Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 53, No. 11, 2009
ISSN 0735-1097/09/$36.00
doi:10.1016/j.jacc.2008.12.013

EXPERT CONSENSUS DOCUMENTS

AHA/ACCF/HRS Recommendations for the Standardization and Interpretation of the Electrocardiogram

Part III: Intraventricular Conduction Disturbances

A Scientific Statement From the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society

Endorsed by the International Society for Computerized Electrocardiology

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The present article introduces the second part of "Recommendations for Standardization and Interpretation of the Electrocardiogram." The project was initiated by the Council on Clinical Cardiology of the American Heart Association and has been endorsed by the American College of Cardiology Foundation, the Heart Rhythm Society, and the International Society for Computerized Electrocardiography. This statement was preceded by 2 articles, "The Electrocardiogram and Its Technology" and "Diagnostic Statements," which were published previously (1,2), and it is followed by statements concerning abnormalities of repolarization, hypertrophy, and ischemia/infarction. The rationale for this initiative and the process by which it was achieved were described earlier (1).

The term *intraventricular conduction disturbances* refers to abnormalities in the intraventricular propagation of supraventricular impulses that give rise to changes in the shape and/or duration of the QRS complex. These changes in intraventricular conduction may be fixed and present at all heart rates, or they may be intermittent and be tachycardia or bradycardia dependent. They may be caused by structural abnormalities in the His-Purkinje conduction system or ventricular myocardium that result from necrosis, fibrosis, calcification, infiltrative lesions, or

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The American Heart Association, the American College of Cardiology Foundation, and the Heart Rhythm Society make every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

Parts I and II of this series, "Recommendations for the Standardization and Interpretation of the Electrocardiogram," were published in the March 13, 2007, issue of the *Journal of the American College of Cardiology* (J Am Coll Cardiol. 2007;49:1109–27 and J Am Coll Cardiol. 2007;49:1128–35). They are available online at http://content.onlinejacc.org/content/vol49/issue10/index.dtl.

Parts IV, V, and VI were published in the March 17, 2009, issue of the *Journal of the American College of Cardiology* (J Am Coll Cardiol. 2009;53:982–91, J Am Coll Cardiol. 2009;53:992–1002, and J Am Coll Cardiol. 2009;53:1003–11).

This statement was approved by the American Heart Association Science Advisory and Coordinating Committee on August 7, 2008, by the American College of Cardiology Foundation Board of Trustees on May 16, 2008, and by the Heart Rhythm Society Board of Trustees on June 18, 2008.

The American College of Cardiology Foundation requests that this document be cited as follows: Surawicz B, Childers R, Deal BJ, Gettes LS. AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram: part III: intraventricular conduction disturbances: a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society. J Am Coll Cardiol 2009;53:976–81.

This article has been copublished in *Circulation*.

Copies: This document is available on the World Wide Web sites of the American Heart Association (my.americanheart.org), the American College of Cardiology (www.acc.org), and the Heart Rhythm Society (www.hrsonline.org). For copies of this document, please contact Elsevier Inc. Reprint Department, fax 212-633-3820, e-mail reprints@elsevier.com.

impaired vascular supply. Alternatively, they may be functional and due to the arrival of a supraventricular impulse during the relative refractory period in a portion of the conducting system, in which case the term *aberrant ventricular conduction* is applied. They may also be due to abnormal atrioventricular connections, which bypass the atrioventricular node, resulting in ventricular preexcitation.

In 1985, the electrocardiography (ECG) criteria for intraventricular conduction disturbances and ventricular preexcitation were reviewed by an ad hoc working group established by the World Health Organization and the International Society and Federation of Cardiology. Recommendations were made for the diagnosis of complete and incomplete left and right bundle-branch blocