms or In lead V4 the Q duration >35 ms
or In lead V3 the R duration <20 ms, S duration >40 ms, and Q duration = 0 ms

or In lead V3 the Q duration >35 ms
or In lead V4 the R duration <25 ms, S duration >40 ms, and Q duration = 0 ms
or In lead V4 the Q duration >40 ms

Then say **possible anterior infarction** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Anterior Infarction

Statement is made if:
Any of **AMI** tests passed
and No low voltage passed and no **IVCB** passed
and In lead V3 the R duration ≤25 ms, the Q duration = 0 ms, and the S duration >40 ms, or
In lead V3 the Q duration >30 ms
and In lead V4 the R duration ≤30 ms, the Q duration = 0 ms, and the S duration >40 ms, or
In lead V4 the Q duration >40 ms
or In lead V3 the R duration <15 ms, S duration >40 ms, and Q duration = 0 ms
or In lead V3 the Q duration >40 ms
or In lead V4 the R duration <20 ms, S duration >40 ms, and Q duration = 0 ms
or In lead V4 the Q duration >50 ms
or Any anterior injury test passed or the special T amplitude in lead V3 <-150 µV

Then say **anterior infarction**

If **LBBB** statement not stated, QRS duration >145 ms, QRS balance in lead V1 is negative, and **RBBB** is not stated:
and In any leads V1 through V6, the QRS balance is positive and Q duration >30 ms, Q amplitude >100 µV, and any anterior infarction test 1 through 5 passed

Then If "possible anterior infarction" test passed, then state **possible anterior infarction**

or If **anterior infarction** passed, then state **anterior infarction**

Determine age of infarct:
If anterior injury is present

Then append **, possibly acute**

Otherwise append **, age undetermined**

Septal Infarction Tests

Skip septal infarction tests if:
Test **WPW** passed
or Tests complete LBBB passed

Test 1
QR is present in lead V1
and Q duration in lead V2 ≥30 µV

Test 2
Q duration ≥30 ms in lead V2

Test 3
Q amplitude ≥100 µV in lead V2
and QRS balance is negative in lead V2 or test **RBBB** passed

Test 4
If no Q present in lead V1, test if R amplitude in lead V2 <R amplitude in lead V1 by more than 50 µV, R amplitude in lead V2 ≤200 µV, **AMI** did not pass, and QRS deflection in lead V2 >50 µV

Cannot Rule Out Septal Infarct

Statement is made if:
Any **SMI** test passed

Then say **cannot rule out septal infarct***

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Septal Infarct

Statement is made if:
Any **SMI** test passed
and either STM >50 µV and T and T' are negative in lead V2
or Test **IVCB** failed and **LVH** is not present

Then say **septal infarct**

Determine age of infarct:
If anterior injury present

Then append **, possibly acute**

Otherwise append **, age undetermined**

Possible Lateral Infarct

If **WPW**, then skip all tests for lateral infarct.

Test 1

		If AMI tests 1, 2, 3, 4, and 5 did not pass	
and		In lead V5 the Q + R + S duration ≤50 ms and QRS deflection >50 µV and maximum R or R' amplitude in lead V5 <100 µV	
	or	In lead V5 the Q + R + S duration >50 ms and R amplitude <100 µV	2 points

Test 2

	In lead V6 if maximum R or R' amplitude <100 µV and Q + R + S duration ≤50 ms and QRS deflection >50 µV	
or	In lead V6 if Q + R + S duration >50 ms and R amplitude <100 µV	2 points

Test 3

Test for the following conditions in leads I, V5, V6, and aVL, 1 point each lead

Q duration >25 ms	
Q amplitude >75 µV	
5 times Q amplitude >R amplitude: when lead V5 or V6	
4 times Q amplitude >R amplitude: when lead I or aVL	1 point

If cumulative point value >2 points, then say **possible lateral infarct***

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Lateral Infarct

Statement is made if in two or more of leads I, aVL, V5, and V6:

		Q duration >30 ms
	and	Q amplitude >75 µV
	and	5 times Q amplitude >R amplitude in lead V5 or V6 or 4 times Q amplitude >R amplitude in lead I or aVL
or		Test for possible lateral infarction passed and test for lateral injury passed

Then say **lateral infarct**

If test any lateral infarct passed, then suppress all **right axis deviation**.

If no Q wave is present and R amplitude >200 µV in lead V3, then suppress all **anterior infarct**. If **left anterior fascicular block** is not passed, then suppress **left posterior fascicular block** and **bifascicular block**.

Determine age of infarct:
If lateral injury present
Then append **, possibly acute**

Otherwise append **, age undetermined**

Anteroseptal Infarct

Statement is made if:
Any **AMI** tests passed
and Any **SMI** test passed
and **LMI** failed

Then say **anteroseptal infarct**

If **cannot rule out** or **possible anterior infarction** passes in the presence of **septal infarction**, then say **possible anteroseptal infarct*** or **cannot rule out anteroseptal infarct**.*
Suppress **AMI**
Suppress **SMI**
Suppress **ILBBB**
Suppress **IVCD**
Suppress **PULD**

Determine age of infarct:
If any were labeled acute, append **, possibly acute**
Otherwise append **, age undetermined**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Anterolateral Infarct

Statement is made if:
Any **AMI** tests passed
and Any **LMI** test passed
Then say **anterolateral infarct**
If **cannot rule out** or **possible anterior infarct** passes and **possible lateral infarct** passes, then say **possible anterolateral infarct** *.
If **LMI** passed in the presence of **cannot rule out** or **possible anterior infarct** or if **AMI** passed in the presence of **possible lateral infarct**, then say **anterolateral infarct**
Suppress **SMI**
Suppress **AMI**
Suppress **LMI**
Suppress **PULD**
Supress **ILBBB**
Supress **IVCD**
Determine age of infarct:
If any were labeled acute, append **, possibly acute**
Otherwise append **, age undetermined**

Inferior Infarct

Skip test inferior infarct if:
Test **WPW** passed
or **LBBB** printed

INFERIOR INFARCT TESTS

Test 1: Test for normal repolarization.

Test repolarization abnormalities
(refer to **STELE**, **STDEP**, and T wave abnormality details)
Normal repolarization = test 1 passes

Test 2: Test for normal QRS and T.

If the QRS axis and T axis <30 degrees apart, use T amplitude threshold of 50 µV
else use T amplitude threshold of 100 µV
If T amplitude in leads aVF and V3 through V6 >T amplitude threshold
and Maximum ST amplitude in leads aVF and V3 through V6 >-20 µV
and Minimum ST amplitude in lead aVF <50 µV
and Minimum ST amplitude in leads V3 through V6 <200 µV
and R amplitude in lead II >500 µV and Q:R ratio in lead II <1:5 (20%)
or R amplitude in lead aVF >500 µV
and QRS balance in lead V5 is positive

and QRS axis >0 degrees
and QRS axis and T axis is <45 degrees apart

then pass **Test 2**

Test 3: Test for normal repolarization and QRS axis and duration

if **Test 1** passed
and QRS axis >10 degrees
and QRS duration < 120 ms

then pass **Test 3**

Test 4: Test for Q wave amplitude in lead aVF

Skip **Test 4** if test 3 fail
Results of **Test 2** are used to adjust for Q wave thresholds
Test 2 pass uses less sensitive Q wave threshold criteria
Test 2 fail uses more sensitive Q wave threshold criteria
(in parentheses)

if		QRS duration < 100 ms
	and	Q amplitude in lead aVF ≥100 µV
	and	Q duration ≥40 (30) ms in lead aVF
	and	Q:R duration >1:5 in lead aVF
or		Q amplitude ≥100 µV in lead aVF
	and	Q duration in lead aVF ≥40 ms
or		Q amplitude >75 µV in lead aVF
	and	Q duration >40 ms in lead aVF
	and	Q:R ratio in lead aVF ≥1:5
or		QRS duration ≥100 ms and <120 ms
and		Q amplitude in lead aVF ≥75 µV
and		Q duration in lead aVF ≥40 (35) ms
	or	Q duration in lead aVF ≥40 (25) ms and Q:R ratio in lead aVF ≥1:5 (20%)
or		QRS duration < 120 ms
	and	Q amplitude in lead aVF >200 µV
	and	Q duration in lead aVF ≥30 ms
	and	Q:R duration in lead aVF >1:3

then pass **Test 4**

If **Test 3** passed and **Test 4** failed (normal QRS axis and duration and no repolarization abnormalities and no significant Q wave in aVF), then stop and do not execute any further **IMI** tests.

Cannot Rule Out Inferior Infarct (Masked by Left Anterior Fascicular Block?)

Statement is made if:

	Q duration + R duration <20 ms in lead aVF
and	R amplitude in lead aVF <50 µV
and	Test left anterior fascicular block passed

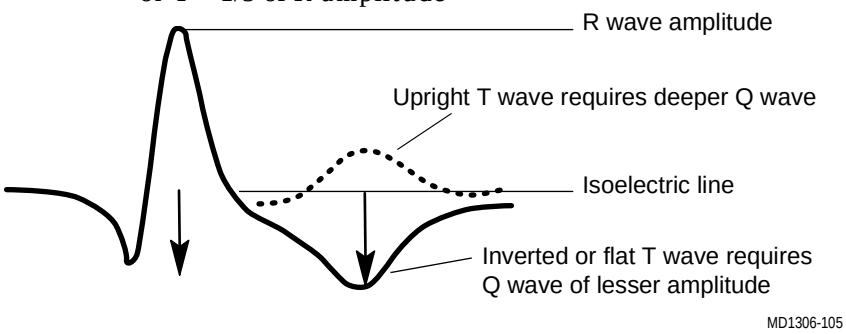
Then say **cannot rule out inferior infarct (masked by left anterior fascicular block?)** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Cannot Rule Out Inferior Infarct

Statement is made if:

In lead II or aVF:
Q amplitude >50 µV
and Q duration ≥25 ms
and Q amplitude minus the minimum of T
or T' >1/5 of R amplitude



or If Q amplitude >50 µV
and Q duration ≥20 ms
and either QRS axis ≤-45 degrees
or QRS axis >240 degrees
and Maximum R amplitude in aVF <100 µV

Then say **cannot rule out inferior infarct** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Possible Inferior Infarct

In lead II or aVF:
Q amplitude >75 µV
and Q duration ≥35 ms
and Q wave minus the minimum of T amplitude or T' amplitude is >1/5 R amplitude

or In lead II or aVF:
Q amplitude >75 µV
and Q duration ≥30 ms
and Q wave minus the minimum of T amplitude or T' amplitude is >1/4 R amplitude

or In lead II or aVF:
Q amplitude >75 µV
and Q duration ≥25 ms
and Q wave minus the minimum of T amplitude or T' amplitude is >1/3 R amplitude

or In lead II or aVF:
Q amplitude >75 µV
and Q duration ≥20 ms
and Both STJ and STM are ≥50 µV
and Special T amplitude ≤-50 µV

or In lead II or aVF:
Q amplitude >75 µV
and Q duration ≥20 ms
and Both STJ and STM are ≥100 µV
and STE + 100 µV ≥T amplitude

Then say **possible inferior infarct***

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Inferior Infarct

Statement is made if:
Cannot rule out IMI passed or **possible IMI** passed and **IINJ** passed
or Any possible inferior infarct test passed

and In lead II or aVF:
STJ >100 µV or special T amplitude – STE <-200 µV
or In lead II or aVF:
Q amplitude >100 µV
and Q duration ≥40 ms
and Q amplitude minus the minimum of T amplitude or T' amplitude >1/4 R amplitude

or In lead II or aVF:
Q amplitude >100 µV
and Q duration ≥35 ms

and Q amplitude minus the minimum of T amplitude or T' amplitude >1/3 R amplitude

or In lead II or aVF:
Q amplitude >100 µV
and Q duration ≥30 ms
and Q amplitude minus the minimum of T amplitude or T' amplitude >1/2 R amplitude

Then say **inferior infarct**

Determine age of infarct:
If inferior injury passed

Then append **, possibly acute**
Otherwise append **, age undetermined**

Inferior-Posterior Infarct

Skip test with posterior extension if:
Test **WPW** passed

Statement is made if:
Any inferior infarct test passed
and No Q wave is present in leads V1 and V2, and QRS duration <120 ms
and Test complete RBBB, failed
and either R duration ≥35 ms in leads V1 and V2,
and QRS balance in leads V1 and V2 is positive
or QRS balance in lead V2 is positive
and Maximum ST amplitude <-50 µV in lead V2
or R duration in lead V1 or V2 >40 ms
and R amplitude in lead V1 or V2 >200 µV
and Maximum ST amplitude in lead V1 or V2 <-100 µV
or Balance in lead V3 is positive
and Maximum ST amplitude in lead V3 <-100 µV
and Maximum ST amplitude in lead V2 <-50 µV
or Maximum ST amplitude in lead V1 <-50 µV
and Maximum ST amplitude in lead V2 <-50 µV
and Maximum ST amplitude in lead V3 <-50 µV

Then say **inferior-posterior infarct**

Suppress all **RVH**, **IRBBB**, **BVH**, and **IMI** statements

Determine age of infarct:

If inferior injury present or maximum ST amplitude in lead V2 <-100 µV

Then append: **, possibly acute**
Otherwise, append: **, age undetermined**

Posterior Infarct

Skip test if inferior-posterior infarct or **WPW** passed

Requires:

Age >30 years
and QRS duration <120 ms
and No **RBBB**, **IRBBB**, or **RVH** passed

Test 1

R amplitude in leads V2 and V3 >700 µV
and R amplitude in leads V2 and V3 >3 times S amplitude

Test 2

QRS balance in leads V1 and V2 is positive
or QRS balance in leads V2 and V3 is positive

Test 3

Maximum ST in lead V1 or V2 <-100 µV

Test 4

T amplitude in lead V1 or V2 is >0 µV

Test PMI 1 TEST FOR R:S RATIO IN LEAD V1

If test 2 or tests 1 and 4
and If test 3 failed
and If R:S ratio in lead V1 $\geq$1:2
and R amplitude in lead V1 >100 µV
and R duration in lead V1 >20 ms
or R:S ratio $\geq$1:3 in lead V1
and R amplitude in lead V1 >100 µV
and R duration in lead V1 $\geq$40 ms
and If T amplitude in V1 $\geq$0 µV
and T amplitude in lead V2 >200 µV
and T amplitude in lead V3 >200 µV
and LVH test failed

Test PMI 2 TEST TRUE POSTERIOR INFARCT

Tests 2, 3, and 4 passed

Statement is made if:

Test PMI 2 passed and any **IMI** test passed
or PMI 1 passed, PMI 2 failed, and **IMI** passed

Then say **inferior-posterior infarct** and suppress **IMI** statement

If test **PMI 2** passed and **IMI** failed, then say **posterior infarct**

If **PMI 1** passed, **PMI 2** failed, and **IMI** failed, then say **increased R/S ratio in V1**, **consider early transition**, or **posterior infarct**

Determine age of infarct if **IMI** and **PMI** or **PMI** is stated:

If test **PMI 2** passed
and **IMI** is acute
or Maximum ST amplitude in lead V2 <-50 µV

Then append **, possibly acute**
Otherwise append **, age undetermined**

If **PMI 1** or **PMI 2** passed then suppress **RSR'** pattern statement

ST Abnormality (Elevation)

Skip test **ST abnormality (elevation)** if:

Test **WPW** passed
or Heart rate >120 bpm and test **RBBB** passed
or Test **LBBB** passed

Nonspecific ST abnormality (Elevation)

Statement is made if:

All tests of infarct failed
and Test **RBBB** failed
and QRS duration <120 ms
and In any 2 of leads I, II, III, aVF, and V3 through V6 STJ, STM, and STE are all $\geq$50 µV
and The slope from QRS onset to J point $\geq$ slope of ST segment
and T is not tall

Then say **nonspecific ST abnormality**

Repolarization Tests

Skip statement if:
QRS >140 ms, or **LBBB**, **RBBB**, or **MI** is present

Continue all early repolarization tests if:
Corrected Q-T interval is between 370 and 460 ms
and Any test infarct failed
and Test **IRBBB** failed
and Test **ILBBB** failed
and Test **RBBB** failed
and Test **RVH** failed
and **LVH** failed
and QRS duration <120 ms
or If any ST elevation ≥200 µV in the precordial leads
and ≥100 µV in the limb leads (other than leads aVR and V1)
and The QRS balance is positive

*** REPOLARIZATION TEST 1 ***
Count leads from leads V1 through V6 with a QRS balance >0 in which both STJ and STM are ≥75 µV
plus The number of leads from I, II, III, aVL, and aVF with a QRS balance >0 in which ST amplitude ≥50 µV
also Compute the sum of the amplitudes of the smaller of STJ and STM for each lead which passes

*** REPOLARIZATION TEST 2 ***
Count the number of leads with tall T waves which passed repolarization test 1

ST Elevation, Early Repolarization, Pericarditis or Injury

Skip statement if QRS >140 ms, or **LBBB**, **RBBB**, or **MI** is present.

Statement is made if:
Three or more leads pass repolarization test 1
and The sum from repolarization test 1 ≥450 µV
or Any ST elevation >200 µV in the precordial leads
and ≥100 µV in the limb leads (other than leads aVR and V1)
and QRS balance is positive
and * In at least one lead of I, II, aVF, and V3 through V6, the T amplitude is negative or
T' amplitude <-50 µV
or * If in lead aVL the T or T' amplitude <-100 µV and either QRS axis <50 degrees or in any leads II, III, and aVF, the minimum ST amplitude >100 µV and in lead V5 or V6 the minimum ST amplitude <50 µV

or * If in at least two leads (other than leads aVR and V1) minimum ST amplitude <0 µV

or * If in at least one lead (other than leads aVR and V1) minimum ST amplitude <-50 µV and in at least two leads (other than leads aVR and V1) minimum ST amplitude <20 µV

Then say **ST elevation, consider early repolarization, pericarditis or injury** †

* If tests marked with "*" pass under any condition, skip to pericarditis tests.
† This statement will not appear if screening criteria is turned on. See Appendix F for more information.

ST Elevation, Probably Due to Early Repolarization

Statement is made if:

Test ST elevation, consider early repolarization, pericarditis, or injury passed

and In more than half of the leads passing repolarization test 1, T is also tall

Then say **ST elevation, probably due to early repolarization** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Early Repolarization

Statement is made if:

More than five leads pass early repolarization test 1 and T wave is tall in five or more leads

and The sum calculated in early repolarization test 1 $\geq$500 µV

Then say **early repolarization** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information

Possible Acute Pericarditis

Skip test acute pericarditis if:
Any test infarct passed
or QRS duration ≥120 ms

Count leads from leads I, II, and aVF in which both STJ and STM are ≥75 µV
plus The count of leads (V2 through V6) in which both STJ and STM are ≥90 µV

Statement is made if:
The total count is at least five
and In any four of leads I, II, V4, V5, and V6 T amplitude is >0 µV and STJ >1/4 of the T amplitude
and In all leads, except leads aVR and V1, both STJ and STM are >-100 µV and T amplitude >0 µV.

Then say **possible acute pericarditis** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acute Pericarditis

Statement is made if possible pericarditis is made and
Count the number of leads (leads I, II, and aVF) in which both STJ and STM are ≥90 µV plus count the number of leads (V2 through V6) in which both STJ and STM are ≥110 µV

If count ≥5, then say **acute pericarditis**

Injury Pattern Tests

Skip test all injuries if:
Any tests pericarditis passed

(Done on all 12 leads individually)

Test 1:

Inspect QRS balance:
Count the number of leads in frontal plane where QRS balance is <1000 µV and in the precordium where the QRS balance <2000 µV. Test 1 passes if count = 12.

Test 2:

Test at all 12 leads (except leads aVR and V1) for ST elevation:

(Skip lead groups with infarct present)
If **AMI** skip leads V2, V3, and V4
If **SMI** skip lead V2
If **IMI** skip leads II, III, and aVF
If **LMI** skip leads I, aVL, V5, and V6

For this test and subsequent tests, the parameter ST LIMIT is set for each lead:

*ST LIMIT = 200 µV unless,
If frontal lead (I, II, III, aVR, aVL, and aVF)
or If in leads V5 and V6 (R-S) ≥0 µV then = 100 µV

If lead is elevated
and QRS balance is positive
or In precordial leads QRS deflection <1500 µV
or In frontal plane QRS deflection <1000 µV
or If QRS balance is negative and ratio of maximum S amplitude to QRS deflection <75%
then Test 2 passes

Test 3:

Look for ST elevation based on QRS duration (except leads V1 and aVR)
SKIP LEAD GROUPS WITH MI PRESENT
*Apply ST LIMIT as above
If lead is elevated
and QRS duration is ≥120 but <130 ms and QRS balance is positive
and Ratio of QRS balance to QRS deflection must be >15%
or QRS duration ≥130 but <150 ms
and Ratio of QRS balance to QRS deflection must be >25%
or QRS duration ≥150 ms
and Ratio of QRS balance to QRS deflection must be >50%
or QRS duration <120 ms and QRS balance is negative or positive
and If minimum STJ and STM >100 µV in frontal leads
and If minimum STJ and STM >200 µV in precordial leads

If any of the leads meet the above criteria, then inspect further for that lead group.

*Apply ST LIMIT as above for specific lead group

If **Test 1** passed
and If in precordial leads minimal STJ and STM >300 µV = set injury flag
or If in precordial leads maximum R + maximum S <1000 µV
and Minimal STJ and STM >200 µV set injury flag
or If in frontal lead minimum STJ and STM >200 µV = set injury flag
or If frontal lead maximum R + maximum S <750 µV
and Minimal STJ and STM >100 µV = set injury flag

Test 3: (Continued)

or In any lead the minimal STJ and STM >½ T amplitude = set injury flag
else If test 2 passed
*Apply ST LIMIT as above
and If precordial lead, ST elevation >300 µV = set injury flag
or If frontal lead, ST elevation >200 µV = set injury flag
or If in any lead, the minimal STJ and STM >1/2 T amplitude
or If in any lead T' amplitude <-150 µV and T' amplitude (absolute value) >1/8 of T amplitude for inspected lead that is elevated
or If T amplitude is negative = set injury flag

Test 4:

If **Test 3** passed:
and If in precordial leads, STJ and STM >100 µV
or If in frontal leads, STJ and STM >50 µV
and If in elevated lead T' amplitude <-150 µV
and T' amplitude (absolute value) >1/8 of T amplitude = set injury flag
or If T amplitude is negative = set injury flag

Test 5:

If **Test 1** or **Test 2** passed, look for reciprocal changes:
and Excluding leads aVR and V1, count the number of leads where:
Test 5a: Maximal STJ and STM <-100 µV in any lead
Test 5b: Maximal STJ and STM <-50 µV in any lead
Test 5c: Maximal STJ and STM <0 µV in any lead
and If **Test 5a** count >0
or **Test 5b** count ≥2
or **Test 5b** count ≥1 and **Test 5c** count ≥3 set injury flag

Test 6:

If **Test 5** fails and injury flag is set:
and No MIs passed
and **QRSV** passed
and No **LVHR** present
Then state **ST elevation, early repolarization, pericarditis or injury**
If **LVH** with repolarization is present, the injury flag is clear and no statement is made.

Anterior Injury

Statement is made if:

In any lead V2, V3, or V4 criteria for ST elevation and any injury flag set

Then say **ST elevation, consider anterior injury or acute infarct**

If there is no evidence of **LVH**, **RBBB**, **IRBBB**, **LBBB**, **IVCB** and the QRS duration is less than 140 msec and the ventricular rate less than 100 bpm and the age of the patient is greater than or equal to 30 years old then use the following more sensitive criteria for **Anterior Injury**.

This Anterior Injury Criteria relies on the use of "Concomitant repolarization" information, (i.e. leads V2 - V4 are inspected for ST elevation and the inferior leads II, III, AVF are inspected for concomitant repolarization changes). The concomitant repolarization changes consist of depressed ST segments, which are weighted more heavily if they are down sloping, and T wave inversion. In this criteria the concept of setting or adapting the ST elevation thresholds based on QRS balance is used. This allows for increased sensitivity by allowing lower ST elevation thresholds to be used to call Anterior Injury but retains high specificity by requiring the presence of other repolarization changes in the inferior leads.

Inspection of the Inferior leads for repolarization changes.

T wave inversion is present if in leads II or AVF the T wave amplitude or T' amplitude is less than -100 µV.

ST depression is present if in leads II, III, AVF the STJ, STM or STE point is depressed more than -20 µV. In addition if the ST segment is depressed and STE is depressed more than the STM point and the STM point is depressed more than the STJ point (down sloping from STJ to STM to STE) then the ST segment is considered to be "down sloping".

The ST elevation thresholds for V2, V3, and V4 are set according to the following:

If the QRS deflection (R+S) is less than or equal to 500 µV the ST threshold is 100 µV.

If the QRS deflection (R+S) is less than or equal to 1000 µV the ST threshold is 150 µV.

If the QRS deflection (R+S) is less than or equal to 1500 µV the ST threshold is 200 µV.

If the QRS deflection (R+S) is less than or equal to 2000 µV the ST threshold is 250 µV.

If the QRS deflection (R+S) is greater than 2000 µV the ST threshold is 300 µV.

If inferior ST depression and T wave inversion and down sloping ST segments are all present, then the Anterior ST elevation threshold is decreased by 25 µV.

The ST elevation in V2, V3 and V4 is established by a point scoring system. For each lead, if the minimum of the STJ and the STM point are greater than the set threshold 1 point is awarded. If two of the inferior leads have depressed and downsloping ST segments with T wave inversion an additional point is awarded. In the case where the QRS deflection is less than 500 µV if the minimum of the STJ and the STM point is elevated by more than 200 µV an additional point is awarded. If the ST threshold is less than 250 and the minimum of the STJ and the STM point is greater than 300 µV an additional point is awarded. Thus a single lead could accrue a maximum point score of 4.

For Anterior Injury to be called the point score for the three leads V2, V3, V4 must be greater than or equal to 2 points and at least one inferior lead must have ST depression and or T wave inversion.

For the case where a Q wave Anterior or Septal MI has been called, the MI is dated as acute if for the Anterior MI the minimum of the STJ and the STM point is greater than 200 µV and the T wave is upright (positive) and the STE point is less than the T wave amplitude in V2 or V3 or V4. For the Septal MI the same criteria is used but only for lead V2.

For the special case where there is a Q wave in V3 that is greater than 100 µV in amplitude and greater than 25 msec in duration. If the points awarded in the ST elevation section are 2 or more and the Anterior Elevation Flag is set, the Anterior MI is dated as Acute.

In addition to the previously described criteria additional Anterior injury criteria was added below and also is used when “dating” a Q wave MI as acute.

Part 1 focuses in on the ST segment in the leads V2 and V3 for ST elevation, and takes into account the T wave amplitude in the leads being inspected for elevation. This enhancement is focusing on the Septal and Antero-Septal manifestations of injury patterns. The Concomitant repolarization changes are confined to leads AVF, I, and V6 in this criteria.

Part 2 uses the ST and T wave data to “date” a Q wave MI which occurs in leads V2 – V4.

NOTE

ECGs in this criteria are included in the analysis if they have no evidence of **LVH**, **RBBB**, **IRBBB**, **LBBB**, **IVCB** and have a QRS duration less than 140 msec with a ventricular rate less than 100 bpm and the age of the patient is greater than or equal to 30 years old.

Part 1 criteria are outlined in three steps.

Step 1: Look for ST elevation in V2 and V3.

The ST elevation criteria is met if in any of V2 or V3 either the STJ point is elevated by more than 150 µV or the STM point is elevated by more than 250 µV with the requirement that the T wave amplitude in that lead be more than 1200 µV.

Step 2: Look for ST and T wave repolarization changes in leads AVF, V6, I.

The ST criteria require that the STJ point be depressed (i.e. less than 0 µV) and the STM point be depressed by more than -50 µV and the T or T' amplitude in that lead be greater than 100 µV.

Step 3: Look for large deflections in V2 and V3. If this pattern is found then do not call Injury.

If the Maximum of either the Q wave or the S wave in leads V2 or V3 exceeds 2000 µV then no injury will be called.

If the Criteria in steps 1 and 2 are met and the criteria for step 3 is not present, then call **Anterior Injury**.

Part 2 of the Anterior Injury Criteria looks in detail at “dating” a Q wave Anterior Infarct as Acute.

Four ST and T wave criteria tests are applied to the leads V1 – V4.

NOTE

The following tests are performed only if the ECG shows no evidence of **LVH**, **IVCB**, **ILBBB**, **LBBB**, **IRBBB**, **RBBB**, and has a QRS duration less than 116 msec, a ventricular rate less than 100 bpm, the patients age is greater than 30 years old and the ECG shows evidence of either a non acute septal, anterior or inferior MI.

Test 1: requires the STM point to be elevated by at least 100 µV and also requires the T amplitude be greater than 150 µV with a T' amplitude being less than -150 µV.

Test 2: requires the STM point be elevated by at least 150 µV and also requires the T amplitude to be greater than 250 µV with a T' amplitude less than -50 µV.

Test 3: requires the STM point to be elevated more than 250 µV and in addition requires the T amplitude to be greater than 1200 µV.

Test 4: requires the STM point to be elevated more than 200 µV and requires the T amplitude to be greater than 500 µV and in addition requires that the T amplitude is greater than the QRS deflection in that particular lead.

If the Maximum of either the Q wave or the S wave in leads V2 or V3 exceeds 2000 µV, then no injury will be called.

If the above test is not met then if test 1 and 2 are met or test 3 and 4 are met or test 4 alone is met, then call **Anterior Injury**.

Lateral Injury

Statement is made if:
In any lead I, aVL, V5, or V6 criteria for ST elevation
and Injury test passed

Then say **ST elevation, consider lateral injury or acute infarct**

Inferior Injury

Statement is made if:
In any lead II or aVF criteria for ST elevation
and Any injury test passed

Then say **ST elevation, consider inferior injury or acute infarct**
If anterior injury, lateral injury, and inferior injury present, then say **ST elevation, consider anterolateral injury or acute infarct**
ST elevation, consider inferior injury or acute infarct

If anterior and lateral injury present, then say **ST elevation, consider anterolateral injury or acute infarct**

If inferior and lateral injury present, then say **ST elevation, consider inferolateral injury or acute infarct**

ST Abnormality (Depression)

Skip ST abnormality (depression) if:
Test **WPW** passed
or Test **LBBB** passed
or QRS duration >125 ms
or Heart rate >120 bpm and **RBBB** passed

Statement not made if:
Acute MI or injury stated
and If ST elevation is > depression

ABNORMALITY TEST

Condition for skipping applies to all ST tests.

Junctional ST Depression, Probably Normal

Skip test if:

Test LVH secondary repolarization passed
or Test RVH with secondary repolarization passed
or Test nonspecific ST abnormality (elevation) passed
or Test RBBB passed
or Any acute infarct or injury test passed
or Any MI test passed

Statement is made if:

In any two of all leads, except lead aVR, STJ <-100 µV, and STE >0

Then say **junctional ST depression, probably normal** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Junctional ST Depression, Probably Abnormal

Skip test if:

Test **LVH** and **RVH** with secondary repolarization passed
or Test nonspecific ST abnormality (elevation) passed
or Test **RBBB** passed
or Test **MI** passed

Statement is made if:

STJ <-100 µV
and STE >1/2 STJ in any two of all leads except aVR

Then say **junctional ST depression, probably abnormal** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

ST Abnormality Probably Digitalis Effect

Skip test if:
- Test **LVH** and **RVH** with secondary repolarization passed
- or Test nonspecific ST abnormality (elevation) passed
- or Test **RBBB** passed
- or Any MI present

Statement is made if:
- either In any two of leads I, II, aVL, and V2 through V6:
- or Minimum of STM or STE < minimum of STJ or -50 µV
- or Heart rate ≤100 bpm
- and PR interval <200 ms
- and In any two of leads I, II, aVL, and V2 through V6:
  Minimum of STM or STE < minimum of STJ,
  P onset amplitude -50 µV, or -25 µV
- and T amplitude >STM +100 µV

Then say **ST abnormality probably digitalis effect**

Nonspecific ST Abnormality

Skip test if:
- Test **LVH** or **RVH** with secondary repolarization passed
- or Test nonspecific ST abnormality (elevation) passed
- or Test **RBBB** passed

Statement is made if in any two of leads I, II, aVL, aVF, V4, V5, and V6:
- STJ <-50 µV and STE <0 µV
- or STE ≤ minimum (STJ and STM) -25 µV

Then say **nonspecific ST abnormality**

If test atrial fibrillation passed simultaneously, then append **probably digitalis effect**

If MI present, suppress all ST abnormality statements.

ST Depression Consider Subendocardial Injury or Digitalis Effect

Skip test if:
Test **LVH** or **RVH** secondary repolarization passed

Statement is made if:
In any two of leads I, II, aVL, aVF, and V2 through V6 STJ and STM are $\leq$-100 µV
(If test RBBB passed, then do not test leads V2, V3, and V4)

Then say **ST abnormality and possible subendocardial injury or digitalis effect**

Suppress nonspecific ST statements.

Septal Subendocardial Injury

Statement is made if:
Test septal and posterior infarct failed
and In lead V1 or V2, STJ and STM are $\leq$-200 µV

Then say **marked ST abnormality possible septal subendocardial injury**

Anterior Subendocardial Injury

Statement is made if:
Test anterior and posterior infarct failed
and Tests LVH with repolarization abnormality failed
and In lead V3 or V4, STJ and STM are $\leq$-200 µV

Then say **marked ST abnormality possible anterior subendocardial injury**

Lateral Subendocardial Injury

Statement is made if:
Test lateral infarct failed
and Test LVH with repolarization abnormality (LVHR) failed
and Test LVH with repolarization abnormality (LVHR) failed

Then say **marked ST abnormality possible lateral subendocardial injury**

Inferior Subendocardial Injury

Statement is made if:

Test **inferior infarct** failed
and Test **LVH** with repolarization abnormality failed
and In lead II or aVF, STJ and STM are ≤-100 µV

Then say **marked ST abnormality possible inferior subendocardial injury**

If any tests **subendocardial injury** passed, then suppress **nonspecific ST abnormality**, **junctional ST depressions**, and **ST depression consider digitalis effect**.

If **inferior myocardial infarction** and lead III has STJ >100 µV, suppress lateral subendocardial injury statement.

If anterior and lateral subendocardial injury present but no septal subendocardial injury present, then say **Marked ST abnormality possible anterolateral subendocardial injury**

If inferior and lateral subendocardial injury present but no septal and no anterior subendocardial injury present, then say **Marked ST abnormality possible inferolateral subendocardial injury**

If septal and anterior subendocardial injury present, then say **Marked ST abnormality possible anteroseptal subendocardial injury**

Special LVHR and anterior subendocardial criteria

If **LVHR** present:

No **LBBB** or **RBBB**
No **subendocardial injury** tests passed
No **ST elevation** test passed
No ST depression abnormalities tests passed
QRS duration <150 ms
No **posterior infarct** passed
No acute MIs passed

Statement is made if:

In two or more of leads V2, V3, or V4
either QRS balance is positive and ratio of maximum R amplitude to QRS deflection <75%
or QRS balance is negative
and Maximum ST amplitude <-100 µV and QRS balance is negative
or Maximum ST amplitude <-100 µV and QRS balance is positive and T amplitude >0 µV
or QRS balance is positive and maximum ST amplitude <0 µV
and T amplitude is positive and T' = 0 and minimum ST amplitude <-150 µV

Then say **Marked ST abnormality, possible anterior subendocardial injury**

T Wave Abnormality

Skip test if:
Test **WPW** passed
or Test **LVH with repolarization abnormality** passed
or Any injury test passed
or Test complete **LBBB** passed
or Test **subendocardial injury** passed
Conditions for skipping test applies to all T wave tests.

Abnormal QRS-T Angle, Consider Primary T Wave Abnormality

Skip test if:
Any test infarct passed
or Test RBBB passed

Statement is made if:
QRS axis -T axis $\geq$60 degrees
and T axis <0 degrees
or QRS axis -T axis $\leq$-60 degrees
and T axis >90 degrees

Then say **abnormal QRS-T angle, consider primary T wave abnormality** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Nonspecific T Wave Abnormality

Skip test if:
Any test infarct passed
or Test **RBBB** passed

NONSPECIFIC T ABNORMALITY TEST

For each lead to be tested:
Set test limit
If QRS amplitude is positive, limit value is 1/20 QRS amplitude + 25 µV
or If QRS amplitude is negative, limit value is 25 µV
Then Count lead as passing test if special T
Amplitude ≤ the test limit and (special T <0 or TA <200 µV)

Test leads as follows:
First test lead V6 to V3
If lead V3 passed test, then test lead V2; then test leads I, II, and aVL
If special T amplitude exceeds 150 µV in leads I, II, and aVL, do not test
and If QRS balance is negative, do not test lead aVL

If more than two leads pass this test, then say **nonspecific T wave abnormality**

If test atrial fibrillation passed simultaneously, then append **, probably digitalis effect**

Anterior Ischemia

Statement is made if:
AMI, **RBBB**, or **RVHR PMI** passed
In any two of leads V2, V3, and V4, special T amplitude ≤-100 µV

Then say **T wave abnormality, consider anterior ischemia**

If test atrial fibrillation passed simultaneously, then append **or digitalis effect**

If test nonspecific ST abnormality passed simultaneously, then prefix **ST &**

Marked T Wave Abnormality Consider Anterior Ischemia

Statement is made if:
AMI, **RBBB**, or **RVH** passed, skip test
and In two leads V2, V3, and V4, special T amplitude ≤-500 mV

Then say
marked T wave abnormality, consider anterior ischemia

If test nonspecific ST abnormality passed simultaneously, then prefix
ST &

Lateral Ischemia

Statement is made if:
Test **lateral infarct** failed
and In any two of leads I, aVL, V4, V5, and V6, special T amplitude ≤-100 µV
(Do not test aVL if QRS balance is negative.)

Then say **T wave abnormality, consider lateral ischemia**

If test **atrial fibrillation** passed simultaneously, then append
or digitalis effect

If test nonspecific ST abnormality simultaneously passed, then prefix
ST &

Marked T Wave Abnormality Consider Lateral Ischemia

Statement is made if:
Test lateral infarct failed
and Any of leads I, aVL, V5, and V6, special T amplitude ≤-500 µV
(Do not test aVL if QRS balance is negative.)

Then say **marked T wave abnormality, consider lateral ischemia**

If test nonspecific ST abnormality simultaneously passed, then prefix
ST &

Anterolateral Ischemia

Statement is made if:
Test T wave abnormality, consider anterior ischemia
and Test T wave abnormality, consider lateral ischemia passed

Then say **T wave abnormality, consider anterolateral ischemia**

If test atrial fibrillation passed, simultaneously then append
or digitalis effect

If test nonspecific ST abnormality simultaneously passed, then prefix
ST &

Marked T Wave Abnormality Consider Anterolateral Ischemia

Statement is made if:
Test T abnormality consider anterior ischemia passed
and Test marked T abnormality consider lateral ischemia passed
or Test marked T abnormality consider anterior ischemia passed

Then say **marked T wave abnormality, consider anterolateral ischemia**

If test nonspecific ST abnormality simultaneously passed, then prefix
ST &

T Wave Abnormality Consider Inferior Ischemia

Statement is made if:
Any test **inferior infarct** failed
and Special T amplitude <-100 µV in lead II or aVF
(Test lead aVF only when QRS amplitude is positive.)

Then say **T wave abnormality, consider inferior ischemia**

If test atrial fibrillation passed simultaneously, append
or digitalis effect

If test nonspecific ST abnormality passed simultaneously, then prefix
ST &

Marked T Wave Abnormality Consider Inferior Ischemia

Statement is made if:

Special T amplitude ≤-500 µV in lead II or aVF
(Test lead aVF only when QRS amplitude is positive.)

Then say **marked T wave abnormality, consider inferior ischemia**

If test nonspecific ST abnormality passed simultaneously, then prefix **ST &**

T Wave Abnormality Consider Inferolateral Ischemia

Statement is made if:

Test T wave abnormality consider inferior ischemia passed
and Test T wave abnormality consider lateral ischemia passed
and Test T wave abnormality consider anterior ischemia failed

Then say **T wave abnormality consider inferolateral ischemia**

If marked T wave abnormality passed with above statements, upgrade the statement to **Marked T wave abnormality consider inferolateral ischemia**

If any ischemia tests pass, suppress **STEREP** and **EREP**.

If any test ischemia pass, suppress **NST**, **STJD1**, **STJD2**, **STDIG**, **NT**, **AQRST**, and **STD**.

Nonspecific ST and T Abnormality

Statement is made if:

Any specific ischemia tests failed
and Pericarditis test failed
and ST depression test failed
and Test nonspecific ST abnormalities passed
and Test nonspecific T abnormality passed

Then say **nonspecific ST & T abnormality**

If test atrial fibrillation passed, simultaneously append **, probably digitalis effect**

If test **NSTT** passed, suppress **NST**, **STJD1**, **STJD2**, **STDIG**, **NT**, **AQRST**, and **STD**.

Prolonged QT

Skip test prolonged QT if:
Test **WPW** passed

Statement is made if:
Ventricular rate <100 bpm
and **IVCB** not present
and **RBBB** not present
and **LBBB** not present
and QRS duration <120 ms
and * QTC ≥460 ms
and Test for nonspecific T wave abnormality passed
or *QTc ≥480 ms
and T wave abnormalities not present
and Any infarction not present
and Any ischemia not present
or * QTc ≥500 ms
and Either infarction or ischemia present

Then say **Prolonged QT**

Suppress **EREP** and **STEREP**.

* An additional 10 ms is added to the above thresholds for female patients over 60 years old.

Acute MI

Statement made if:
Any injury pattern is cited
and Any MI labeled age undetermined
or Infarct statement is labeled as possibly acute.

Then say **** ** ** ** * Acute MI * ** ** ** **

7 Pediatric Contour Criteria

For your notes

Overview

If an age of 15 years or less is entered, a pediatric analysis is performed.

Pediatric analysis employs a set of tables which contain the normal values for 12 different age groups. QRS duration limits are important in the diagnosis of conduction blocks. Amplitude limits are used in the diagnosis of ventricular hypertrophy. These tables are included in appendix C for your perusal.

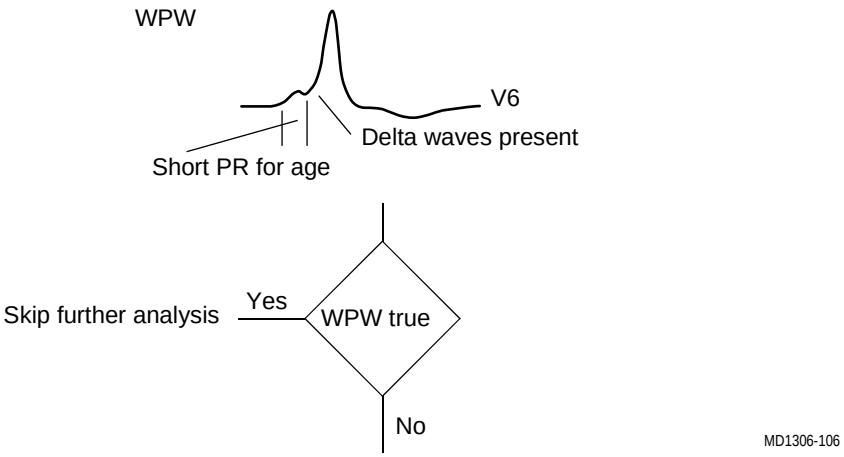
Listed below are the categories of abnormalities that the pediatric analysis program always checks for. This outline is expanded upon in succeeding figures which describe, in very simplistic terms, the basic flow and logic of the pediatric criteria. Note that the order of the steps is important since information obtained from tests performed earlier in the sequence are applied to subsequent tests. Refer to Chapter 3 for definitions of the wave measurements used in this chapter.

Table 1. Pediatric Contour Criteria Summary

Major Category	Subcategory	Acronyms/Statements
Dextrocardia		**DEXTRO**
Wolff-Parkinson-White		**WPW**
Atrial Hypertrophy		**RAE, Right Atrial Enlargement** **LAE, Left Atrial Enlargement** **BAE, Biatrial Enlargement**
QRS Abnormalities	Low Voltage QRS QRS Axis Conduction Abnormalities Ventricular Hypertrophy Infarction	**LOWV** **RAD, Right Axis Deviation** **LAD, Left Axis Deviation** **NWA, North West Axis** **RBBB, Right Bundle Branch Block** **RBBRVH, Right Bundle Branch Block or Right Ventricular Hypertrophy** **LBBB, Left Bundle Branch Block** **IRBBB, Incomplete Right Bundle Branch Block** **ILBBB, Incomplete Left Bundle Branch Block** **IVCB, Intraventricular Conduction Block** **IVCD, Intraventricular Conduction Delay** **LVH, Left Ventricular Hypertrophy** **RVH, Right Ventricular Hypertrophy** **BIVH, Biventricular Hypertrophy** **QRSW, With QRS Widening** **MI, Myocardial Infarction** **LMI, Lateral** **IMI, Inferior**
ST Abnormalities—QRS Related	ST + T abnormality with Ventricular Hypertrophy Dating Infarcts	**2ST, With Repolarization Abnormality** **WSTR, With Strain Pattern** **AC, Possibly Acute** **AU, Age Undetermined**

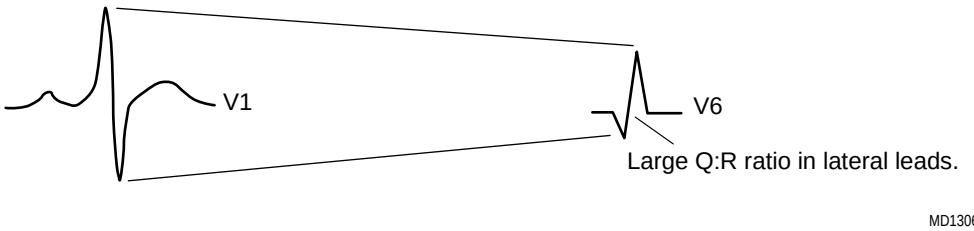
Table 1. Pediatric Contour Criteria Summary (Continued)		
Major Category	**Subcategory**	**Acronyms/Statements**
ST Elevation Abnormalities	Marked ST Elevation	**STELIN, ST Elevation In**
	Pericarditis	**PCARD, Acute Pericarditis**
	Early Repolarization	**REPOL, Early Repolarization**
	Undefined ST Elevation	**STEL, ST Elevation Probably Due to Repolarization, Injury or Acute Pericarditis**
	Nonspecific	**NST, Nonspecific ST Abnormality**
ST Depression Abnormalities	Marked ST Depression	**STDEPIN, ST Depression In**
	Undefined ST Depression	**STDEP, ST Depression, Consider Subendocardial Injury or Digitalis Effect**
	Digitalis Effect	**PDIG, Probably Digitalis Effect**
		STDIG, ST Abnormality, Possible Digitalis Effect
	Junctional ST Depression	**JST, Junctional ST Depression Probably Abnormal**
		JSTN, Junctional ST Depression, Probably Normal
	Nonspecific	**NST, Nonspecific ST Abnormality**
T Wave Abnormalities	T Wave Inversion	**TINVIN, T Wave Inversion In**
		INF, Inferior Leads
		LAT, Lateral Leads
		IFLAT, Inferolateral Leads
	Nonspecific	**NT, Nonspecific T Wave Abnormality**
		NSTT, Nonspecific ST and T Wave Abnormality
	QRS-T Angle	**AQRST, Abnormal QRS-T Angle**
	QT Interval	**LNGQT, Prolonged QT**

Wolff-Parkinson-White

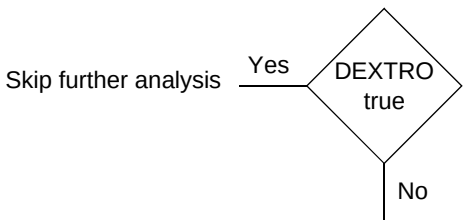


Dextrocardia

DEXTRO
QRS deflection much greater in right precordial leads as opposed to left lateral leads.

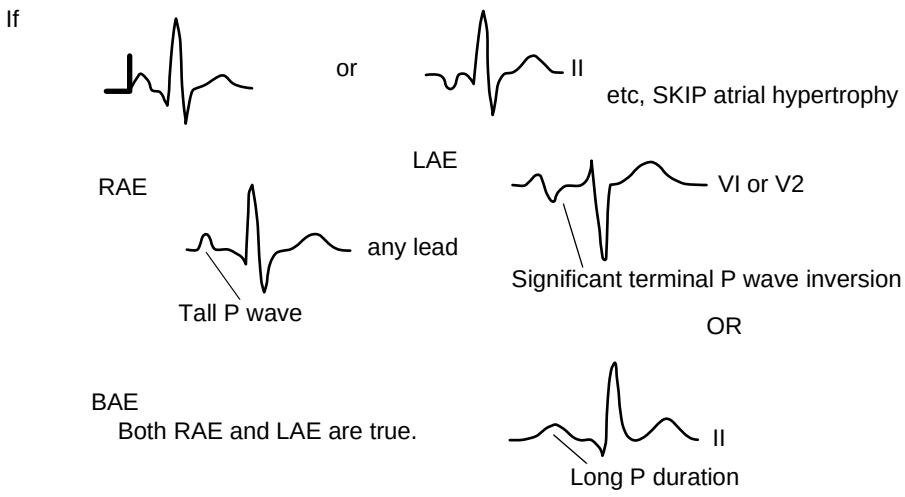


If dextrocardia is stated, do no further analysis.



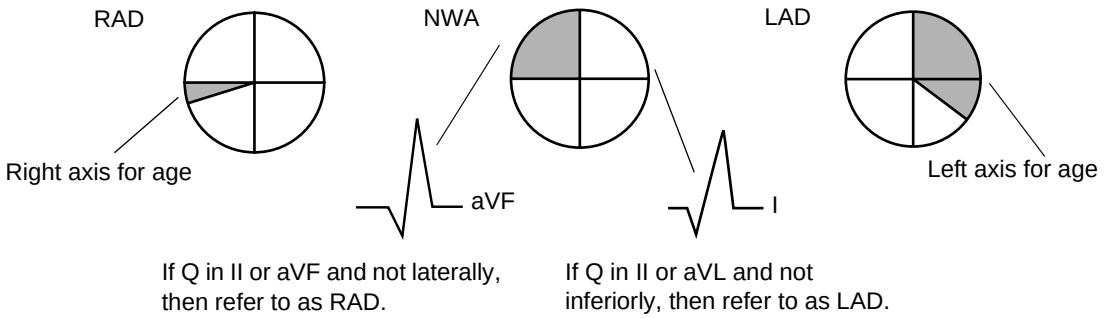
Atrial Enlargement

Skip the test if it is not a sinus rhythm.



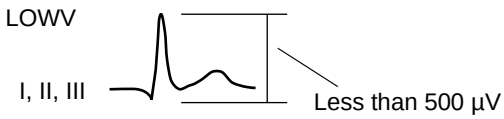
MD1306-108, -109, -110, -111, -112

QRS Axis



MD1306-037, -113, -114, -115, -153

Low Voltage QRS



MD1306-116

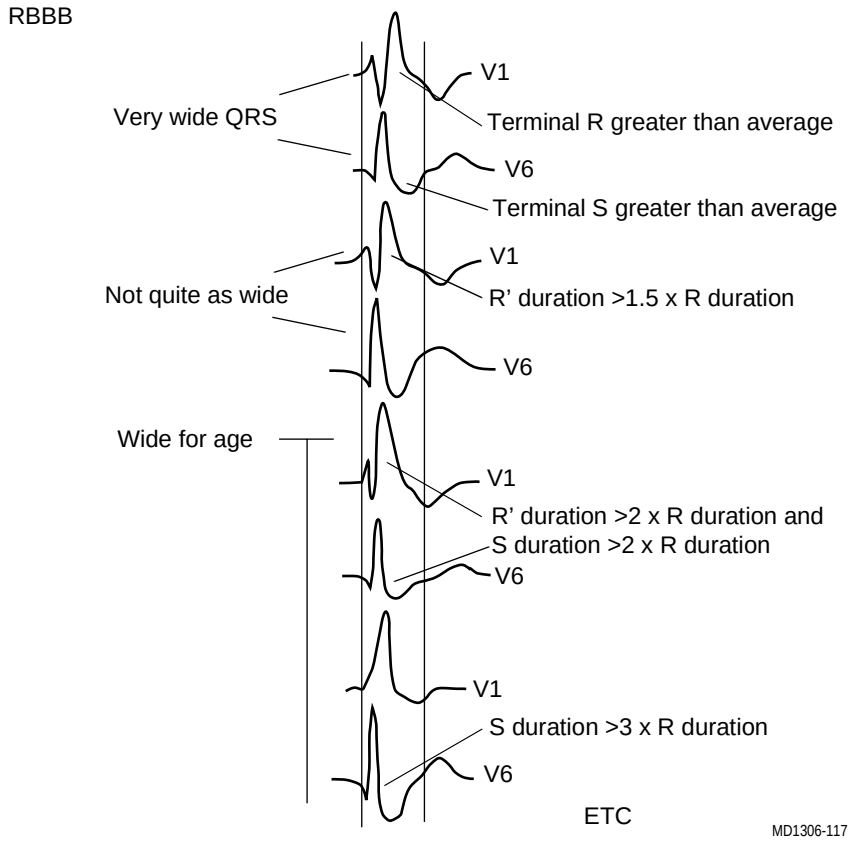
Standard requirement of limb leads less than 500 µV. However, if horizontal plane exhibits low voltage for age and the limb leads have voltage close to the standard requirement, state **low voltage QRS**.

Conduction Abnormalities

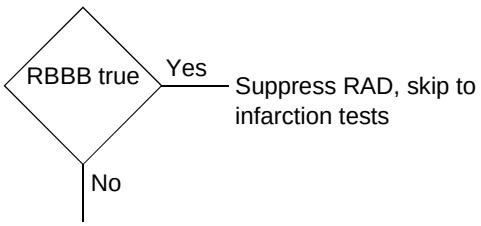
Right Bundle Branch Block

It is sometimes difficult to discriminate among **RBBB**, **RVH**, or normal variants. Therefore, the pediatric criteria for **RBBB** is the most complicated of the conduction abnormalities.

If the QRS is very wide, the program tests for terminal slowing on the right. As the QRS gets narrower, the tests for terminal slowing on the right become increasingly more difficult to pass.

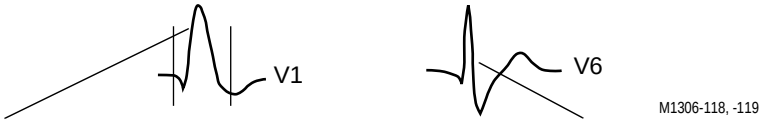


If **RBBB** is true, suppress all statements concerning right axis deviation and do not test for hypertrophy.

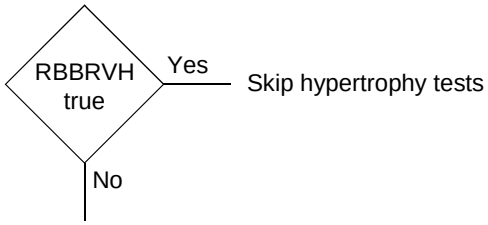


RBBRVH

If the QRS is wide for age, and it has some of the components of RBBB which do not quite meet the criteria, the program will state: "Right bundle branch block or right ventricular hypertrophy."

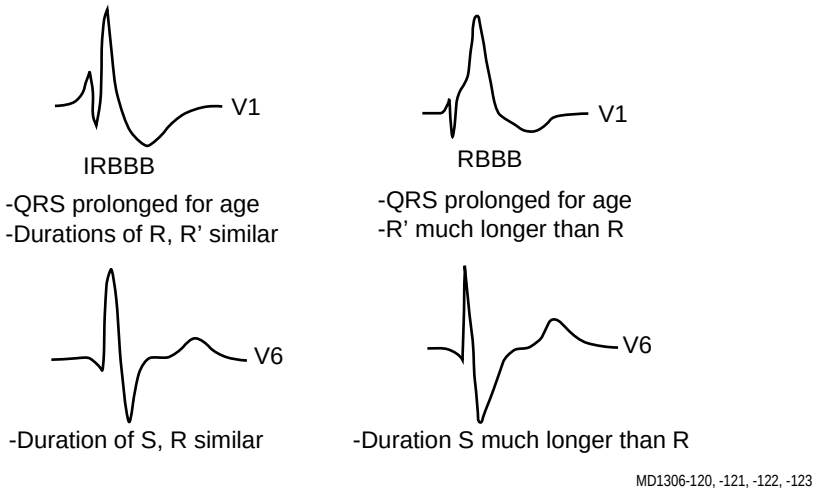


QRS is wide. Although the terminal force is towards the right, there is no evidence of terminal conduction delay. This could be due to **RVH** or **RBBB**. If **RBBRVH** is called, bypass hypertrophy tests.



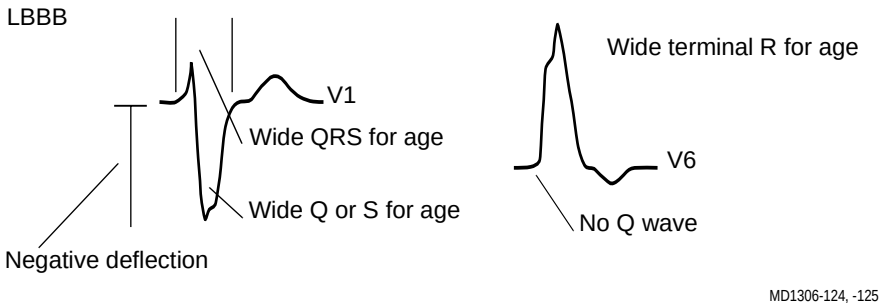
IRBBB

IRBBB is called if the QRS has some of the attributes of RBBB, but the rightward terminal slowing is not evident enough for the criteria to state a complete block.

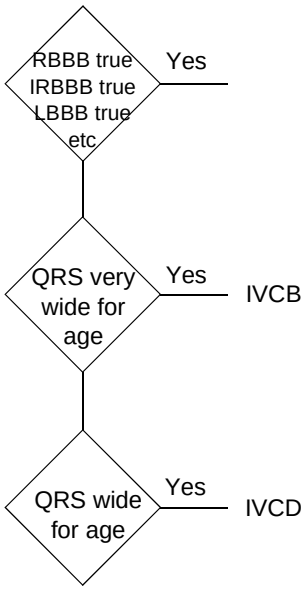


MD1306-120, -121, -122, -123

Left Bundle Branch Block

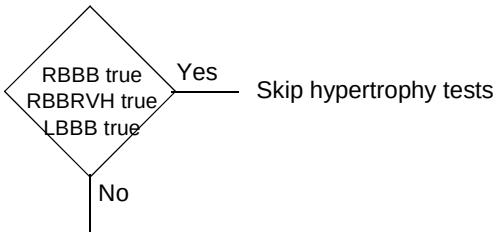


!LBBB
Same criteria as **LBBB** but QRS is slightly prolonged for age, as opposed to wide.
If a conduction abnormality has not been cited, and the QRS is wide for age, a nonspecific conduction delay or block will be cited.



Ventricular Hypertrophies

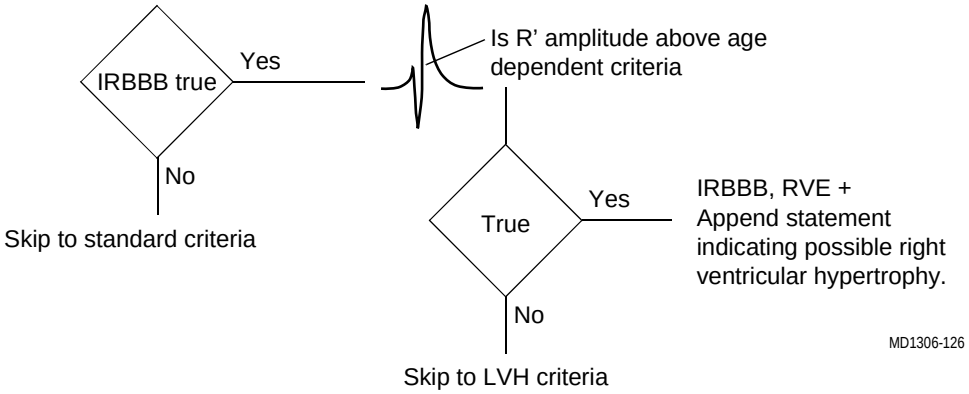
If any complete block has been stated, do not test for ventricular hypertrophy.



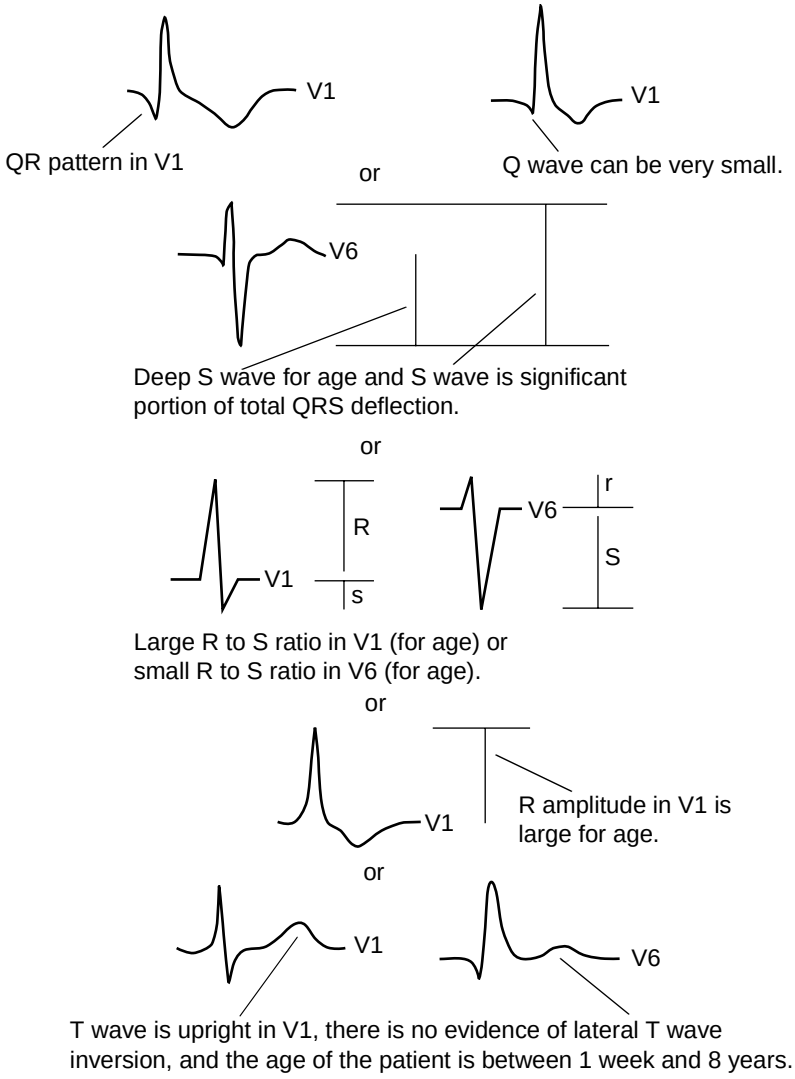
Right Ventricular Hypertrophy

RVH

If **IRBBB** has been stated, use special criteria for **RVH**, avoid the standard criteria.

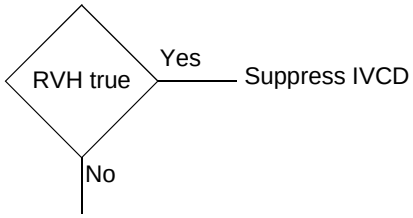


There are several ways in which **RVH** can be diagnosed via the standard criteria. Possible **RVH** is stated if any of these tests are true.

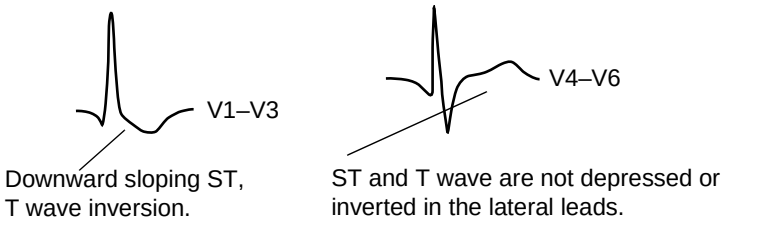


MD1306-127, -128, -129, -130, -131, -132, -133

If the R amplitude in V1 is large for age, or there is a QR pattern in V1, the program states **RVH** without the prefix "possible." If **RVH** is stated, suppress **IVCD**.

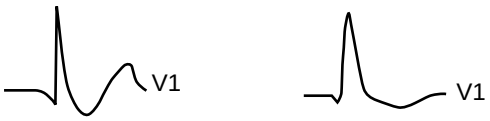


When **RVH** is stated, the repolarization of the right precordial leads is inspected.



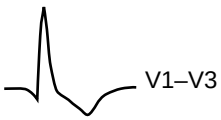
MD1306-134, -135

If the ST-T meets these requirements, but is not typical of **RVH** with strain, the program will state: "With repolarization abnormality."



MD1306-136, -137

If the ST-T is typical of **RVH** with strain, the program will state: **With strain pattern**.

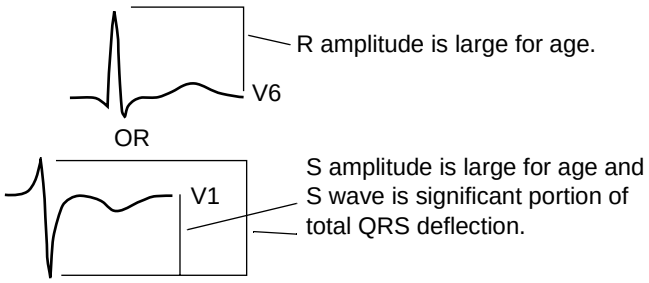


MD1306-138

Left Ventricular Hypertrophy

LVH

The criteria first tests the voltage in leads V1 and V6.

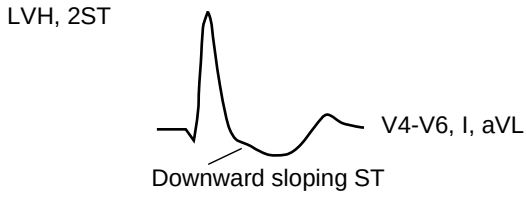


MD1306-139, -140

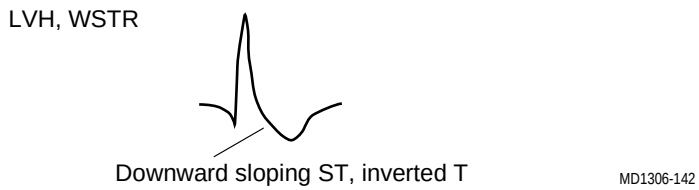
If either of these criteria are true, the program will state possible **LVH**. If the voltage significantly exceeds this criteria, the program will state **LVH** without any qualifier.

Repolarization in the lateral leads is the next item tested.

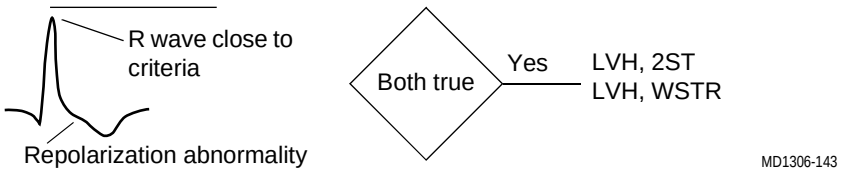
If this repolarization abnormality is found in conjunction with voltage criteria for **LVH**, the program will state: **Left ventricular hypertrophy with repolarization abnormality**.



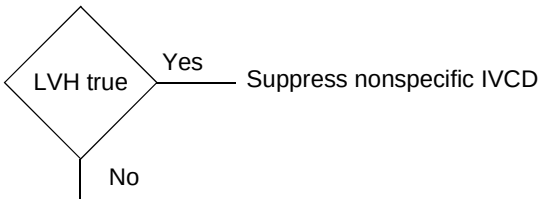
If the repolarization abnormality is more typical of a strain pattern, the program will modify the statement by using **with strain pattern**.



T wave inversion in the lateral leads is abnormal for all ages. If a repolarization abnormality is detected in the lateral leads and the ECG exhibited voltage that was close to the aforementioned criteria, the program would upgrade the diagnosis to **LVH**.



If **LVH** is cited, suppress the statement nonspecific interventricular conduction delay.

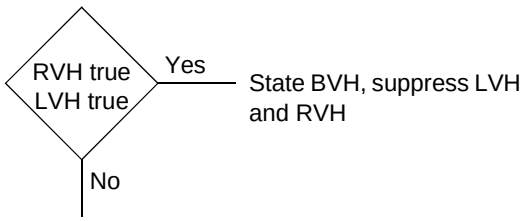


Biventricular Hypertrophy

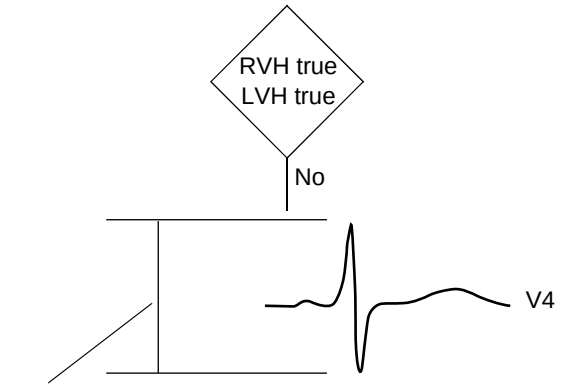
BVH

The way in which the program detects **BVH** is dependent upon what hypertrophy has already been detected by the program.

If both **LVH** and **RVH** have already been detected by the program, the program will state **BVH**.

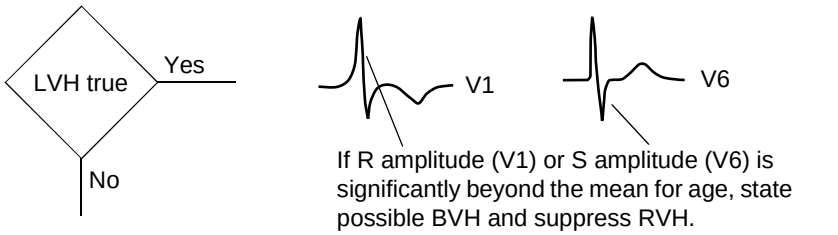


If neither **LVH** or **RVH** have been detected, then inspect mid-precordial leads.



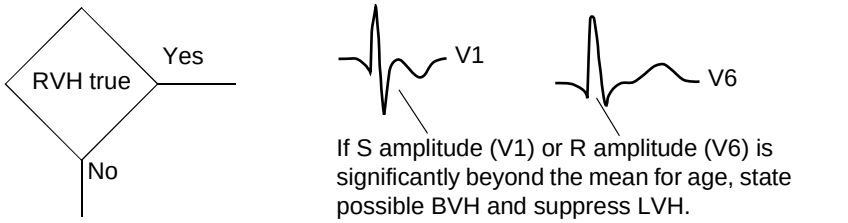
MD1306-144

If definite **LVH** has been detected, then see if there are some indications of **RVH**.



MD1306-145, -146

If definite **RVH** has been detected, then see if there are some indications of **LVH**.



MD1306-147, -148

Infarct

Septal Myocardial Infarct

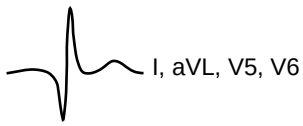
SMI
Not diagnosed by pediatric program.

Anterior Myocardial Infarct

AMI
Not diagnosed by pediatric program.

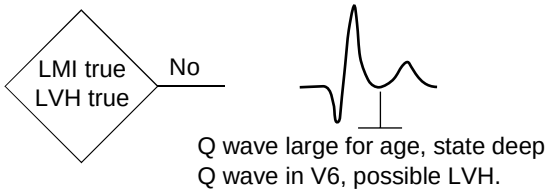
Lateral Myocardial Infarct

LMI
Criteria for lateral MI is very specific. Deep, wide Q waves with a large Q:R ratio are required for diagnosis. This criteria is used to avoid the deep Q waves that occur normally in the pediatric ages.



MD1306-149

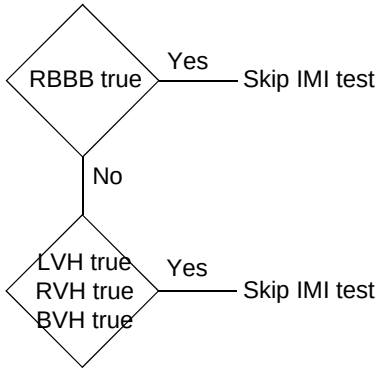
If there are deep Q waves for age, that do not meet the criteria for LMI, and LVH was not stated, the program will state: **Deep Q wave in V6, possible LVH**.



MD1306-150

Inferior Myocardial Infarct

IMI
Do not execute if RBBB or any hypertrophy is detected.



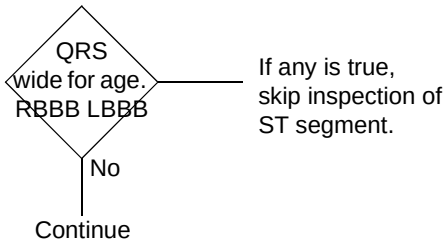
Criteria for inferior MI is very specific. Deep, wide Q waves with a large Q:R ratio are required for diagnosis. This criteria is used in order to avoid the large Q waves that occur normally in the pediatric ages.

MD1306-151

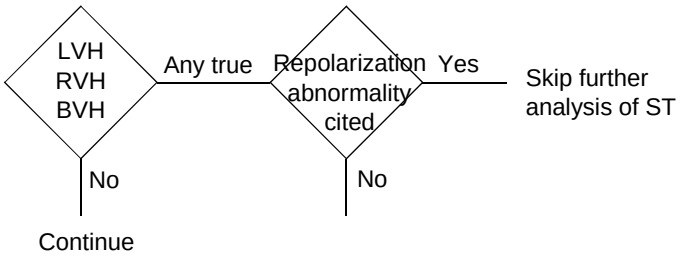
AC: Possibly acute
AU: Age undetermined
statements for the dating of MIs are not used by the pediatric program.

ST Abnormalities

Inspection of the ST segment is dependent upon what was found in the QRS.

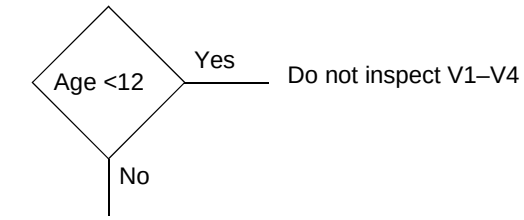


If repolarization abnormality has already been stated with **RVH**, **LVH**, or **BVH**, do not inspect the ST segment.

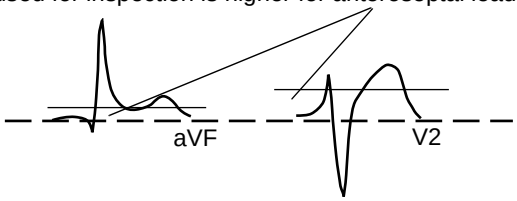


ST Elevation Abnormalities

The number of leads inspected for ST elevation is dependent on age.

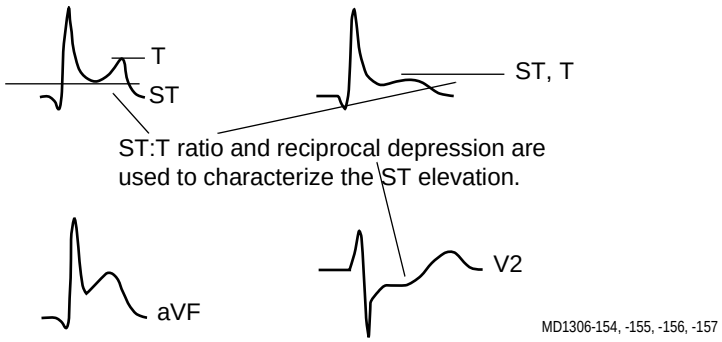


The threshold used for inspection is higher for anteroseptal leads.



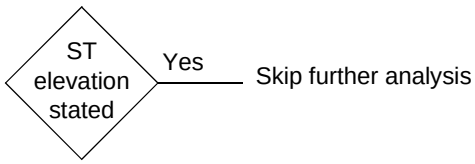
If any ST segment is over threshold, then several other tests are applied.

An injury character is suspected the larger the ST elevation and ST:T ratio. Reciprocal depression is also considered to be an indicator of injury.



ST elevation that has an injury-like character is descriptively stated; for example: **ST elevation in anterior leads**.

Once it is stated, no further ST elevation analysis is done.



Early Repolarization

Early repolarization is stated if the ST elevation has low ST:T ratio and a repolarization character that appears normal (that is, T waves upright in appropriate leads and ST aligned with T).

Acute Pericarditis

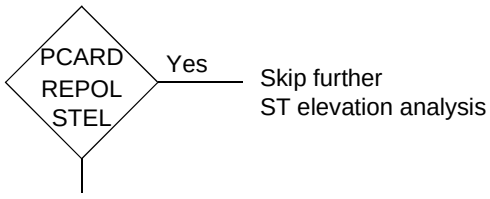
Acute pericarditis has similar criteria except more ST elevation is required.

ST Elevation, Mechanism Unknown

If pericarditis or early repolarization cannot be stated, the program identifies the ST elevation and suggests the three aforementioned mechanisms.

STEL
ST elevation, consider early repolarization, pericarditis, or injury

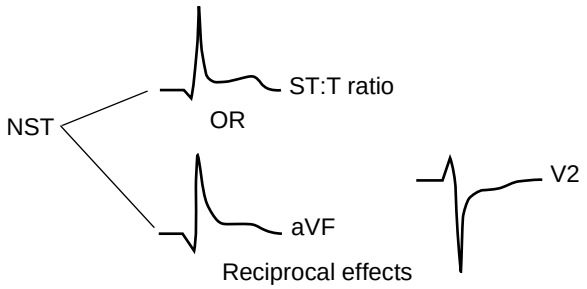
If **PCARD**, **REPOL**, or **STEL** is stated, do no further ST elevation analysis.



Nonspecific ST Elevation

NST

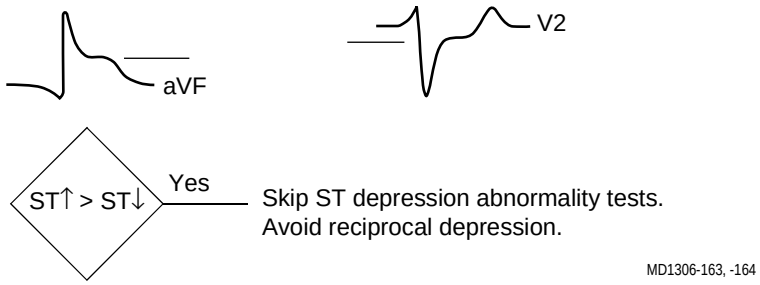
Nonspecific ST elevation abnormality is detected using the same methods as outlined above. The difference is that the threshold for elevation is twice as sensitive. Furthermore, the program only states the elevation as a nonspecific abnormality if it has characteristics that meet the criteria outlined for injury.



MD1306-160, -161, -162

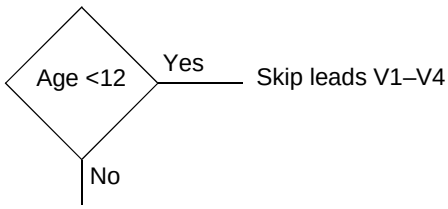
ST Depression Abnormalities

If injury has been called and the ST elevation is larger than the depression, do not test for any ST depression abnormality.

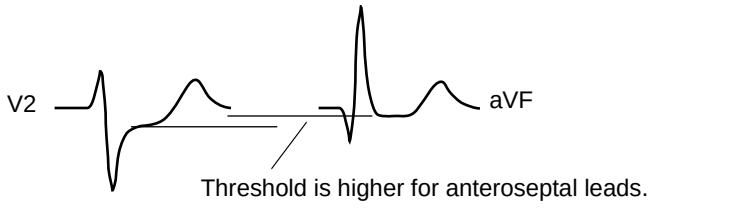


MD1306-163, -164

Inspect all leads for ST segment depression. The anteroseptal leads are not inspected if the age is less than 12 years.

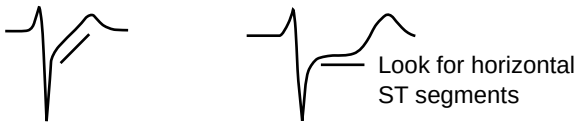


Compare ST segments to threshold. The threshold for anterior leads is less sensitive.



MD1306-165

Avoid upward sloping ST segments.

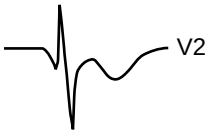


MD1306-167, -168

Avoid anteriolateral lead groups when LVH, 2ST is stated.

MD1306-169

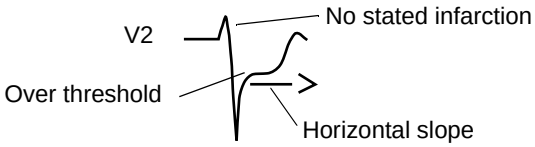
Avoid leads with stated infarction.



MD1306-170

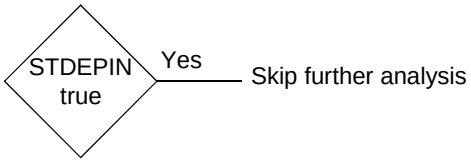
If all of these items are true, state ST depression in specific lead group.

STDEPIN

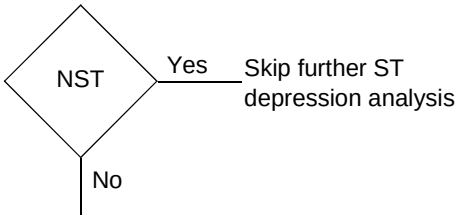


MD1306-171

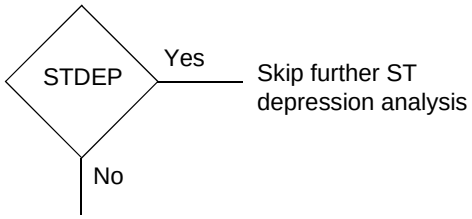
If ST depression is true, skip further analysis.



If a nonspecific ST elevation abnormality has already been found (from NST elevation tests), do no further ST depression analysis.

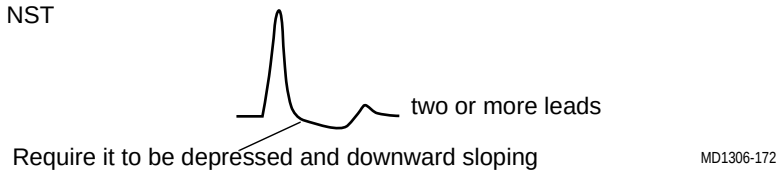


Now look for ST depression as before but with more sensitivity. If true, state **ST depression, consider subendocardial injury or digitalis effect**. Also skip further ST depression analysis.

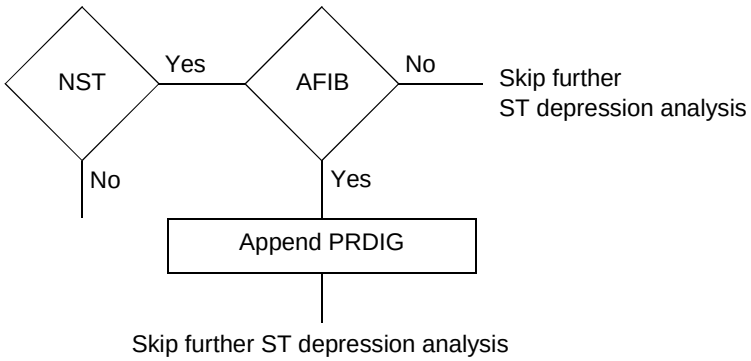


Nonspecific ST Abnormality

Again, analyze the ST segment with even more sensitivity.

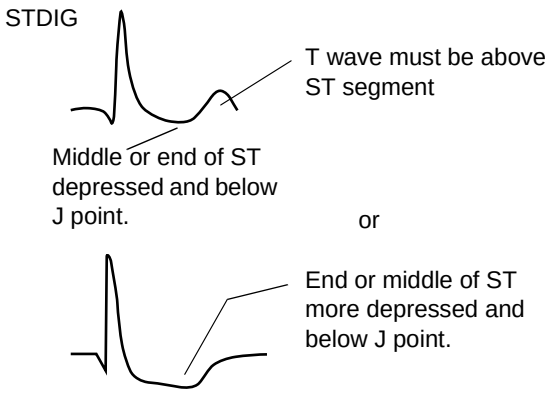


If this occurs in at least two leads, state **NST**.
If atrial fibrillation is present, append **PRDIG**.

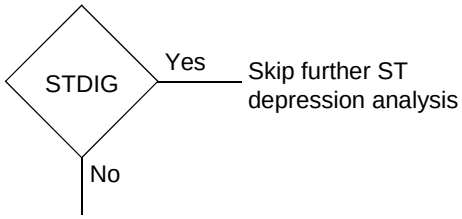


Digitalis Effect

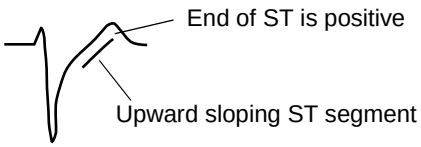
Now inspect for digitalis effect.



If digitalis is stated, do no further ST depression analysis.

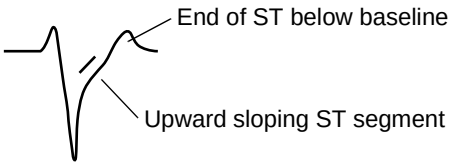


Junctional ST Depression



MD1306-175

If true, state: **Junctional ST depression, probably normal**.

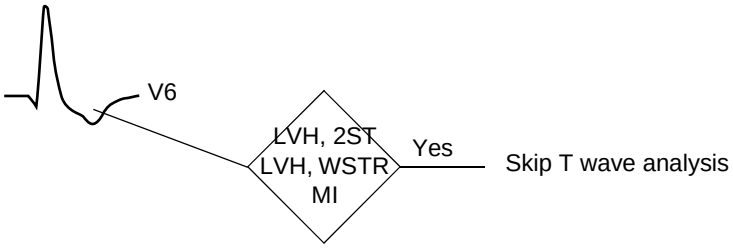


MD1306-176

If true, state: **Junctional ST depression, probably abnormal**.

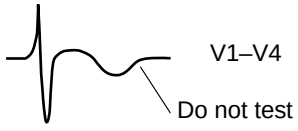
T Wave Abnormalities

If **LVH** with a repolarization abnormality has already been stated, do not test T waves. Likewise, if an **MI** has been cited, skip T wave analysis in respective lead group.



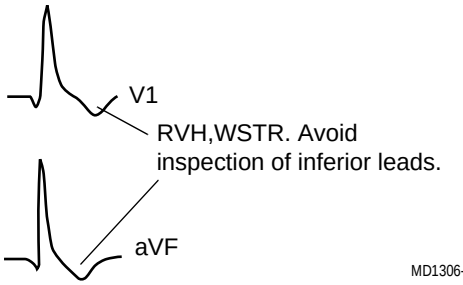
MD1306-177

Avoid inspection of leads V1–V4. T wave inversion in this lead group is normal for age.



MD1306-178

If **RVH** with strain pattern was noted, also avoid inspection of inferior leads.



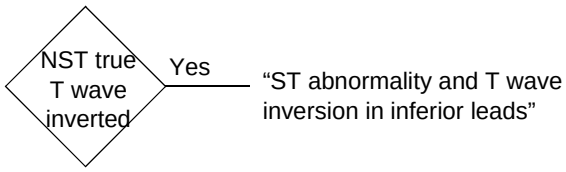
MD1306-179, -180

If T waves are inverted, then state descriptively as opposed to stating ischemia.

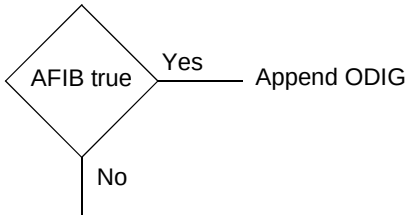
"T wave inversion in inferior leads"

MD1306-181

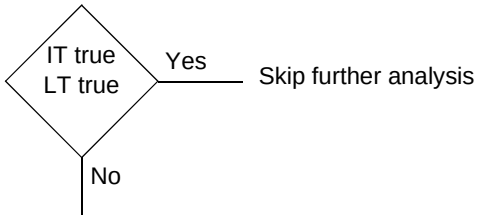
If a nonspecific ST abnormality was previously detected, make one statement as opposed to two.



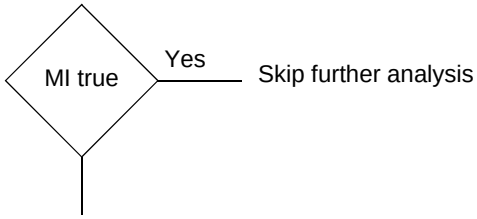
If atrial fibrillation is present, append **or digitalis effect**.



If T wave inversion is stated, skip further analysis of T waves.

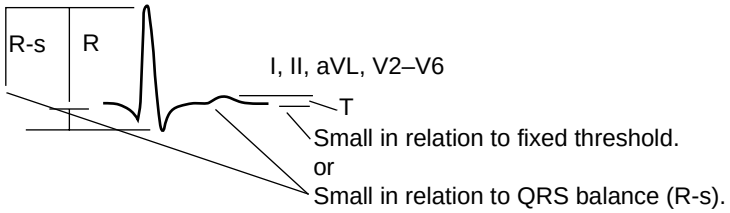


If infarction is present, skip further analysis.



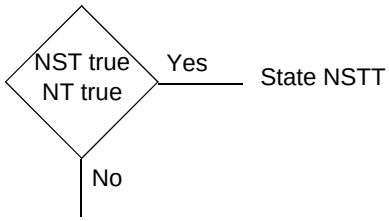
Nonspecific T Wave Abnormality

NT
Small T waves or shallow T wave inversion are found in at least two leads.

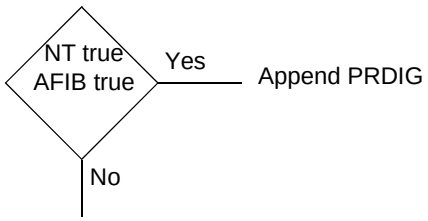


MD1306-182

If a nonspecific ST abnormality is found in conjunction with NT, then make one statement as opposed to two.



If atrial fibrillation is present, append **probably digitalis effect**.



Abnormal QRS-T Angle

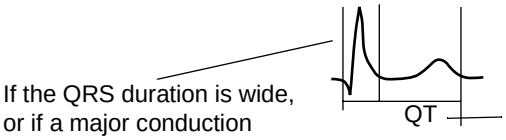
AQRST
Do not test for abnormal QRS-T angle if any other T wave abnormality has already been stated.

Abnormal T axis
and
Abnormally large QRS-T angle

MD1306-183, -184

Prolonged QT

QT interval is corrected for rate. As the ventricular rate increases, the corrected QT increases.



If the QRS duration is wide, or if a major conduction block is indicated, skip prolonged QT analysis

QT interval is measured across all 12 leads from earliest onset to latest offset.

MD1306-185

LNGQT
If QTc >460 ms and rate <100 bpm, stage **LNGQT**.

If QTc >450 ms, say **borderline prolonged QT**.

If any hypertrophy or incomplete block is cited, append: **May be secondary to QRS abnormality**.

Details

WPW

Skip test **WPW** if:

Atrial flutter or atrial fibrillation is present
or No P wave is present

Statement is made if:

Delta wave is present in three or more of 12 leads
and PR interval is not = 0 ms
and P axis is >-30 degrees and <120 ms
and PR interval ≤ mean PR interval for age
or PR interval ≤ mean PR interval for age + 25 ms
and QRS onset <12 ms after P offset
and There are ≥5 delta waves present

Then say **Ventricular pre excitation WPW**

If test **WPW** passed, then suppress short PR and skip any contour tests.

Dextrocardia

Skip test if **WPW** present

Statement is made if:

QRS deflection in lead V1 ≥QRS deflection in lead V5 times 1.9
and QRS deflection in lead V1 ≥QRS deflection in lead V6 times 1.9
and QRS duration <IVCB QRS duration for age
and In two of leads I, aVL, V5, and V6
either Q amplitude >1/4 the QRS deflection and R amplitude >100 µV
or RSR' pattern present where R amplitude <50 µV and R' amplitude >100 µV and S amplitude >1/4 the QRS deflection

Then say **dextrocardia**

If **dextrocardia** present, then skip any contour tests.

Atrial Enlargement

Skip all atrial enlargement tests if:

Test **WPW** passed
or PR interval = 0 ms
or No sinus rhythm or atrial pacemaker present
or P axis is < the upper limit for right atrial rhythm for age
or P axis is > the upper limit for left atrial rhythm for age

Right Atrial Enlargement

Statement is made if:

P wave amplitude >250 µV in any lead

Then say **Right atrial enlargement**

Left Atrial Enlargement

Statement is made if:

P duration in lead II >125 ms and P amplitude >100 µV
or P amplitude in lead V1 >40 ms and P' amplitude <-100 µV and P' duration >60 ms
or P amplitude in lead V1 >40 ms and P' amplitude <-125 µV and P' duration >50 ms
or P amplitude in lead V1 >40 ms and P' amplitude <-150 µV and P' duration >40 ms

Then say **Possible left atrial enlargement** *

If Any test for **possible LAE** passed
and P' amplitude in lead V1 <-200 µV
or P duration in lead II >140 ms and P' amplitude in lead V1 <-100 µV

Then say **Left atrial enlargement**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Biatrial Enlargement

Statement is made if:

Test left atrial enlargement passed
and Test right atrial enlargement passed

Then say **biatrial enlargement**

Frontal Plane Axis Deviation

Skip test frontal plane axis deviation if:
Test **WPW** passed and **dextrocardia** passed.

Left Axis Deviation

Statement is made if:

	QRS axis is ≤LAD lower limit for age
or	QRS axis is > superior NWA limit for age
and	Q amplitude >40 µV in lead I or aVL
and	Q amplitude ≤40 µV in leads II, III, and aVF

Then say **Left axis deviation**

Right Axis Deviation

Statement is made if:

	QRS axis is ≥RAD upper limit for age
or	QRS axis is ≥NWA upper limit for age
and	Q amplitude in leads I and aVL ≤40 µV
and	Q amplitude in lead II, III, or aVF >40 µV

Then say **Right axis deviation** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

North West Axis

Statement is made if:

	QRS axis is > superior NWA limit for age
and	Q amplitude in lead I or aVL >40 µV
and	Q amplitude in lead II, III, or aVF >40 µV
or	No Q wave in leads I, aVL, II, III, and aVF

Then say **North West Axis** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Indeterminate Axis

Statement is made if:

R amplitude minus S amplitude ≤50 µV in leads I, II, and III

or The QRS balance in leads I, II, and III is <10% of the QRS deflection

Then say **Indeterminate axis**

Low Voltage and Lung Disease

Skip test low voltage and lung disease if:

Test **WPW** or **dextrocardia** passed

or QRS duration >120 ms

Low Voltage QRS

Statement is made if:

Total QRS deflection <500 µV in all frontal leads

or QRS deflection <1500 µV in all precordial leads

and QRS deflection <1000 µV in all frontal leads

Then say **Low voltage QRS**

Conduction Defects

Skip all tests for conduction defect if:
Test **WPW** or **dextrocardia** passed

Incomplete Right Bundle Branch Block

Statement is made if:
QRS duration ≥upper QRS duration for age 98% confidence level
and QRS area is positive in lead V1
and Test **RBBB** 1 passed
and if any of the following are true:

Test 1
RBBB criteria 1-8 failed (see below criteria)
and QRS duration <90 ms
and R' amplitude in lead V1 not = 0 µV
and S' amplitude in lead V1 <100 µV
and R amplitude in lead V1 >100 µV

Test 2
RBBB criteria 1-10 failed (see below criteria)
and **IRBBB** test 1 failed
and **RBBB** test 6 failed
and R' duration in lead V1 >R duration in lead V1 times 1.3
and S duration in lead V6 >R duration in lead V6 times 1.5
and QRS duration < maximum QRS duration for age for block
and R amplitude in lead V1 >100 µV

Test 3
RBBB criteria 1-12 failed (see below criteria)
and **IRBBB** tests 1 and 2 failed
and **RBBB** test 6 failed
R amplitude in lead V1 >100 µV
R' amplitude in lead V1 >100 µV
S amplitude in lead V1 >100 µV
and S duration in lead V6 > maximum QRS duration for age block divided by two
and QRS duration >IVCB QRS duration for age – 20 ms
and QRS duration <IVCB QRS duration for age

Then say **Incomplete right bundle branch block** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Right Bundle Branch Block Tests

Test 1

R or R' (with no S or S') is present in lead V1

Test 2

If test 1 fails:
and QRS duration > maximum QRS duration for age for block
and In any two leads I, aVL, V4, V5, and V6
S duration >1/3 QRS maximum duration for age
and QRS area in lead V1 is positive
and S amplitude + minimum STJ or STM <100 µV and <R amplitude in lead V1
or S amplitude + minimum STJ or STM to R amplitude Ratio <30% in lead V1
or S amplitude + minimum STJ or STM to R amplitude Ratio <50% in lead V1 and QRS >130 ms
or S' amplitude + minimum STJ or STM <100 µV and <R' amplitude in lead V1
or S' amplitude + minimum STJ or STM to R' amplitude Ratio <30% in lead V1
or S' amplitude + minimum STJ or STM to R' amplitude Ratio <50% in lead V1 and QRS >130 ms

Test 3

R' wave present in lead V1 with duration >40 ms
(To obtain R' duration, subtract from the measured QRS duration the Q duration + R duration + S duration + R' duration + S' duration)

Test 4

R' duration in lead V1 > duration variable lead V1 times two
and S duration in lead V6 > duration variable lead V6 times two
Duration variable lead V1 Add Q duration + R duration + S duration in lead V1
Duration variable lead V6 Add Q duration + R duration in lead V6

Test 5A

QRS area is positive in lead V1
Notch present in lead V1 (after peak of R wave)
Notch depth ≥200 µV

Test 5B

QRS area is present in lead V1
Notch present in lead V1 (after peak of R wave)
Notch depth ≥100 µV

Test 6A

QRS duration <90 ms
and **RBBB** criteria 1-8 failed (see below criteria)
and Criteria for **IRBBB** test 1 failed

Test 6B

All **RBBB** criteria 1-12 failed
and **IRBBB** test failed
and **RBBB** test 6A failed
and QRS duration ≤ maximum QRS duration for age for block + 20 ms
and S duration in lead V6 <R duration in lead V6 times 1.4

Right Bundle Branch Block

Statement is made if:

QRS duration > upper QRS duration for age 98% confidence level
and QRS area is positive in lead V1
and Test **RBBB** 1 passed
or Test **RBBB** 2 passed
or Test **RBBB** 3 passed
And any of the following criteria are met:

Criteria 1:

Test **RBBB** 4 passed

Criteria 2:

QRS duration ≥120 ms
and S duration in lead V6 >R duration in lead V6 times two

Criteria 3:

R' duration in lead V1 > duration variable lead V1 + 10 ms
and S duration in lead V6 >R duration in lead V6 times two
and S duration in lead V6 > duration variable lead V6 times 1.5
or Q amplitude in lead V6 <200 µV

Criteria 4:

S duration in lead V6 >R duration in lead V6 times three
or S duration in lead V5 >R duration in lead V5 times five

Criteria 5:

R' in lead V1 > duration variable in lead V1 times 1.5
and QRS duration >130 ms

Criteria 6:

R' amplitude in lead V1 = 0 µV
and S amplitude in lead I <100 µV
and RBBB test 5 passed
and S duration in lead V6 >R duration in lead V6 times two
and S duration in lead V6 > duration variable in lead V6 times 1.5
or Q amplitude in lead V6 <200 µV

Criteria 7:

R amplitude in lead V1 >100 µV
and R' amplitude in lead V1 >100 µV
and R' duration in lead V1 >R duration in lead V1 times two
and R' duration in lead V1 >R + S duration in lead V1
and S duration in lead V6 >R duration in lead V6 times two
and S duration in lead V6 > duration variable in lead V6 times 1.5
or Q amplitude in lead V6 <200 µV

Criteria 8:

QRS duration > maximum QRS duration for age for block
and S duration in lead V6 >R duration in lead V6 times 2.5
and S duration in lead V7 > duration variable in lead V6 times 1.5

Criteria 9:

QRS duration >140 ms
and At lead one lead of I, aVL, V4, V5, or V6 has
either S duration >60 ms
and R' duration in lead V6 = 0 ms
or R' duration in lead V6 not = 0 ms
and S' duration in lead V6 >60 ms

Criteria 10:

QRS duration >130 ms
and In more than one lead of I, aVL, V4, V5, and V6
either S duration >70 ms
and R' duration in lead V6 = 0 ms
or R' duration in lead V6 not = 0 ms
and S' duration in lead V6 >70 ms

Criteria 11:

IRBBB test 1 failed
and Test **RBBB** 6 passed
and Criteria 1-10 failed
and R' duration in lead V1 >R duration in lead V1 times 1.3
and S duration in lead V6 >R duration in lead V6 times 1.5
and QRS duration > maximum QRS duration for age for block

Criteria 12:

IRBBB tests 1 and 2 failed
and Test **RBBB** 6 failed
and Criteria 1-11 failed
and R amplitude in lead V1 >100 µV
and R' amplitude in lead V1 >100 µV
and S amplitude in lead V1 >100 µV

and S duration in lead V6 > maximum QRS duration for age for block divided by two
and QRS duration > maximum QRS duration for age for block + 20 ms

Then say **Right bundle branch block**

If test **RBBB** passed, then suppress all right axis deviation.

Right Bundle Branch Block or Right Ventricular Hypertrophy

Statement is made if any of the following:

Test 1:
If QRS area in V1 >0 µV
and Test 1 or 2 passed
and All **RBBB** criteria 1-12 failed (see above criteria)
and All **IRBBB** tests failed
and **RBBB** test 6A failed
and **RBBB** test 6B failed
and QRS duration > maximum QRS duration for age for block + 20 ms
and S duration in lead V6 not = 0 ms
and R' not present in lead V6

Test 2:
If QRS area in V1 >0 µV
and Test 1 or 2 passed
and All **RBBB** criteria 1-12 failed (see above criteria)
and All **IRBBB** tests failed
and **RBBB** test 6A and 6B failed
and S duration in lead V6 >R duration in lead V6 + 10 ms
and **RBBB** test 5B passed

Then say **Right bundle branch block** or **right ventricular hypertrophy**

If **IRBBB** test passed and **RBBB** criteria 1-12 failed, then say **Incomplete right bundle branch block**
If Age is <1 year
and Maximum R amplitude in V1 >1000 µV
or Age ≥1 year
and Maximum R amplitude in lead V1 >1500 µV

Then say **Incomplete right bundle branch block plus right ventricular hypertrophy** *
If any **RBBB** statement made, suppress any **RAD** statements.

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Incomplete Left Bundle Branch Block

Statement is made if:

QRS duration >ILBBB QRS duration for age and < maximum QRS duration for age for block

and In leads V1 and V2, QRS balance is negative

and In leads V1 and V2, Q or S wave duration ≥2/3 maximum QRS for age for block

and In any two of leads I, V5, and V6, no Q wave is present

and In any two of leads I, aVL, V5, and V6, ≥1/2 maximum QRS for age for block

Then say **Incomplete left bundle branch block**

If test **ILBBB** passed, then suppress leftward axis.

Left Bundle Branch Block

Statement is made if:

Two x QRS area >1/40 of (QRS duration x maximum R amplitude) in lead V1 or V6

and QRS balance is negative in leads V1 and V2

and In leads V1 and V2, Q or S duration ≥1/6 QRS duration for age for block

and In any two of leads I, V5, and V6, no Q wave is present

and In any one of lead I, V5, or V6, R duration + R' duration ≥ maximum QRS duration for age for block -20 ms

and either QRS duration ≥maximum QRS duration for age for block times 1.3

or QRS duration ≥maximum QRS duration for age for block (+ 1/6 of this value)

and Over leads I, aVL, and V6 the sum of R duration

and R' duration totals > maximum QRS duration for age for block times two

or QRS duration ≥ maximum QRS duration for age for block

and Over leads I, aVL, and V6, the sum of R duration total > maximum QRS duration for age for block times two

and Five x QRS area >1/10 times (QRS duration x maximum R wave amplitude) in any two of leads I, aVL, and V6

Then say **Left bundle branch block**

* If **LBBB** not stated, but QRS balance is negative in lead V1, QRS duration >QRS duration for age for block (plus 1/6 of this value), then remember this ECG has passed as complete **LBBB**. This is not printed on the analysis report, but the ECG will be treated as complete **LBBB** in the analysis program logic.

Nonspecific Intraventricular Conduction Delay

Statement is made if:
QRS duration is >QRS duration for age for block minus 7 ms
and QRS duration is <QRS duration for age for block
and Tests **RBBB** and complete **LBBB** failed
and Tests **IRBBB** and **ILBBB** failed

Then say **Nonspecific intraventricular conduction delay** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Nonspecific Intraventricular Conduction Block

Statement is made if:
QRS duration >QRS duration for age for block
and Test **RBBB** and **LBBB** failed
Then say **Nonspecific intraventricular conduction block**

Ventricular Hypertrophy

Right Ventricular Hypertrophy

Skip test right ventricular hypertrophy if:

Test **WPW** or **dextrocardia** passed

or Test **IRBBB**, **RBBRVH**, **IRBBB** + **RVH**, and **LBBB** passed

Statement is made if:

Maximum S or S' amplitude in lead V6 > Large S in lead V6 for age + 200 µV

and Maximum S or S' amplitude in lead V6 >1/4 QRS deflection in lead V6

or S amplitude in lead V6 not = 0 µV

and Ratio of maximum R amplitude in lead V6 to maximum S amplitude in lead V6 < low R to S Ratio in lead V6 for age

or S amplitude in lead V1 is not = 0 µV

and Maximum R amplitude to S amplitude ratio in lead V1 > high R/s ratio for age in lead V1

or Age <8 years and >0 years

and T amplitude in lead V1 >100 µV and T' amplitude in lead V1 = 0 µV

and STE in lead V6 >0 and special T amplitude in leads V5 and V6 >50 µV

or Q amplitude in lead V1 >20 µV and maximum R amplitude in lead V1 >500 µV

Then say **Possible right ventricular hypertrophy**

Maximum R amplitude in lead V1 > large R in lead V1 for age

or Q amplitude in lead V1 >20 µV and maximum R amplitude in lead V1 >750 µV

Then say **Right ventricular hypertrophy**

If **RVH** present, suppress **IVCD** and **LOWV**.

RVH with Repolarization Abnormality

Statement is made if:

Test **RVH** passed
and No **IRBBB** test passed
and In all leads V1, V2, and V3
either STJ >STM or STJ >STE
or STM or STE or T amplitude ≤-100 µV
and In no more than one lead of leads V4, V5, and V6 STM or STE or T amplitude <-100 µV

Then say **Right ventricular hypertrophy with repolarization abnormality**

Right Ventricular Hypertrophy with Strain Pattern

Statement is made if:

In two or more leads V1, V2, and V3 the STM >STE and STE >T amplitude
and T amplitude <-200 µV

Then say **Right ventricular hypertrophy with strain pattern**

If **RVH2REP** and **RVHWSTER** both pass, only append with strain pattern

Left Ventricular Hypertrophy

Skip test if:
- Test **WPW dextrocardia** passed
- or Test complete **LBBB** passed
- or Test **RBBB** passed

Statement is made if:
- Maximum S amplitude in lead V1 > large S in lead V1 for age
- and Maximum S amplitude in lead V1 ≥1/4 QRS deflection in lead V1
- or Maximum R amplitude in lead V6 > large R in lead V6 for age

Then say **possible left ventricular hypertrophy** *

If test for possible **LVH** passed:
- and Maximum R amplitude in lead V6 + maximum S amplitude in lead V1 > top deflection in horizontal plane for age
- or Maximum S amplitude in lead V1 > large S in lead V1 for age + 500 µV
- and Maximum R amplitude in lead V6 > large R in lead V6 for age + 500 µV

Then say **Left ventricular hypertrophy**

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

With Repolarization Abnormality

Statement is made if any of leads I, aVL, V4, V5, and V6 have:
- STJ >STM or STJ >STE
- and STE <-50 µV
- and R amplitude ≥1100 µV
- and Possible LVH passed or LVH passed or maximum R amplitude in lead V6 > large in lead V6 for age -200 µV

Then say **left ventricular hypertrophy with repolarization abnormality**

With Strain Pattern

Statement is made if:

Test for **LVH** with repolarization abnormality passed
and In at least two of leads I, aVL, V4, V5, and V6 QRS balance is positive
and STM >STE and STE >T amplitude and T amplitude <-200 µV

Then say **left ventricular hypertrophy with strain pattern**

If any **LVH** passed, then suppress **IVCD** and **LOWV**.

If tests for possible **LVH**, **LVH**, or **LVH2REP** failed and the Q amplitude in lead V6 > the deep Q in lead V6 for age + 200 µV, then say **Deep Q wave in lead V6, possible left ventricular hypertrophy**

Biventricular Hypertrophy

Skip test of **biventricular hypertrophy** if:

Test **WPW** or **dextrocardia** passed
or If any test **RBBB** passed
or Test **LBBB** passed

Statement is made if:

Test 1:

LVH passed
and Maximum R amplitude in lead V1 ≥ mean R amplitude in lead V1 for age + 300 µV
or Maximum S amplitude in lead V6 > mean S amplitude in lead V6 for age + 300 µV

Test 2:

LVH failed and RVH passed
and Maximum S amplitude in lead V1 > mean S amplitude in lead V1 for age + 300 µV
or Maximum R amplitude in lead V6 > mean R amplitude in lead V6 for age + 300 µV

Test 3:

LVH failed and **RVH** failed
and Lead V4 ratio of QRS deflection <35%
and Lead QRS deflection >R amplitude + S amplitude in lead V4 for age

Then say **possible biventricular hypertrophy** *

If **BVH** test 3 passed, then say **prominent midprecordial voltage, possible biventricular hypertrophy** *

If **LVH** and **RVH** passed and **LVH2REP** or **RVH2REP** passed, then say **BVH with secondary repolarization abnormality**

If **LVH** and **RVH** passed and **LVHWSTR** or **RVHWSTR** passed, then say **biventricular hypertrophy with strain pattern**

If **LVH** and **RVH** passed with no **2REP** or **WSTR**, then say **biventricular hypertrophy**

If **BVH**, suppress **RVH** and **LVH** statements.

If **PMDPV** and possible **BVH** passed, then suppress QV6.

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Infarction

Possible Lateral Infarct

Statement is made if:

Test **LBBB** failed
and In at least three of leads I, aVL, V4, V5, and V6 Q amplitude >100 µV
and Q duration >24 ms
and Q/R ratio >40%

Then say **possible lateral infarct**

Suppress QV6

Possible Inferior Infarct

Statement is made if:

Tests for **RVH**, **BVH**, **LVH**, and **RBBB** failed
and Q duration in lead aVF >30 ms
and Q amplitude in lead aVF >100 µV
and Q/R ratio in aVF >35%

Then say **possible inferior infarct**

Then suppress QV6

ST Abnormality (Elevation)

Skip all test ST abnormality (elevations) if:
Test **WPW** or **dextrocardia** passed
or Heart rate >120 bpm and **RBBB** passed
or Test **LBBB** passed

Nonspecific ST Abnormality (Elevation)

Statement is made if:
All tests of infarct failed
and Test **RBBB** failed
and QRS duration <120 ms
and In any two of leads I, II, III, aVF, and V3 through V6 (if age <12 years skip lead V3) Minimum STJ, STM, and STE are all ≥50 µV
and The slope from QRS onset to J point ≥ slope of ST segment
and T is not tall

Then say **nonspecific ST abnormality**

Repolarization Tests

Skip statement if:
QRS >140 ms, or **LBBB**, **RBBB**, or **MI** is present

Continue all early repolarization tests if:
Corrected Q-T interval is between 370 and 460 ms
and Any test infarct failed
and Test **IRBBB** failed
and Test **ILBBB** failed
and Test **RBBB** failed
and Test **RVH** failed
and Test **LVH** failed
and QRS duration <120 ms
or If any ST elevation >200 µV in the precordial leads
and ≥100 µV in the limb leads (other than leads aVR and V1)
and The QRS balance is positive

*** REPOLARIZATION TEST 1 ***

Count leads from leads V1 through V6 with a QRS balance >0 in which both STJ and STM are >75 µV
plus The number of leads from I, II, III, aVL, and aVF with a QRS balance >0 in which ST amplitude ≥50 µV
also Compute the sum of the amplitudes of the smaller of STJ and STM for each lead which passes

*** REPOLARIZATION TEST 2 ***

Count the number of leads with tall T waves which passed repolarization test 1

ST Elevation, Early Repolarization, Pericarditis or Injury

Skip statement if QRS >140 ms, or **LBBB**, **RBBB**, or **MI** is present.
Statement is made if:

- Three or more leads pass repolarization test 1
- and — The sum from repolarization test 1 ≥450 µV

or

- Any ST elevation >200 µV in the precordial leads
- and — ≥100 µV in the limb leads (other than leads aVR and V1)
- and — QRS balance is positive
- or either * — In at least one lead of I, II, aVF, and V3 through V6 (skip lead V3 if age <12 years) the T amplitude is negative
  - or — T' amplitude <-50 µV
- or * — If in lead aVL the T or T' amplitude <-100 µV and
  - either — QRS axis <50 degrees
  - or — Any lead II, III, and aVF the minimum ST amplitude >100 µV and Lead V5 or V6 the minimum ST amplitude <50 µV
- or * — If in at least two leads (other than leads aVR, V1, V2, and V3 if age <12 years) minimum ST amplitude <0 µV
- or * — If in at least one lead (other than leads aVR, V1, V2, and V3 if age <12 years) minimum ST amplitude <-50 µV and if in at least two leads (other than lead aVR, V1, V2, or V3 if age <12 years) minimum ST amplitude <20 µV

Then say **ST elevation consider early repolarization, pericarditis or injury** †

* If tests marked with asterisk pass under any condition, skip to pericarditis tests.

† This statement will not appear if screening criteria is turned on.
See Appendix F for more information.

ST Elevation, Probably Due to Repolarization

Statement is made if:

Test ST elevation, consider early repolarization, pericarditis, or injury not stated

and In more than half of the leads passing repolarization test 1, T is also tall

Then say **ST elevation, probably due to repolarization** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Early Repolarization

Statement is made if:

More than five leads pass early repolarization test 1 and T wave is tall in five or more leads

and The sum calculated in early repolarization test 1 $\geq$500 µV

Then say **early repolarization** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Possible Acute Pericarditis

Skip test acute pericarditis if:

Any test infarct passed

or QRS duration >120 ms

Count leads from leads I, II, and aVF in which both STJ and STM are $\geq$75 µV

plus The count of leads (leads V2 through V6 and skip leads V2 and V3 if age <12 years) in which both STJ and STM are $\geq$90 µV

Statement is made if:

The total count is at least five

and In any of leads I, II, V4, V5, and V6 T amplitude minus the minimum (STJ or STM) is positive and STJ minus (STJ or STM) >T amplitude minus the minimum (STJ or STM)

and In all leads (other than leads aVR and V1 and skip leads V2 and V3 if age <12 years) both STJ and STM are >-100 µV or T or T' $\geq$0 µV

Then say **possible acute pericarditis** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Acute Pericarditis

Statement is made if **possible pericarditis** is made and:

The count of leads (lead I, II, or aVF) in which both STJ and STM are ≥90 µV plus the count of leads (leads V2 through V6 and skip leads V2 and V3 if age <12 years) in which both STJ and STM are ≥110 µV ≥5 µV

Then say **acute pericarditis**

Injury Pattern Tests

Skip test all injuries if:

Any tests pericarditis passed

(Done on all 12 leads individually)
For all of the following INJURY tests, if age <12 years skip testing leads V1, V2, and V3.

Test 1:
Inspect QRS balance:

Count the number of leads in frontal plane where QRS balance is <1000 µV and in the precordium where the QRS balance <2000 µV. Test 1 passes if count = 12.

Test 2:
Test at all 12 leads (except leads aVR and V1) for ST elevation. Skip lead groups with infarct present.
For this test and subsequent tests, the parameter ST limit is set for each lead:

*ST LIMIT = 200 µV unless,
If frontal leads (I, II, III, aVR, aVL, and aVF)
or If in leads V5 and V6 (R-S) ≥0 µV then = 100 µV
If lead is elevated
and QRS balance is positive
or In precordial leads maximum R + maximum S <1500 µV
or In frontal plane maximum R + maximum S <1000 µV
or If QRS balance is negative and ratio of maximum S amplitude to maximum R + maximum S <75%
then Test 2 passes

Test 3:
Look for ST elevation based on QRS duration (except leads V1 and aVR)
Skip lead groups with MI present

*Apply ST LIMIT as above
If lead is elevated
and QRS duration is 120 to 130 ms and QRS balance is positive
and Ratio of QRS balance to QRS deflection must be >15%

or QRS duration ≥130 but <150 ms
Ratio of QRS balance to QRS deflection must be >25%
or QRS duration ≥150 ms
Ratio of QRS balance to QRS deflection must be >50%
or QRS duration <120 ms and QRS balance is negative or positive

If any of the leads meet the above criteria, then inspect further for that lead group.

*Apply ST LIMIT as above for specific lead group
If test 1 passed
and If in precordial leads minimal STJ and STM >300 µV = set injury flag
or If in precordial leads maximum R + maximum S <1000 µV
and Minimal STJ and STM >200 µV + set injury flag
or If in frontal lead minimum STJ and STM >200 µV = set injury flag
or If frontal lead maximum R + maximum S <750 µV
and Minimal STJ and STM >100 µV = set injury flag
or In any lead the minimal STJ and STM >1/2 T amplitude = set injury flag

else

If test 2 passed
*Apply ST LIMIT as above
and If precordial lead, ST elevation >300 µV = set injury flag
or If frontal lead, ST elevation >200 µV = set injury flag
or If in any lead, the minimal STJ and STM >1/2 T amplitude
or If in any lead T' amplitude <-150 µV
and T' amplitude (absolute value) >1/8 of T amplitude for inspected lead that is elevated
or If T amplitude is negative = set injury flag

Test 4

If test 3 passes:

and If in precordial leads, STJ and STM >100 µV
or If in frontal leads, STJ and STM >50 µV
and If in elevated lead T' amplitude <-150 µV
and T' amplitude (absolute value) >1/8 of T amplitude = set injury flag
or If T amplitude is negative = set injury flag

Test 5

If test 1 or 2 passed, look for reciprocal changes:

and Count the number of leads where:
Test 1 minimal STJ and STM <-100 µV in any lead
Test 2 minimal STJ and STM <-50 µV in any lead
Test 3 minimal STJ and STM <0 µV in any lead
and If Test 1 count >0
or If Test 2 count ≥2
or If Test 2 count ≥1 and test 3 count ≥3 set injury flag

Test 6
If test 5 fails and injury flag is set:
and No MIs passed
and **QRSV** passed
and No **LVHR** present

Then state **ST elevation, early repolarization, pericarditis or injury**

If **LVH** with repolarization is present, the injury flag is clear and no statement is made.

ST Elevation in Anterior Leads

Statement is made if:
In any lead V2, V3, or V4 criteria for ST elevation
and Any injury test passed

Then say **ST elevation in anterior leads**

ST Elevation in Lateral Leads

Statement is made if:
In any lead I, aVL, V5, or V6 criteria for ST elevation
and Any Injury test passed

Then say **ST elevation in lateral leads**

ST Elevation in Inferior Leads

Statement is made if:
In any lead II or aVF criteria for ST elevation
and Any injury test passed

Then say **ST elevation in inferior leads**

If anterior injury, lateral injury, and inferior injury present, then say **ST elevation in anterolateral leads ST elevation in inferior leads**

If anterior and lateral injury present, then say **ST elevation in anterolateral leads**

If inferior and lateral injury present, then say **ST elevation in inferolateral leads**

ST Abnormality (Depression)

Skip ST abnormality (depression) if:

Test **WPW** or **dextrocardia** passed
Test **LBBB** passed
QRS duration >100 ms
Test **RBBB** passed
Test **LVH2REP** passed
Test **RVH2REP** passed

Statement is made if:

Acute MI or injury present
and Any precordial leads and acute anterior infarct present
or Anterior injury present
or Acute septal infarct present
or In lateral leads (leads I, aVL, V5 and V6) and lateral injury present or acute lateral infarct present
or In inferior leads (leads II, III, and aVF) and inferior injury present or acute inferior infarct
and If the largest of (STJ and STM minimum value greater than 0 µV) in any lead > the smallest of the absolute value of (STJ, STM, or STE maximum value <-100 µV) in any lead except lead aVR

Then SKIP ST ABNORMALITY TEST

Condition for skipping applies to all ST tests and if age <12 years skip testing leads V1, V2, and V3.

Junctional ST Depression Probably Normal

Skip test if:

Test **LVH** secondary repolarization passed
or Test **RVH** with secondary repolarization passed
or Test nonspecific ST abnormality (elevation) passed
or Test **RBBB** passed
or Any acute infarct or injury test passed

Statement is made if:

In any two of all leads, except lead aVR, STJ <-100 µV and STE >0 µV

Then say **junctional ST depression probably normal** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Junctional ST Depression Probably Abnormal

Skip test if:
Test **LVH** and **RVH** with secondary repolarization passed
or Test **nonspecific ST abnormality (elevation)** passed
or Test **RBBB** passed
or Test **MI** passed
Statement is made if:
STJ <-100 µV
and STE >1/2 STJ in any two of all leads except aVR
Then say **junctional ST depression probably abnormal** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

ST Abnormality Probably Digitalis Effect

Skip test if:
Test **LVH** or **RVH** secondary repolarization passed
Test **nonspecific ST abnormality (elevation)** passed
Test **RBBB** passed

Statement is made if:
either In any two of leads I, II, aVL, V4, V5, and V6:
Minimum STM or STE < minimum STJ and also -50 µV
or Heart rate ≤100 bpm
and PR interval <200 ms
and In any two of leads I, II, aVL, and V1 through V6:
Minimum STM or STE < minimum STJ
or P onset amplitude -50 µV
or -25 µV
and T amplitude >STM +100 µV

Then say **ST abnormality probably digitalis effect**

Nonspecific ST Abnormality

Skip test if:
Test **LVH** or **RVH with secondary repolarization** passed
or Test nonspecific ST abnormality (elevation) passed
or Test **RBBB** passed

Statement is made if in any two of leads I, II, aVL, aVF, V4, V5, and V6:
STJ $\leq$-50 µV and STE <0 µV
or STE $\leq$ minimum (STJ and STM) -25 µV

Then say **nonspecific ST abnormality**

If test **atrial fibrillation** passed simultaneously, then append **probably digitalis effect**

If **MI** present, suppress all ST abnormality statements.

ST Depression Consider Subendocardial Injury or Digitalis Effect

Skip test if:
Test **LVH** or **RVH** secondary repolarization passed

Statement is made if:
In any two of leads I, II, aVL, aVF, and V2 through V6 STJ and STM are <-100 µV (If test **RBBB** passed, then do not test leads V2, V3, and V4)

Then say **ST abnormality consider subendocardial injury or digitalis effect**

Suppress nonspecific ST statements.

ST Depression in Septal Leads

Statement is made if:
Test septal and posterior infarct failed
and In lead V1 or V2, STJ and STM are $\leq$-200 µV

Then say **ST depression in septal leads**

ST Depression in Anterior Leads

Statement is made if:
Test anterior and posterior infarct failed
and Tests LVH with repolarization abnormality failed
and In lead V3 or V4, STJ and STM are ≤-200 µV

Then say **ST depression in anterior leads**

ST Depression in Lateral Leads

Statement is made if:
Test **lateral infarct** failed
and Test **LVH with repolarization abnormality** failed
and Lead V5 or V6, STJ and STM are ≤200µV
and In lead I or aVL, STJ and STM are ≤100µV

Then say **ST depression in lateral leads**

ST Depression in Inferior Leads

Statement is made if:
Test **inferior infarct** failed
and Test **LVH** with repolarization abnormality failed
and In lead II or aVF, STJ and STM are ≤-100 µV

Then say **ST depression in inferior leads**

If any tests subendocardial injury passed, then suppress **nonspecific ST abnormality**, **junctional ST depressions**, and **ST depression consider digitalis effect**.

If inferior myocardial infarction and lead III has STJ >100 µV, suppress ST depression in lateral leads statement.

If ST depression in anterior and lateral leads present but no ST depression in septal leads present, then say
ST depression in anterolateral leads

If ST depression in inferior and lateral leads present but no ST depression in septal and anterior leads present, then say
ST depression in inferolateral leads

If ST depression in septal and anterior leads present, then say
ST depression in anteroseptal leads

T Wave Abnormality

Skip test if:
Test **WPW** or **dextrocardia** passed
or Test **LVH with repolarization abnormality** passed
or Test complete **RBBB** passed
or Test complete **LBBB** passed

Conditions for skipping test applies to all T wave tests.

Abnormal QRS-T Angle, Consider Primary T Wave Abnormality

Skip test if:
Any test infarct passed
or Test **RBBB** passed

Statement is made if:
QRS axis – T axis ≥60 degrees
and T axis <0 degrees
or QRS axis – T axis ≤-60 degrees
and T axis >90 degrees

Then say **abnormal QRS-T angle, consider primary T wave abnormality** *

* This statement will not appear if screening criteria is turned on. See Appendix F for more information.

Nonspecific T Wave Abnormality

Skip test if:
Any test infarct passed
or Test **RBBB** passed

For age <16 years skip testing leads V1 through V4.
NONSPECIFIC T ABNORMALITY TEST

For each lead to be tested:
Set test limit
If QRS amplitude is positive, limit value
Is 1/20 QRS amplitude + 25 µV
or If QRS amplitude is negative, limit value is 25 mV
Then Count lead as passing test if special T Amplitude ≤ the test limit and (special T <0 or TA <200 µV)

Test leads as follows:

First test lead V3 through V6
If lead V3 passed test, then test lead V2; then test leads I, II, and aVL
If special T amplitude exceeds 150 µV in leads I, II, and aVL do not test

and If QRS balance minus special T <0 µV in aVL, or if QRS balance is negative, do not test aVL

If more than two leads pass this test, then say **nonspecific T wave abnormality**

If test **atrial fibrillation** passed simultaneously, then append **probably digitalis effect**

T Wave Inversion in Lateral Leads

Statement is made if:

Test lateral infarct failed

and In any two of leads I, aVL, V5, and V6, special T amplitude $\leq$-100 µV
(Do not test aVL if QRS balance is negative.)

Then say **T wave inversion in lateral leads**

If test atrial fibrillation passed simultaneously, then append **or digitalis effect**

If test nonspecific ST abnormality simultaneously passed, then prefix **ST&**

T Wave Inversion in Inferior Leads

Statement is made if:

Any test inferior infarct failed

and Special T amplitude $\leq$-100 µV in lead II or aVF (Test lead aVF only when QRS amplitude is positive.)

Then say **T wave inversion in inferior leads**

If test atrial fibrillation passed simultaneously, append **or digitalis effect**

If test nonspecific ST abnormality simultaneously passed, then prefix **ST&**

T Wave Inversion in Inferolateral Leads

Statement is made if:
Test T wave abnormality consider inferior ischemia passed
and Test T wave abnormality consider lateral ischemia passed

Then say **T wave inversion in inferolateral leads**

If any T wave inversion tests pass, suppress **STEREP** and **EREP**.

If any T wave inversion tests pass, suppress **NST**, **STJD1**, **STJD2**, **STDIG**, **NT**, **AQRST**, and **STD**.

Nonspecific ST and T Abnormality

Statement is made if:
Any specific T wave inversion tests failed
and Pericarditis test failed
and ST depression test failed
and Test nonspecific ST abnormalities passed
and Test nonspecific T abnormality passed

Then say **nonspecific ST & T abnormality**

If test atrial fibrillation passed, simultaneously append **probably digitalis effect**

If test **NSTT** passed, suppress **NST**, **STJD1**, **STJD2**, **STDIG**, **NT**, **AQRST**, and **STD**.

QT Abnormalities

Skip test prolonged QT if:
Test **WPW** or **dextrocardia** passed

Statement is made if:
QTc ≥High QT for age
and Ventricular rate ≤100 bpm
and **IVCB** not present
and **RBBB** not present
and **LBBB** not present
and QRS duration <120 ms

Then say **Borderline prolonged QT**

Suppress **EREP and STEREP**.

If **LVH** or **RVH**, **BVH** or **IVCD**, or **IRBBB** or **ILBBB** append **, may be secondary to QRS abnormality**

For your notes

8 ECG Classification

For your notes

Overview

Unless generation of ECG Classification is suppressed in a particular platform's setup, each ECG is assigned one of the following classifications by the 12SL analysis program (listed in order of increasing severity):

- Normal ECG (N)
- Otherwise normal ECG (O)
- Borderline ECG (B)
- Abnormal ECG (A)

Most statements generated by 12SL have a classification associated with them. Some statements are informative only and do not have an associated classification. These are typically statements that are appended or prepended to a primary statement. The classification of each 12SL statement is given in Appendix B – "Statement Library by Number". The overall ECG classification is made based on the most severe single statement in the 12SL diagnosis.

As a very simple example, say an ECG contained the single 12SL statement: "Normal Sinus Rhythm". The classification for this statement is "N". The overall classification for this ECG would be "Normal ECG".

As another example, say 12SL generated the following statements for an ECG (the classification of each single statement is shown in parentheses):

- Sinus bradycardia (O)
- with frequent (none)
- premature ventricular complexes (O)
- in a pattern of bigeminy (O)
- Left ventricular hypertrophy (A).

In this case, the most severe single statement is "Left ventricular hypertrophy", with a classification of "A", which would result in an ECG classification of "Abnormal ECG".

For your notes

9 Serial Comparison

For your notes

Introduction

In clinical settings the general practice of providing a complete interpretation of an ECG requires a comparison of the current ECG to a previous ECG[1]. The technique of comparing the current ECG to the previous ECG of a patient is termed serial electrocardiography. Serial electrocardiography is used to identify changes in the patient's electrocardiogram. More importantly, it is used to detect "clinically significant changes" in a patient's electrocardiogram and to determine if an ECG abnormality is new, old, or unchanged. Serial ECGs have been shown to be most helpful in the detection of acute infarction.[3, 4] Studies have shown that a physician's accuracy in diagnosing acute myocardial infarction rose from 51% to 83% when serial ECG tracings were used[3], and in some cases was the sole factor in the detection of infarction[5]. Additionally, research has shown that the number of statements that are edited or changed by overreading physicians can be reduced by as much as 76% when a computerized serial comparison program is used. When previously edited changes on the ECGs are used by the serial comparison program, the number of statements needing changes can be reduced by 84%[1].

GE's Marquette 12SL Serial ECG Comparison Program has been developed to emulate the techniques used by trained electrocardiographers in the comparison of serial electrocardiograms and is designed to take advantage of the Marquette 12SL ECG analysis program's interpretation and measurements. The Marquette 12SL ECG serial comparison program was developed to use statements, ECG measurements, and waveform comparison techniques to maximize performance and accuracy in the detection of clinically significant changes in rhythm, P, QRS, ST and T waves. The MUSE system, which stores electrocardiograms with physician edited interpretations to both individual ECGs and serial comparisons, in unison with the serial comparison program, allows for accurate and expedient processing of a patient's ECG data.

Although the 12SL analysis is completed at the cardiograph at the time of the ECG acquisition, the serial comparison analysis is done at the MUSE when the MUSE receives the ECGs. This is transparent to the electrocardiographer who reads the ECGs printed from the MUSE workstation, and because of the integration of the programs, the serial comparison interpretation is appended to the original 12SL interpretation.

Overview of Serial Comparison Analysis

Rhythm Analysis

- Dominant rhythms compared first (sinus, ventricular, atrial fibrillation, etc.) via statements
- Rhythm modifiers compared second only if dominant rhythm does not change

QRS Analysis

- QRS comparison is done via statements, measurements, and waveform analysis
- Aim is to detect changes in conduction and/or infarction
- Changes in axis and voltage (amplitude) are also detected
- Looks for the first occurrence of an infarct and labels it on the ECG
- For infarction (if acute) more sensitive criteria is used
- Time between ECGs is used to adapt criteria sensitivity

ST-T Analysis

- Looks for the presence/absence of acute infarction or ischemia
- Looks for evolution of the ST-T changes in an acute MI
- Uses MI age categories to “adapt sensitivity of detection”
- < 4 days old

NOTE

The serial comparison program looks for significant changes in the waveforms when doing the contour comparisons. It is not unusual to have an ECG that may have narrowly met the criteria for a particular 12SL statement and have another ECG that just missed the criteria thresholds, yet there are no significant differences in the waveforms themselves. In such a case, the first ECG would have a statement that would be absent from the second, and could possibly even have a different overall ECG classification. However, if the serial comparison program does not discern a significant difference in the actual waveforms, it will simply state that “no significant changes have occurred.”

Details of Serial Comparison Analysis

Rhythm Comparison

Rhythm comparison is done via statements. (Edited rhythm statements may be used by the program if they are from the original MUSE system library and are not user added statements or free text.) However, actual Marquette 12SL program measurements are compared to assist in the detection of significant changes for first degree AV block and short PR interval. If a major rhythm change occurs, it is stated without reference to changes that occur in the rhythm modifier statements. Major rhythm changes are stated without reference to rate. For example, the statement "sinus rhythm has replaced junctional rhythm" is made instead of "sinus tachycardia has replaced unusual P axis and short PR, probable junctional bradycardia." Only when the basic rhythm is the same, does the program mention changes that occur in the rhythm modifier statements (e.g., PVCs, PACs, 1st degree AV Block, etc.).

Clustering of rhythm modifier changes is used. The program "clusters" modifier statements regarding ectopic beats as either premature ventricular or premature supraventricular. Other rhythm modifiers that are also clustered are (complete heart block and AV dissociation), (sinus pause and second degree SA block Mobitz I and II), (second degree AV block Mobitz I and II). Certain rhythm modifier statements such as second degree AV block, complete heart block or AV dissociation are given a higher priority than other rhythm modifier statements. For example, if the previous ECG has complete heart block and the current ECG has first degree AV block, then no statement is made about the PR interval for first degree AV block, but complete heart block is stated to be no longer present.

Rate dependent and PR interval calls are checked against the measurements before statements about change are made. Rate change statements are made at a more sensitive level if both ECGs contain electronic ventricular pacemakers. If a rhythm change (i.e. WPW or electronic pacing) results in a QRS change, the QRS-ST-T comparison is suppressed. If either of the ECGs being compared has "undetermined rhythm" then no rhythm comparison is performed.

QRS Comparison

QRS comparison uses statements, measurements and waveforms. The emphasis is in detecting conduction and infarction changes. However, changes concerning axis and/or voltage are also stated but with less sensitive criteria to take into account "normal variability" in the ECG and changes that may be caused by inaccurate and inconsistent lead placement.

When WPW is stated in either the current or the previous ECG interpretation, then further QRS and repolarization comparisons are inhibited.

For conduction, measurement comparison and waveform correlation are used to determine whether the change is large enough to warrant the program stating it. If a major conduction change occurs, comparison of the repolarization is suppressed (skipped) since these are considered secondary changes.

Comparison concerning infarction is the most complicated and sophisticated analysis scheme in the program. Once a statement concerning infarction occurs in either of the ECGs being compared, then parameters related to infarction along with waveform correlation techniques and measurements are used to detect "clinically significant" change. The program will also search all of a patient's previous records and inform the user as to when the infarction first appeared in the series of ECGs.

If both ECGs have definite evidence of infarction (or if a lesser degree of infarction evidence is unchanged, i.e. the ECG waveform data in the leads exhibiting the infarction "look very similar"), then the program states "no significant change has occurred." If a "clinically significant" waveform change is evident, then the program will state it appropriately as "(specific location) MI now present" or "criteria for (specific location) MI no longer present" or if subtle changes in the Q-waves (initial part of the QRS) have been detected, the program will state "questionable change in initial forces of (specific location)."

This approach is used until repolarization changes or injury (ST-elevation) is evident in either of the ECGs. Upon development of a significant repolarization change in the presence of myocardial infarction evidence (QRS changes), the program becomes much more sensitive to changes in the QRS-ST-T. When there are ST-T wave changes detected by the program, the comparison becomes much more detailed. Sensitivity for detection of "clinically significant changes" changes with respect to the time difference between the two ECGs. Sensitivity and program statements will change depending on the following time differences between the acquisition dates of the ECGs: same day to 3 days, 4 days to 21 days, 22 days to 365 days and more than 365 days (1 year). When the ST-T wave changes occur within the first 3 days, the changes will be labeled as new or acute or as "serial changes of an evolving myocardial infarction." ST-T wave changes occurring between 4 days to 1 year which are becoming less severe (ST-T becoming more normal) will be described as "serial changes of myocardial infarction." If at any time the repolarization (ST-T) become more abnormal, the program will state that there are new changes present.

Repolarization Comparison

The ST segments and T waves are compared via the 12SL measurements. When significant changes are detected, they are indicated using "descriptive statements." For example, the program will state that the "T wave amplitude in (specific lead group) has increased or decreased." The same is done for ST segment elevation and depression. If there is T wave inversion, the comparison will indicate the extent of the T wave inversion by making the statement "T wave inversion in (specific lead group) is more evident, less evident, now evident or no longer evident." When the T wave abnormality is "non-specific," then the

program will indicate whether the nonspecific T wave abnormality is worse or improved in (specific lead group).

Miscellaneous Comparisons

Pediatric ECGs are not compared but the previous ECGs date and time are indicated by the program.

The Serial Comparison program tracks the length of the total interpretation. This includes the original ECG as well as the serial comparison interpretation. If more than 10 lines of text occurs and the serial comparison interpretation is more than 6 full lines of text, then the serial comparison program will suppress the comparison interpretation and simply state “significant changes have occurred.” This is done to prevent the use of an additional page for the printing of the ECG.

If all of the previous ECGs are on an archive volume that is not “on-line" then the serial comparison program informs the user with the statement “manual comparison required data is off line and on volume#.” If all previous ECGs are analog ECGs, then the program states “manual comparison required, analog tracing.”

References

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5. Kannel WB, Abbott Rd. Incidence and prognosis of unrecognized myocardial infarction; an update on the Framingham study. N Engl J Med 1984;311:1144-1147.
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Appendix A – Statement Library by Acronym

For your notes

Acronym	Statement
AB	ABNORMAL ECG
ABCOND	ABERRANT CONDUCTION
ABER	WITH PREMATURE VENTRICULAR OR ABERRANTLY CONDUCTED COMPLEXES
ABR	OTHERWISE NORMAL ECG
AC	, POSSIBLY ACUTE
ACCEL	ACCELERATED
ACUMI	** ** ** ** * ACUTE MI * ** ** ** **
AFB	LEFT ANTERIOR FASCICULAR BLOCK
AFIB	ATRIAL FIBRILLATION
AGSPAMI	** AGE AND GENDER SPECIFIC ECG ANALYSIS **
AINJ	ANTERIOR INJURY PATTERN
AIOHAI	ST ELEVATION CONSIDER ANTERIOR INJURY OR ACUTE INFARCT
ALAD	ABNORMAL LEFT AXIS DEVIATION
ALIHAI	ST ELEVATION CONSIDER ANTEROLATERAL INJURY OR ACUTE INFARCT
ALINJ	ANTEROLATERAL INJURY PATTERN
ALMI	ANTEROLATERAL INFARCT
ALT	T WAVE ABNORMALITY, CONSIDER ANTEROLATERAL ISCHEMIA
ALTWPW	WITH FUSION OR INTERMITTENT VENTRICULAR PRE-EXCITATION (WPW)
AMI	ANTERIOR INFARCT
AND	AND
ANLERR 1	*** MEMORY ALLOCATION FAILURE, NO ECG INTERPRETATION POSSIBLE ***
ANLERR 2	** NO QRS COMPLEXES FOUND, NO ECG ANALYSIS POSSIBLE **
ANLERR 3	** LESS THAN 4 QRS COMPLEXES DETECTED, NO INTERPRETATION POSSIBLE **
ANT	ANTERIOR LEADS
ANTLAT	ANTEROLATERAL LEADS
ANTSEP	ANTEROSEPTAL LEADS
APCK	ELECTRONIC ATRIAL PACEMAKER
ARAD	ABNORMAL RIGHT AXIS DEVIATION
ARAT	(ATRIAL RATE
ARM	*** SUSPECT ARM LEAD REVERSAL, INTERPRETATION ASSUMES NO REVERSAL
ASBINJ	MARKED ST ABNORMALITY, POSSIBLE ANTERIOR SUBENDOCARDIAL INJURY

Acronym	Statement
ASINJ	ANTEROSEPTAL INJURY PATTERN
ASMI	ANTEROSEPTAL INFARCT
AT	T WAVE ABNORMALITY, CONSIDER ANTERIOR ISCHEMIA
ATAC	ATRIAL TACHYCARDIA
AU	, AGE UNDETERMINED
AVDIS	WITH A-V DISSOCIATION
AVPCK	AV SEQUENTIAL OR DUAL CHAMBER ELECTRONIC PACEMAKER
BAE	BIATRIAL ENLARGEMENT
BIFB	*** BIFASCICULAR BLOCK ***
BIGEM	IN A PATTERN OF BIGEMINY
BIVH	BIVENTRICULAR HYPERTROPHY
BLKED	BLOCKED
BO	BORDERLINE
BORDE	BORDERLINE ECG
CAPTUR	SINUS/ATRIAL CAPTURE
CCWRT	COUNTER CLOCKWISE ROTATION OF THE HEART, MAY INVALIDATE CRITERIA FOR VENTRICULAR HYPERTROPHY
CHB	WITH COMPLETE HEART BLOCK
CJP	WITH A COMPETING JUNCTIONAL PACEMAKER
CRO	CANNOT RULE OUT
CRS	COARSE
CSEC	, AND CONSECUTIVE
CWRT	CLOCKWISE ROTATION OF THE HEART, MAY INVALIDATE CRITERIA FOR VENTRICULAR HYPERTROPHY
DPCK	DEMAND PACEMAKER; INTERPRETATION IS BASED ON INTRINSIC RHYTHM
DXTRO	DEXTROCARDIA
EABRAD	UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL BRADYCARDIA
EAR	UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL RHYTHM
EATACH	UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL TACHYCARDIA
FAV	WITH 1ST DEGREE A-V BLOCK
FLUT	ATRIAL FLUTTER
FREQ	WITH FREQUENT
FUS	FUSION COMPLEXES

Acronym	Statement
IFLAT	INFEROLATERAL LEADS
IINJ	INFERIOR INJURY PATTERN
IIOHAI	ST ELEVATION CONSIDER INFERIOR INJURY OR ACUTE INFARCT
ILBBB	INCOMPLETE LEFT BUNDLE BRANCH BLOCK
ILIHAI	ST ELEVATION CONSIDER INFEROLATERAL INJURY OR ACUTE INFARCT
ILINJ	INFEROLATERAL INJURY PATTERN
ILT	T WAVE ABNORMALITY, CONSIDER INFEROLATERAL ISCHEMIA
IMI	INFERIOR INFARCT
INDAX	INDETERMINATE AXIS
INF	INFERIOR LEADS
INFPOS	INFEROPOSTERIOR LEADS
INJONV	ST ELEVATION, CONSIDER INJURY OR VARIANT ASSOCIATED WITH LVH
IPMI	INFERIOR-POSTERIOR INFARCT
IRBBB	INCOMPLETE RIGHT BUNDLE BRANCH BLOCK
IRR	IRREGULAR
IRREG	WITH UNDETERMINED RHYTHM IRREGULARITY
ISBINJ	MARKED ST ABNORMALTIY, POSSIBLE INFERIOR SUBENDOCARDIAL INJURY
IT	T WAVE ABNORMALITY, CONSIDER INFERIOR ISCHEMIA
IVCB	NON-SPECIFIC INTRA-VENTRICULAR CONDUCTION BLOCK
IVCD	NON-SPECIFIC INTRA-VENTRICULAR CONDUCTION DELAY
IVR	IDIOVENTRICULAR RHYTHM
JBRAD	UNUSUAL P AXIS AND SHORT PR, PROBABLE JUNCTIONAL BRADYCARDIA
JESC	WITH JUNCTIONAL ESCAPE COMPLEXES
JR	UNUSUAL P AXIS AND SHORT PR, PROBABLE JUNCTIONAL RHYTHM
JST	JUNCTIONAL ST DEPRESSION, PROBABLY ABNORMAL
JSTN	JUNCTIONAL ST DEPRESSION, PROBABLY NORMAL
JTACH	UNUSUAL P AXIS AND SHORT PR, PROBABLE JUNCTIONAL TACHYCARDIA
JUNBRAD	JUNCTIONAL BRADYCARDIA
JUNCTR	JUNCTIONAL RHYTHM
LABRAD	LEFT ATRIAL BRADYCARDIA
LAE	LEFT ATRIAL ENLARGEMENT
LAD	LEFTWARD AXIS

Acronym	Statement
LAD3	LEFT AXIS DEVIATION
LAR	LEFT ATRIAL RHYTHM
LARG	LARGE
LAT	LATERAL LEADS
LATACH	LEFT ATRIAL TACHYCARDIA
LBBB	LEFT BUNDLE BRANCH BLOCK
LINJ	LATERAL INJURY PATTERN
LIOHAI	ST ELEVATION CONSIDER LATERAL INJURY OR ACUTE INFARCT
LMI	LATERAL INFARCT
LNGQT	PROLONED QT
LOWV	LOW VOLTAGE QRS
LSBINJ	MARKED ST ABNORMALITY, POSSIBLE LATERAL SUBENDOCARDIAL INJURY
LT	T WAVE ABNORMALITY, CONSIDER LATERAL ISCHEMIA
LVH	VOLTAGE CRITERIA FOR LEFT VENTRICULAR HYPERTROPHY
LVH2	LEFT VENTRICULAR HYPERTROPHY
LVH3	MODERATE VOLTAGE CRITERIA FOR LVH, MAY BE NORMAL VARIANT
MAFB	(MASKED BY FASCICULAR BLOCK?)
MALT	MARKED T WAVE ABNORMALITY, CONSIDER ANTEROLATERAL ISCHEMIA
MAT	MARKED T WAVE ABNORMALITY, CONSIDER ANTERIOR ISCHEMIA
MBZI	WITH 2ND DEGREE A-V BLOCK (MOBITZ I)
MBZII	WITH 2ND DEGREE A-V BLOCK (MOBITZ II)
MILT	MARKED T-WAVE ABNORMALITY, CONSIDER INFEROLATERAL ISCHEMIA
MISIZ	*** QRS CONTOUR SUGGESTS INFARCT SIZE IS PROBABLY
MIT	MARKED T WAVE ABNORMALITY, CONSIDER INFERIOR ISCHEMIA
MLT	MARKED T WAVE ABNORMALITY, CONSIDER LATERAL ISCHEMIA
MOD	MODERATE
MSAR	WITH MARKED SINUS ARRHYTHMIA
MSBRAD	MARKED SINUS BRADYCARDIA
MSTDAL	MARKED ST ABNORMALITY, POSSIBLE ANTEROLATERAL SUBENDOCARDIAL INJURY
MSTDAS	MARKED ST ABNORMALITY, POSSIBLE ANTEROSEPTAL SUBENDOCARDIAL INJURY
MSTDIL	MARKED ST ABNORMALITY, POSSIBLE INFEROLATERAL SUBENDOCARDIAL INJURY
NML	NORMAL ECG

Acronym	Statement
NOPF	(NO P-WAVES FOUND)
NQTACH	NARROW QRS TACHYCARDIA
NSR	NORMAL SINUS RHYTHM
NST	NONSPECIFIC ST ABNORMALITY
NSTT	NONSPECIFIC ST AND T WAVE ABNORMALITY
NT	NONSPECIFIC T WAVE ABNORMALITY
NWA	NORTHWEST AXIS
OCC	WITH OCCASIONAL
ODIG	OR DIGITALIS EFFECT
OR	OR
PAC	PREMATURE ATRIAL COMPLEXES
PAUSE	WITH SINUS PAUSE
PCARD	ACUTE PERICARDITIS
PCK	ELECTRONIC VENTRICULAR PACEMAKER
PDIG	, PROBABLY DIGITALIS EFFECT
PEC	PREMATURE ECTOPIC COMPLEXES
PEDANL	** ** ** ** * PEDIATRIC ECG ANALYSIS * ** ** ** **
PFB	LEFT POSTERIOR FASCICULAR BLOCK
PJC	PREMATURE JUNCTIONAL COMPLEXES
PLV	PROMINENT LATERAL VOLTAGE
PMDPV	PROMINENT MID-PRECORDIAL VOLTAGE,
PO	POSSIBLE
POS	POSTERIOR LEADS
POSTMI	POSTERIOR INFARCT
PPV	PROMINENT POSTERIOR VOLTAGE
PSVC	PREMATURE SUPRAVENTRICULAR COMPLEXES
PULD	PULMONARY DISEASE PATTERN
PVC	PREMATURE VENTRICULAR COMPLEXES
PVCF	PREMATURE VENTRICULAR AND FUSION COMPLEXES
PXT	, WITH POSTERIOR EXTENSION
QCERR	*** POOR DATA QUALITY, INTERPRETATION MAY BE ADVERSELY AFFECTED
QESPMI	EARLY TRANSITION INCREASED R/S RATIO IN V1, CONSIDER POSTERIOR INFARCT

Acronym	Statement
QRST	ABNORMAL QRS-T ANGLE, CONSIDER PRIMARY T WAVE ABNORMALITY
QRSV	MINIMAL VOLTAGE CRITERIA FOR LVH, MAY BE NORMAL VARIANT
QRSW	WITH QRS WIDENING
QRSW-2ST	WITH QRS WIDENING AND REPOLARIZATION ABNORMALITY
QV6	DEEP Q-WAVE IN LEAD V6,
RABRAD	LOW RIGHT ATRIAL BRADYCARDIA
RAD	RIGHTWARD AXIS
RAD4	RIGHT AXIS DEVIATION
RAD5	RIGHT SUPERIOR AXIS DEVIATION
RAE	RIGHT ATRIAL ENLARGEMENT
RAR	LOW RIGHT ATRIAL RHYTHM
RATACH	LOW RIGHT ATRIAL TACHYCARDIA
RBBB	RIGHT BUNDLE BRANCH BLOCK
RBBRVH	RIGHT BUNDLE BRANCH BLOCK -OR- RIGHT VENTRICULAR HYPERTROPHY
REPOL	EARLY REPOLARIZATION
RETC	WITH RETROGRADE CONDUCTION
RSAD	ABNORMAL RIGHT SUPERIOR AXIS DEVIATION
RSR	RSR' OR QR PATTERN IN V1 SUGGESTS RIGHT VENTRICULAR CONDUCTION DELAY
RVE+	, PLUS RIGHT VENTRICULAR HYPERTROPHY
RVH	RIGHT VENTRICULAR HYPERTROPHY
RVR	WITH RAPID VENTRICULAR RESPONSE
SABI	WITH 2ND DEGREE SA BLOCK (MOBITZ I)
SABII	WITH 2ND DEGREE SA BLOCK (MOBITZ II)
SAR	WITH SINUS ARRHYTHMIA
SAV	WITH 2ND DEGREE A-V BLOCK
SBRAD	SINUS BRADYCARDIA
SEP	SEPTAL LEADS
SERYR1	ST ELEVATION, CONSIDER EARLY REPOLARIZATION, PERICARDITIS, OR INJURY
SERYR2	ST ELEVATION, CONSIDER EARLY REPOLARIZATION
SINJ	SEPTAL INJURY PATTERN
SMA	SMALL
SMI	SEPTAL INFARCT

Acronym	Statement
, SNDQA	MAYBE SECONDARY TO QRS ABNORMALITY
SNF	STATEMENT NOT FOUND
SPR	WITH SHORT PR
SRTH	SINUS RHYTHM
SSBINJ	MARKED ST ABNORMALITY, POSSIBLE SEPTAL SUBENDOCARDIAL INJURY
ST&	ST &
STABAND	ST ABNORMALITY AND
STACH	SINUS TACHYCARDIA
STDEP	ST DEPRESSION, CONSIDER SUBENDOCARDIAL INJURY OR DIGITAL EFFECT
STDIG	ST ABNORMALITY, POSSIBLE DIGITALIS EFFECT
STDPIN	ST DEPRESSION IN
STELIN	ST ELEVATION IN
SVR	WITH SLOW VENTRICULAR RESPONSE
S1S2S3	S1-S2-S3 PATTERN, CONSIDER PULMONARY DISEASE, RVH, OR NORMAL VARIANT
SVT	SUPRAVENTRICULAR TACHYCARDIA
TINVIN	T-WAVE INVERSION IN
UR	UNDETERMINED RHYTHM
VAVB	WITH VARIABLE A-V BLOCK
VESC	WITH VENTRICULAR ESCAPE COMPLEXES
VFIB	VENTRICULAR FIBRILLATION
VLAR	VERY LARGE
VSMA	VARY SMALL
VTACH	VENTRICULAR TACHYCARDIA
WITH	WITH
WQR	WIDE QRS RHYTHM
WPW	WOLFF-PARKINSON-WHITE
WPWA	VENTRICULAR PRE-EXCITATION, WPW PATTERN TYPE A
WPWB	VENTRICULAR PRE-EXCITATION, WPW PATTERN TYPE B
WQTACH	WIDE QRS TACHYCARDIA
WSTR	WITH STRAIN PATTERN
W2T1	WITH 2:1 A-V CONDUCTION

Acronym	Statement
W3T1	WITH 3:1 A-V CONDUCTION
W4T1	WITH 4:1 A-V CONDUCTION
W5T1	WITH 5:1 A-V CONDUCTION
2ST	WITH REPOLARIZATION ABNORMALITY

Appendix B – Statement Library by Statement Number

For your notes

Acronym	Statement	Statement #	Classification
SNF	STATEMENT NOT FOUND	1	*
PEDANL	** ** ** ** * PEDIATRIC ECG ANALYSIS * ** ** ** **	2	NA
AGSPAMI	** AGE AND GENDER SPECIFIC ECG ANALYSIS **	3	NA
SRTH	SINUS RHYTHM	19	N
ARAT	ATRIAL RATE	20	*
SBRAD	SINUS BRADYCARDIA	21	O
NSR	NORMAL SINUS RHYTHM	22	N
STACH	SINUS TACHYCARDIA	23	O
MSBRAD	MARKED SINUS BRADYCARDIA	24	A
RABRAD	LOW RIGHT ATRIAL BRADYCARDIA	25	A
RATACH	LOW RIGHT ATRIAL TACHYCARDIA	26	A
LABRAD	LEFT ATRIAL BRADYCARDIA	27	A
LATACH	LEFT ATRIAL TACHYCARDIA	28	A
RAR	LOW RIGHT ATRIAL RHYTHM	29	A
LAR	LEFT ATRIAL RHYTHM	30	A
NOPF	(NO P-WAVES FOUND)	31	*
BLKED	BLOCKED	32	NA
ACCEL	ACCELERATED	33	NA
JUNBRAD	JUNCTIONAL BRADYCARDIA	34	A
JBRAD	UNUSUAL P AXIS AND SHORT PR, PROBABLE JUNCTIONAL BRADYCARDIA	41	A
JR	UNUSUAL P AXIS AND SHORT PR, PROBABLE JUNCTIONAL RHYTHM	42	A
JTACH	UNUSUAL P AXIS AND SHORT PR, PROBABLE JUNCTIONAL TACHYCARDIA	43	A
EABRAD	UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL BRADYCARDIA	61	A
EAR	UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL RHYTHM	62	A
EATACH	UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL TACHYCARDIA	63	A
FAV	WITH 1ST DEGREE A-V BLOCK	101	O
SPR	WITH SHORT PR	102	O
MBZI	WITH 2ND DEGREE A-V BLOCK (MOBITZ I)	103	A
MBZII	WITH 2ND DEGREE A-V BLOCK (MOBITZ II)	104	A
SAV	WITH 2ND DEGREE A-V BLOCK	105	A
CHB	WITH COMPLETE HEART BLOCK	106	A
VAVB	WITH VARIABLE A-V BLOCK	107	A
AVDIS	WITH A-V DISSOCIATION	108	A

Acronym	Statement	Statement #	Classification
SABII	WITH 2ND DEGREE SA BLOCK (MOBITZ II)	111	*
SABI	WITH 2ND DEGREE SA BLOCK (MOBITZ I)	112	*
PAUSE	WITH SINUS PAUSE	113	*
W2T1	WITH 2:1 A-V CONDUCTION	141	NA
W3T1	WITH 3:1 A-V CONDUCTION	142	NA
W4T1	WITH 4:1 A-V CONDUCTION	143	NA
W5T1	WITH 5:1 A-V CONDUCTION	144	NA
AFIB	ATRIAL FIBRILLATION	161	A
FLUT	ATRIAL FLUTTER	162	A
CRS	COARSE	163	*
ATAC	ATRIAL TACHYCARDIA	164	*
RVR	WITH RAPID VENTRICULAR RESPONSE	171	NA
SVR	WITH SLOW VENTRICULAR RESPONSE	172	NA
CJP	WITH A COMPETING JUNCTIONAL PACEMAKER	174	A
IRREG	WITH UNDETERMINED RHYTHM IRREGULARITY	175	O
IRR	IRREGULAR	176	NA
WITH	WITH	177	NA
OR	OR	178	NA
AND	AND	179	NA
ABER	WITH PREMATURE VENTRICULAR OR ABERRANTLY CONDUCTED COMPLEXES	181	O
OCC	WITH OCCASIONAL	211	NA
FREQ	WITH FREQUENT	212	NA
PSVC	PREMATURE SUPRAVENTRICULAR COMPLEXES	221	O
PAC	PREMATURE ATRIAL COMPLEXES	222	O
PJC	PREMATURE JUNCTIONAL COMPLEXES	223	*
PVC	PREMATURE VENTRICULAR COMPLEXES	231	O
PVCF	PREMATURE VENTRICULAR AND FUSION COMPLEXES	232	*
CSEC	, AND CONSECUTIVE	233	A
BIGEM	IN A PATTERN OF BIGEMINY	234	O
WQTACH	WIDE QRS TACHYCARDIA	235	A
NQTACH	NARROW QRS TACHYCARDIA	236	O
WQR	WIDE QRS RHYTHM	237	O
IVR	IDIOVENTRICULAR RHYTHM	238	A

Acronym	Statement	Statement #	Classification
PEC	PREMATURE ECTOPIC COMPLEXES	241	*
JESC	WITH JUNCTIONAL ESCAPE COMPLEXES	242	O
VESC	WITH VENTRICULAR ESCAPE COMPLEXES	243	O
FUS	FUSION COMPLEXES	244	O
RETC	WITH RETROGRADE CONDUCTION	245	O
ABCOND	ABERRANT CONDUCTION	246	O
CAPTUR	SINUS/ATRIAL CAPTURE	247	NA
VTACH	VENTRICULAR TACHYCARDIA	248	A
VFIB	VENTRICULAR FIBRILLATION	249	A
SAR	WITH SINUS ARRHYTHMIA	251	NA
MSAR	WITH MARKED SINUS ARRHYTHMIA	252	O
JUNCTR	JUNCTIONAL RHYTHM	267	A
SVT	SUPRAVENTRICULAR TACHYCARDIA	271	O
PCK	ELECTRONIC VENTRICULAR PACEMAKER	290	NA
DPCK	DEMAND PACEMAKER; INTERPRETATION IS BASED ON INTRINSIC RHYTHM	291	NA
APCK	ELECTRONIC ATRIAL PACEMAKER	292	NA
AVPCK	AV SEQUENTIAL OR DUAL CHAMBER ELECTRONIC PACEMAKER	293	NA
UR	UNDETERMINED RHYTHM	299	O
WPWA	VENTRICULAR PRE-EXCITATION, WPW PATTERN TYPE A	300	A
WPWB	VENTRICULAR PRE-EXCITATION, WPW PATTERN TYPE B	302	A
ALTWPW	WITH FUSION OR INTERMITTENT VENTRICULAR PRE-EXCITATION (WPW)	303	A
WPW	WOLFF-PARKINSON-WHITE	304	A
CWRT	CLOCKWISE ROTATION OF THE HEART, MAY INVALIDATE CRITERIA FOR VENTRICULAR HYPERTROPHY	305	*
CCWRT	COUNTER CLOCKWISE ROTATION OF THE HEART, MAY INVALIDATE CRITERIA FOR VENTRICULAR HYPERTROPHY	306	*
DXTRO	DEXTROCARDIA	307	A
RAE	RIGHT ATRIAL ENLARGEMENT	350	B
LAE	LEFT ATRIAL ENLARGEMENT	360	B
BAE	BIATRIAL ENLARGEMENT	369	A
LAD	LEFTWARD AXIS	370	*
ALAD	ABNORMAL LEFT AXIS DEVIATION	371	*
LAD3	LEFT AXIS DEVIATION	372	A
RAD	RIGHTWARD AXIS	380	B

Acronym	Statement	Statement #	Classification
ARAD	ABNORMAL RIGHT AXIS DEVIATION	381	*
RSAD	ABNORMAL RIGHT SUPERIOR AXIS DEVIATION	382	*
RAD4	RIGHT AXIS DEVIATION	383	A
RAD5	RIGHT SUPERIOR AXIS DEVIATION	384	A
INDAX	INDETERMINATE AXIS	390	B
NWA	NORTHWEST AXIS	391	A
LOWV	LOW VOLTAGE QRS	410	B
PULD	PULMONARY DISEASE PATTERN	411	A
S1S2S3	S1-S2-S3 PATTERN, CONSIDER PULMONARY DISEASE, RVH, OR NORMAL VARIANT	412	A
RBBB	RIGHT BUNDLE BRANCH BLOCK	440	A
RVE+	, PLUS RIGHT VENTRICULAR HYPERTROPHY	441	A
RBBRVH	RIGHT BUNDLE BRANCH BLOCK -OR- RIGHT VENTRICULAR HYPERTROPHY	442	A
IRBBB	INCOMPLETE RIGHT BUNDLE BRANCH BLOCK	445	B
RSR	RSR' OR QR PATTERN IN V1 SUGGESTS RIGHT VENTRICULAR CONDUCTION DELAY	450	B
LBBB	LEFT BUNDLE BRANCH BLOCK	460	A
ILBBB	INCOMPLETE LEFT BUNDLE BRANCH BLOCK	465	B
AFB	LEFT ANTERIOR FASCICULAR BLOCK	470	A
PFB	LEFT POSTERIOR FASCICULAR BLOCK	471	A
BIFB	*** BIFASCICULAR BLOCK ***	480	A
IVCB	NON-SPECIFIC INTRA-VENTRICULAR CONDUCTION BLOCK	482	A
IVCD	NON-SPECIFIC INTRA-VENTRICULAR CONDUCTION DELAY	487	B
RVH	RIGHT VENTRICULAR HYPERTROPHY	520	A
LVH	VOLTAGE CRITERIA FOR LEFT VENTRICULAR HYPERTROPHY	540	A
LVH2	LEFT VENTRICULAR HYPERTROPHY	541	A
QRSV	MINIMAL VOLTAGE CRITERIA FOR LVH, MAY BE NORMAL VARIANT	542	B
QRSW	WITH QRS WIDENING	543	A
2ST	WITH REPOLARIZATION ABNORMALITY	544	A
QRSW-2ST	WITH QRS WIDENING AND REPOLARIZATION ABNORMALITY	545	A
LVH3	MODERATE VOLTAGE CRITERIA FOR LVH, MAY BE NORMAL VARIANT	548	B
BIVH	BIVENTRICULAR HYPERTROPHY	570	A
PMDPV	PROMINENT MID-PRECORDIAL VOLTAGE	571	*
QV6	DEEP Q-WAVE IN LEAD V6	572	*

Acronym	Statement	Statement #	Classification
PPV	PROMINENT POSTERIOR VOLTAGE	573	*
PLV	PROMINENT LATERAL VOLTAGE	574	*
SMI	SEPTAL INFARCT	700	A
AMI	ANTERIOR INFARCT	740	A
LMI	LATERAL INFARCT	760	A
IMI	INFERIOR INFARCT	780	A
MAFB	(MASKED BY FASCICULAR BLOCK?)	782	NA
PXT	WITH POSTERIOR EXTENSION	800	*
IPMI	INFERIOR-POSTERIOR INFARCT	801	A
POSTMI	POSTERIOR INFARCT	802	A
QESPMI	EARLY TRANSITION INCREASED R/S RATIO IN V1, CONSIDER POSTERIOR INFARCT	803	A
ASMI	ANTEROSEPTAL INFARCT	810	A
ALMI	ANTEROLATERAL INFARCT	820	A
ACUMI	** ** ** ** * ACUTE MI * ** ** ** **	829	A
AC	, POSSIBLY ACUTE	830	NA
AU	, AGE UNDETERMINED	831	NA
MISIZ	*** QRS CONTOUR SUGGESTS INFARCT SIZE IS PROBABLY	880	*
VSMA	VERY SMALL	881	*
SMA	SMALL	882	*
MOD	MODERATE	883	*
LARG	LARGE	884	*
VLAR	VERY LARGE	885	*
NST	NONSPECIFIC ST ABNORMALITY	900	A
PCARD	ACUTE PERICARDITIS	901	A
SERYR1	ST ELEVATION, CONSIDER EARLY REPOLARIZATION, PERICARDITIS, OR INJURY	902	A
SERYR2	ST ELEVATION, CONSIDER EARLY REPOLARIZATION	903	B
SINJ	SEPTAL INJURY PATTERN	920	*
AINJ	ANTERIOR INJURY PATTERN	930	A
LINJ	LATERAL INJURY PATTERN	940	A
IINJ	INFERIOR INJURY PATTERN	950	A
ASINJ	ANTEROSEPTAL INJURY PATTERN	960	*
ALINJ	ANTEROLATERAL INJURY PATTERN	961	A

Acronym	Statement	Statement #	Classification
ILINJ	INFEROLATERAL INJURY PATTERN	962	A
IIOHAI	ST ELEVATION CONSIDER INFERIOR INJURY OR ACUTE INFARCT	963	A
AIOHAI	ST ELEVATION CONSIDER ANTERIOR INJURY OR ACUTE INFARCT	964	A
LIOHAI	ST ELEVATION CONSIDER LATERAL INJURY OR ACUTE INFARCT	965	A
ALIHAI	ST ELEVATION CONSIDER ANTEROLATERAL INJURY OR ACUTE INFARCT	966	A
ILIHAI	ST ELEVATION CONSIDER INFEROLATERAL INJURY OR ACUTE INFARCT	967	A
INJONV	ST ELEVATION, CONSIDER INJURY OR VARIANT ASSOCIATED WITH LVH	968	*
REPOL	EARLY REPOLARIZATION	1000	N
JSTN	JUNCTIONAL ST DEPRESSION, PROBABLY NORMAL	1001	B
JST	JUNCTIONAL ST DEPRESSION, PROBABLY ABNORMAL	1002	A
STDIG	ST ABNORMALITY, POSSIBLE DIGITALIS EFFECT	1020	A
STDEP	ST DEPRESSION, CONSIDER SUBENDOCARDIAL INJURY OR DIGITALIS EFFECT	1022	A
SSBINJ	MARKED ST ABNORMALITY, POSSIBLE SEPTAL SUBENDOCARDIAL INJURY	1040	A
ASBINJ	MARKED ST ABNORMALITY, POSSIBLE ANTERIOR SUBENDOCARDIAL INJURY	1050	A
LSBINJ	MARKED ST ABNORMALITY, POSSIBLE LATERAL SUBENDOCARDIAL INJURY	1060	A
ISBINJ	MARKED ST ABNORMALITY, POSSIBLE INFERIOR SUBENDOCARDIAL INJURY	1070	A
MSTDIL	MARKED ST ABNORMALITY, POSSIBLE INFEROLATERAL SUBENDOCARDIAL INJURY	1071	A
MSTDAS	MARKED ST ABNORMALITY, POSSIBLE ANTEROSEPTAL SUBENDOCARDIAL INJURY	1080	A
MSTDAL	MARKED ST ABNORMALITY, POSSIBLE ANTEROLATERAL SUBENDOCARDIAL INJURY	1081	A
STDPIN	ST DEPRESSION IN	1082	A
STELIN	ST ELEVATION IN	1083	A
WSTR	WITH STRAIN PATTERN	1084	A
ST&	ST &	1100	A
STABAND	ST ABNORMALITY AND	1138	A
SNDQA	, MAYBE SECONDARY TO QRS ABNORMALITY	1139	NA
NT	NONSPECIFIC T WAVE ABNORMALITY	1140	A
NSTT	NONSPECIFIC ST AND T WAVE ABNORMALITY	1141	A
QRST	ABNORMAL QRS-T ANGLE, CONSIDER PRIMARILY T WAVE ABNORMALITY	1142	A
LNGQT	PROLONGED QT	1143	A

Acronym	Statement	Statement #	Classification
ILT	T WAVE ABNORMALITY, CONSIDER INFEROLATERAL ISCHEMIA	1145	A
AT	T WAVE ABNORMALITY, CONSIDER ANTERIOR ISCHEMIA	1150	A
MAT	MARKED T WAVE ABNORMALITY, CONSIDER ANTERIOR ISCHEMIA	1151	A
LT	T WAVE ABNORMALITY, CONSIDER LATERAL ISCHEMIA	1160	A
MLT	MARKED T WAVE ABNORMALITY, CONSIDER LATERAL ISCHEMIA	1161	A
IT	T WAVE ABNORMALITY, CONSIDER INFERIOR ISCHEMIA	1170	A
MIT	MARKED T WAVE ABNORMALITY, CONSIDER INFERIOR ISCHEMIA	1171	A
MILT	MARKED T-WAVE ABNORMALITY, CONSIDER INFEROLATERAL ISCHEMIA	1172	A
ALT	T WAVE ABNORMALITY, CONSIDER ANTEROLATERAL ISCHEMIA	1180	A
MALT	MARKED T WAVE ABNORMALITY, CONSIDER ANTEROLATERAL ISCHEMIA	1181	A
TINVIN	T-WAVE INVERSION IN	1182	A
SEP	SEPTAL LEADS	1450	NA
ANT	ANTERIOR LEADS	1451	NA
LAT	LATERAL LEADS	1452	NA
INF	INFERIOR LEADS	1453	NA
POS	POSTERIOR LEADS	1454	NA
ANTSEP	ANTEROSEPTAL LEADS	1455	NA
ANTLAT	ANTEROLATERAL LEADS	1456	NA
INFPOS	INFEROPOSTERIOR LEADS	1457	NA
IFLAT	INFEROLATERAL LEADS	1458	NA
PDIG	, PROBABLY DIGITALIS EFFECT	1670	NA
ODIG	OR DIGITALIS EFFECT	1671	NA
ARM	*** SUSPECT ARM LEAD REVERSAL, INTERPRETATION ASSUMES NO REVERSAL	1672	NA
QCERR	*** POOR DATA QUALITY, INTERPRETATION MAY BE ADVERSELY AFFECTED	1673	NA
ANLERR 3	** LESS THAN 4 QRS COMPLEXES DETECTED, NO INTERPRETATION POSSIBLE **	1676	NA
ANLERR 1	*** MEMORY ALLOCATION FAILURE, NO ECG INTERPRETATION POSSIBLE ***	1677	*
ANLERR 2	** NO QRS COMPLEXES FOUND, NO ECG ANALYSIS POSSIBLE **	1678	NA
PO	POSSIBLE	1680	NA
CRO	CANNOT RULE OUT	1682	NA
NML	NORMAL ECG	1684	NA
ABR	OTHERWISE NORMAL ECG	1687	NA

Acronym	Statement	Statement #	Classification
BORDE	BORDERLINE ECG	1693	NA
BO	BORDERLINE	1694	NA
AB	ABNORMAL ECG	1699	NA
KEY: N = NORMAL ECG A = ABNORMAL ECG B = BORDERLINE ECG O = OTHERWISE NORMAL ECG * = STATEMENT NOT USED BY 12SL ANALYSIS PROGRAM NA = NOT APPLICABLE - DESCRIPTIVE STATEMENT			

Appendix C – Pediatric Tables

For your notes

Overview

The normal values included in this appendix, and used by the pediatric analysis program, are those collected and published by Davignon et al. This data is based on more than 2000 children who were found to have a normal physical examination. The total population was divided into 12 age groups, with 7 age groups in the first year of life in order to reflect the greater changes in the ECG during this time.

References

Davignon A., Rautaharju P., Boisselle E., et al.,
Normal ECG standards for infants and children. Pediatric Cardiology 1:123-152, 1979.

Less Than One Day Old

Item	Value	Description
Heart Rate	154	Upper heart rate
	93	Lower heart rate
Axis Limit	187	Right axis limit
	59	Left axis limit
	N/A	Northwest axis limit
PR Interval	80	Lower PR interval
	110	Mean PR interval
	160	Upper PR interval
QRS Duration	75	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	450	Large Q amplitude for III
	200	Large Q amplitude for V6
Lead V1	500	Small R amplitude for V1
	2600	Large R amplitude for V1
	1380	Mean R amplitude for V1
	NA	Small S amplitude for V1
	2300	Large S amplitude for V1
	850	Mean S amplitude for V1
	0.1	Lower R/S ratio in V1
	NA	Upper R/S ratio in V1
Lead V6	1100	Large R amplitude for V6
	NA	Small R amplitude for V6
	420	Mean R amplitude for V6
	950	Large S amplitude for V6
	320	Mean S amplitude for V6
	0.1	Lower R/S ratio in V6
Total Deflection	2800	V6 R amplitude + V1 S amplitude in horizontal plane
	5250	R amplitude + S amplitude in V4
QT Interval	450	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

At Least a Day Old but not More Than 2 Days

Item	Value	Description
Heart Rate	159	Upper heart rate
	91	Lower heart rate
Axis Limit	187	Right axis limit
	59	Left axis limit
	NA	Northwest axis limit
PR Interval	80	Lower PR interval
	110	Mean PR interval
	160	Upper PR interval
QRS Duration	66	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	650	Large Q amplitude for III
	250	Large Q amplitude for V6
Lead V1	500	Small R amplitude for V1
	2700	Large R amplitude for V1
	1440	Mean R amplitude for V1
	NA	Small S amplitude for V1
	2100	Large S amplitude for V1
	850	Mean S amplitude for V1
	0.1	Lower R/S ratio in V1
	NA	Upper R/S ratio in V1
Lead V6	1200	Large R amplitude for V6
	NA	Small R amplitude for V6
	450	Mean R amplitude for V6
	950	Large S amplitude for V6
	300	Mean S amplitude for V6
	0.1	Lower R/S ratio in V6
Total Deflection	2900	V6 R amplitude + V1 S amplitude in horizontal plane
	5200	R amplitude + S amplitude in V4
QT Interval	450	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

3 to 6 Days Old

Item	Value	Description
Heart Rate	166	Upper heart rate
	91	Lower heart rate
Axis Limit	187	Right axis limit
	77	Left axis limit
	NA	Northwest axis limit
PR Interval	70	Lower PR interval
	100	Mean PR interval
	140	Upper PR interval
QRS Duration	68	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	550	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	300	Small R amplitude for V1
	2400	Large R amplitude for V1
	1290	Mean R amplitude for V1
	NA	Small S amplitude for V1
	1700	Large S amplitude for V1
	660	Mean S amplitude for V1
	0.2	Lower R/S ratio in V1
	NA	Upper R/S ratio in V1
Lead V6	1200	Large R amplitude for V6
	50	Small R amplitude for V6
	520	Mean R amplitude for V6
	1000	Large S amplitude for V6
	350	Mean S amplitude for V6
	0.1	Lower R/S ratio in V6
Total Deflection	2450	V6 R amplitude + V1 S amplitude in horizontal plane
	4900	R amplitude + S amplitude in V4
QT Interval	450	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

1 to 3 Weeks Old

Item	Value	Description
Heart Rate	182	Upper heart rate
	107	Lower heart rate
Axis Limit	161	Right axis limit
	65	Left axis limit
	NA	Northwest axis limit
PR Interval	70	Lower PR interval
	100	Mean PR interval
	140	Upper PR interval
QRS Duration	80	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	600	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	300	Small R amplitude for V1
	2100	Large R amplitude for V1
	1060	Mean R amplitude for V1
	NA	Small S amplitude for V1
	1100	Large S amplitude for V1
	420	Mean S amplitude for V1
	1	Lower R/S ratio in V1
	NA	Upper R/S ratio in V1
Lead V6	1650	Large R amplitude for V6
	250	Small R amplitude for V6
	760	Mean R amplitude for V6
	1000	Large S amplitude for V6
	340	Mean S amplitude for V6
	0.1	Lower R/S ratio in V6
Total Deflection	2100	V6 R amplitude + V1 S amplitude in horizontal plane
	4900	R amplitude + S amplitude in V4
QT Interval	450	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

1 to 2 Months Old

Item	Value	Description
Heart Rate	179	Upper heart rate
	121	Lower heart rate
Axis Limit	113	Right axis limit
	13	Left axis limit
	180	Northwest axis limit
PR Interval	70	Lower PR interval
	100	Mean PR interval
	130	Upper PR interval
QRS Duration	76	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	750	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	300	Small R amplitude for V1
	1800	Large R amplitude for V1
	950	Mean R amplitude for V1
	NA	Small S amplitude for V1
	1200	Large S amplitude for V1
	500	Mean S amplitude for V1
	0.3	Lower R/S ratio in V1
	NA	Upper R/S ratio in V1
Lead V6	2150	Large R amplitude for V6
	500	Small R amplitude for V6
	1160	Mean R amplitude for V6
	650	Large S amplitude for V6
	270	Mean S amplitude for V6
	0.2	Lower R/S ratio in V6
Total Deflection	2900	V6 R amplitude + V1 S amplitude in horizontal plane
	5350	R amplitude + S amplitude in V4
QT Interval	450	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

3 to 5 Months Old

Item	Value	Description
Heart Rate	186	Upper heart rate
	106	Lower heart rate
Axis Limit	104	Right axis limit
	7	Left axis limit
	180	Northwest axis limit
PR Interval	70	Lower PR interval
	110	Mean PR interval
	150	Upper PR interval
QRS Duration	80	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	650	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	300	Small R amplitude for V1
	2000	Large R amplitude for V1
	980	Mean R amplitude for V1
	NA	Small S amplitude for V1
	1700	Large S amplitude for V1
	570	Mean S amplitude for V1
	0.1	Lower R/S ratio in V1
	NA	Upper R/S ratio in V1
Lead V6	2250	Large R amplitude for V6
	650	Small R amplitude for V6
	1310	Mean R amplitude for V6
	1000	Large S amplitude for V6
	290	Mean S amplitude for V6
	0.2	Lower R/S ratio in V6
Total Deflection	3200	V6 R amplitude + V1 S amplitude in horizontal plane
	6150	R amplitude + S amplitude in V4
QT Interval	450	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

6 to 11 Months Old

Item	Value	Description
Heart Rate	169	Upper heart rate
	109	Lower heart rate
Axis Limit	99	Right axis limit
	6	Left axis limit
	180	Northwest axis limit
PR Interval	70	Lower PR interval
	110	Mean PR interval
	160	Upper PR interval
QRS Duration	76	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	850	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	150	Small R amplitude for V1
	2000	Large R amplitude for V1
	940	Mean R amplitude for V1
	50	Small S amplitude for V1
	1800	Large S amplitude for V1
	640	Mean S amplitude for V1
	0.1	Lower R/S ratio in V1
	3.9	Upper R/S ratio in V1
Lead V6	2250	Large R amplitude for V6
	600	Small R amplitude for V6
	1260	Mean R amplitude for V6
	700	Large S amplitude for V6
	210	Mean S amplitude for V6
	0.2	Lower R/S ratio in V6
Total Deflection	3200	V6 R amplitude + V1 S amplitude in horizontal plane
	5350	R amplitude + S amplitude in V4
QT Interval	440	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

1 to 2 Years Old

Item	Value	Description
Heart Rate	151	Upper heart rate
	89	Lower heart rate
Axis Limit	101	Right axis limit
	7	Left axis limit
	180	Northwest axis limit
PR Interval	80	Lower PR interval
	110	Mean PR interval
	150	Upper PR interval
QRS Duration	76	98% confidence interval for QRS duration, prolonged
	90	Wide QRS
	110	Very wide QRS, block
Q Amplitude	600	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	250	Small R amplitude for V1
	1700	Large R amplitude for V1
	890	Mean R amplitude for V1
	60	Small S amplitude for V1
	2100	Large S amplitude for V1
	840	Mean S amplitude for V1
	0.05	Lower R/S ratio in V1
	4.3	Upper R/S ratio in V1
Lead V6	2250	Large R amplitude for V6
	600	Small R amplitude for V6
	1330	Mean R amplitude for V6
	650	Large S amplitude for V6
	190	Mean S amplitude for V6
	0.3	Lower R/S ratio in V6
Total Deflection	3900	V6 R amplitude + V1 S amplitude in horizontal plane
	4950	R amplitude + S amplitude in V4
QT Interval	440	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

3 to 4 Years Old

Item	Value	Description
Heart Rate	137	Upper heart rate
	73	Lower heart rate
Axis Limit	104	Right axis limit
	6	Left axis limit
	180	Northwest axis limit
PR Interval	90	Lower PR interval
	120	Mean PR interval
	160	Upper PR interval
QRS Duration	72	98% confidence interval for QRS duration, prolonged
	100	Wide QRS
	120	Very wide QRS, block
Q Amplitude	500	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	100	Small R amplitude for V1
	1800	Large R amplitude for V1
	810	Mean R amplitude for V1
	20	Small S amplitude for V1
	2100	Large S amplitude for V1
	1020	Mean S amplitude for V1
	0.03	Lower R/S ratio in V1
	2.8	Upper R/S ratio in V1
Lead V6	2450	Large R amplitude for V6
	800	Small R amplitude for V6
	1480	Mean R amplitude for V6
	500	Large S amplitude for V6
	150	Mean S amplitude for V6
	0.6	Lower R/S ratio in V6
Total Deflection	4200	V6 R amplitude + V1 S amplitude in horizontal plane
	5350	R amplitude + S amplitude in V4
QT Interval	440	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

5 to 7 Years Old

Item	Value	Description
Heart Rate	133	Upper heart rate
	65	Lower heart rate
Axis Limit	143	Right axis limit
	11	Left axis limit
	180	Northwest axis limit
PR Interval	90	Lower PR interval
	120	Mean PR interval
	160	Upper PR interval
QRS Duration	79	98% confidence interval for QRS duration, prolonged
	100	Wide QRS
	120	Very wide QRS, block
Q Amplitude	400	Large Q amplitude for III
	450	Large Q amplitude for V6
Lead V1	50	Small R amplitude for V1
	1400	Large R amplitude for V1
	670	Mean R amplitude for V1
	30	Small S amplitude for V1
	2400	Large S amplitude for V1
	1200	Mean S amplitude for V1
	0.02	Lower R/S ratio in V1
	2.0	Upper R/S ratio in V1
Lead V6	2650	Large R amplitude for V6
	850	Small R amplitude for V6
	1630	Mean R amplitude for V6
	400	Large S amplitude for V6
	120	Mean S amplitude for V6
	0.9	Lower R/S ratio in V6
Total Deflection	4700	V6 R amplitude + V1 S amplitude in horizontal plane
	5400	R amplitude + S amplitude in V4
QT Interval	440	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

8 to 11 Years Old

Item	Value	Description
Heart Rate	130	Upper heart rate
	62	Lower heart rate
Axis Limit	114	Right axis limit
	9	Left axis limit
	180	Northwest axis limit
PR Interval	90	Lower PR interval
	130	Mean PR interval
	170	Upper PR interval
QRS Duration	85	98% confidence interval for QRS duration, prolonged
	100	Wide QRS
	120	Very wide QRS, block
Q Amplitude	300	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	30	Small R amplitude for V1
	2500	Large R amplitude for V1
	540	Mean R amplitude for V1
	30	Small S amplitude for V1
	2500	Large S amplitude for V1
	1190	Mean S amplitude for V1
	NA	Lower R/S ratio in V1
	1.8	Upper R/S ratio in V1
Lead V6	2550	Large R amplitude for V6
	900	Small R amplitude for V6
	1630	Mean R amplitude for V6
	400	Large S amplitude for V6
	100	Mean S amplitude for V6
	1.5	Lower R/S ratio in V6
Total Deflection	4550	V6 R amplitude + V1 S amplitude in horizontal plane
	5300	R amplitude + S amplitude in V4
QT Interval	440	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

12 to 15 Years Old

Item	Value	Description
Heart Rate	119	Upper heart rate
	50	Lower heart rate
Axis Limit	130	Right axis limit
	11	Left axis limit
	180	Northwest axis limit
PR Interval	90	Lower PR interval
	140	Mean PR interval
	180	Upper PR interval
QRS Duration	87	98% confidence interval for QRS duration, prolonged
	100	Wide QRS
	120	Very wide QRS, block
Q Amplitude	300	Large Q amplitude for III
	300	Large Q amplitude for V6
Lead V1	NA	Small R amplitude for V1
	1000	Large R amplitude for V1
	410	Mean R amplitude for V1
	30	Small S amplitude for V1
	2100	Large S amplitude for V1
	1080	Mean S amplitude for V1
	NA	Lower R/S ratio in V1
	1.7	Upper R/S ratio in V1
Lead V6	2300	Large R amplitude for V6
	650	Small R amplitude for V6
	1430	Mean R amplitude for V6
	400	Large S amplitude for V6
	80	Mean S amplitude for V6
	1.4	Lower R/S ratio in V6
Total Deflection	4100	V6 R amplitude + V1 S amplitude in horizontal plane
	5000	R amplitude + S amplitude in V4
QT Interval	440	Upper QT threshold

Amplitude in microvolts; Duration in milliseconds

For your notes

Appendix D – Standardization of Terminology and Interpretation

For your notes

Overview

The 12SL Analysis Program interpretive statements are consistent with the terminology and interpretation classifications recommended by the 10th Bethesda conference on Optimal Electrocardiography (1978). The interpretive statements, classified as type A, B, or C are defined as follows:

Type A Statements

Refer to an anatomic lesion or pathophysiologic state which is verifiable by nonelectrocardiographic means. Examples include statements about hypertrophy and infarction.

Type B Statements

Refer to an anatomic or functional disturbance that is detectable by the ECG itself. Examples include statements about arrhythmias and conduction disturbances.

Type C Statements

Refer to descriptive ECG features that do not fit into type A or B categories. Examples include statements about electrical axis, nonspecific T wave abnormalities and unusual voltage.

Criteria for each statement was developed from a variety of sources including cardiologist experts, World Health Organization standards and Common Standards for Quantitative Electrocardiography.

Table 1. Statement Types

Category	Description	Examples
A	Diagnosis of an anatomic lesion of pathophysiologic state	■ Anterior infarct ■ Left ventricular hypertrophy
B	Diagnosis of electrophysiologic changes	■ Atrial fibrillation ■ Right bundle branch block
C	Descriptive ECG features	■ Nonspecific ST abnormality ■ Flat T waves

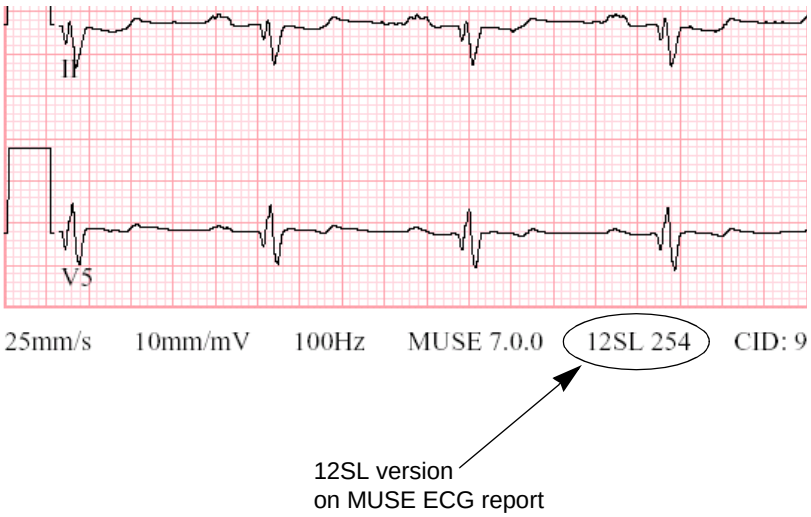
For your notes

Appendix E – 12SL Version Identification

For your notes

Introduction

The 12SL analysis program has continually evolved since it was first introduced in 1980. Each released version of the program contains one or more changes to it and is associated with a unique version number. A version number appears on the ECG report printed by an electrocardiograph or a MUSE system; encoded within this number are the actual 12SL version number and information about the specific platform on which the ECG was acquired.



The following table can be used to convert the value displayed on the ECG report to the actual 12SL version number. Some values are reserved for future use. This table lists all possible values which may appear on the ECG report; not all of these values have been (or ever will be) used.

Conversion Table

Version on Report	Actual 12SL version
1	14
2	1
3	15
4	2
5	16
6	3
7	17
8	4
9	18
10	5
11	19
12	6
13	20
14	7
15	reserved
16	8
17	reserved
18	9
19	reserved
20	10
21	reserved
22	11
23	reserved
24	12
25	reserved
26	13
27	reserved
28	14
29	reserved
30	15
31	reserved
32	reserved
33	14
34	1
35	15
36	2
37	16
38	3
39	17
40	4
41	18
42	5
43	19
44	6
45	20
46	7
47	reserved
48	8
49	reserved
50	9
51	reserved
52	10
53	reserved
54	11
55	reserved
56	12
57	reserved
58	13
59	reserved
60	14
61	reserved
62	15
63	reserved
64	reserved
65	14
66	1
67	15
68	2
69	16
70	3
71	17
72	4
73	18
74	5
75	19
76	6
77	20
78	7
79	reserved
80	8
81	reserved
82	9
83	reserved
84	10
85	reserved
86	11
87	reserved
88	12
89	reserved
90	13
91	reserved
92	14
93	reserved
94	15
95	reserved
96	reserved
97	14
98	1
99	15
100	2
101	16
102	3
103	17
104	4
105	18
106	5
107	19
108	6
109	20
110	7
111	reserved
112	8
113	reserved
114	9
115	reserved
116	10
117	reserved
118	11
119	reserved
120	12
121	reserved
122	13
123	reserved
124	14
125	reserved
126	15
127	reserved
128	reserved
129	14
130	1
131	15
132	2
133	16
134	3
135	17
136	4
137	18
138	5
139	19
140	6

Continued on next page

Version on Report	Actual 12SL version
141	20
142	7
143	reserved
144	8
145	reserved
146	9
147	reserved
148	10
149	reserved
150	11
151	reserved
152	12
153	reserved
154	13
155	reserved
156	14
157	reserved
158	15
159	reserved
160	reserved
161	14
162	1
163	15
164	2
165	16
166	3
167	17
168	4
169	18

Version on Report	Actual 12SL version
170	5
171	19
172	6
173	20
174	7
175	reserved
176	8
177	reserved
178	9
179	reserved
180	10
181	reserved
182	11
183	reserved
184	12
185	reserved
186	13
187	reserved
188	14
189	reserved
190	15
191	reserved
192	reserved
193	14
194	1
195	15
196	2
197	16
198	3

Version on Report	Actual 12SL version
199	17
200	4
201	18
202	5
203	19
204	6
205	20
206	7
207	reserved
208	8
209	reserved
210	9
211	reserved
212	10
213	reserved
214	11
215	reserved
216	12
217	reserved
218	13
219	reserved
220	14
221	reserved
222	15
223	reserved
224	reserved
225	14
226	1
227	15

Version on Report	Actual 12SL version
228	2
229	16
230	3
231	17
232	4
233	18
234	5
235	19
236	6
237	20
238	7
239	reserved
240	8
241	reserved
242	9
243	reserved
244	10
245	reserved
246	11
247	reserved
248	12
249	reserved
250	13
251	reserved
252	14
253	reserved
254	15
255	reserved

For your notes

Appendix F – Screening Criteria

For your notes

Introduction

With *Screening Criteria* turned at the electrocardiograph (also referred to as Hi-Spec, or High Specificity mode) certain lower-acuity 12SL statements are suppressed from appearing on the report. By suppressing these statements when *Screening Criteria* is turned on, 12SL is placed in a higher specificity mode; that is, fewer interpretive statements will be generated. Most statements that are suppressed are either of lower clinical acuity, such as "incomplete right bundle branch block", or represent lower confidence levels of abnormalities, such as those prefixed with "cannot rule out" or "possible".

Note that not all platforms offer the screening mode as a user-configurable choice. Screening mode is turned off by default (i.e., statements are not suppressed).

NOTE

Running 12SL with the Screening Criteria turned on can affect the ECG classification. For example, an ECG with the diagnosis "Normal sinus rhythm; Right axis deviation", will be classified as an Abnormal ECG when Screening mode is off. However, if Screening mode is on, "right axis deviation" will not be stated and the ECG will be classified as a Normal ECG. Refer to Chapter 8, "ECG Classification" for details on classification of ECGs.

Suppressed Statements

The following table lists all statements that are suppressed when Screening mode is turned on.

Table 1. Statements Suppressed When Screening Criteria Turned On	
Statement Text	**Acronym**
Rhythm Statements	
... with undetermined rhythm irregularity	IRREG
... with rapid ventricular response	RVR
... with slow ventricular response	SVR
... with a competing junctional pacemaker	CJP
... with x:1 AV conduction (zix=2,3,4,5)	W2T1, W3T1, W4T1, W5T1
... with retrograde conduction	RETC
... [and/with] possible premature atrial complexes with aberrant conduction	[AND/WITH] + PO + PAC + WITH + ABCOND
Axis / Voltage	
Rightward axis	RAD
Right axis deviation	RAD4
Northwest axis *	NWA
Right superior axis deviation	RAD5
Pulmonary disease pattern	PULD
Ventricular conduction	
RSR' or QR pattern in V1 suggests right ventricular conduction delay	RSR
Incomplete right bundle branch block	IRBBB
Nonspecific intraventricular conduction delay	IVCD
Hypertrophy	
Minimal voltage criteria for LVH, may be normal variant	QRSV
Moderate voltage criteria for LVH, may be normal variant	LVH3
Possible right ventricular hypertrophy	PO + RVH
... plus right ventricular hypertrophy	RVE+
Possible left atrial enlargement	PO + LAE
Possible left ventricular hypertrophy *	PO + LVH
Deep Q wave in lead V6, possible left ventricular hypertrophy *	QV6 + PO + LVH
Possible biventricular hypertrophy *	PO + BIVH

Table 1. Statements Suppressed When Screening Criteria Turned On (Continued)	
Statement Text	**Acronym**
Prominent mid-precordial voltage, possible biventricular hypertrophy *	PMDPV + PO + BIVH
Myocardial Infarction	
Cannot rule out septal infarct	CRO + SMI
Cannot rule out anteroseptal infarct	CRO + ASMI
Cannot rule out anterior infarct	CRO + AMI
Cannot rule out inferior infarct	CRO + IMI
Cannot rule out inferior infarct (masked by fascicular block?)	CRO + IMI + MAFB
Possible anteroseptal infarct	PO + ASMI
Possible anterior infarct	PO + AMI
Possible anterolateral infarct	PO + ALMI
Possible lateral infarct	PO + LMI
Possible inferior infarct	PO + IMI
ST - T	
ST elevation, consider early repolarization, pericarditis, or injury	SERYR1
ST elevation, probably due to early repolarization	SERYR2
Early repolarization	REPOL
Possible acute pericarditis	PO + PCARD
Junctional ST depression, probably normal	JSTN
Junctional ST depression, probably abnormal	JST
Abnormal QRS-T angle, consider primary T wave abnormality	QRST

* Statements marked with asterisk are statements that are only made when doing pediatric ECG analysis (age < 16 years).

For your notes

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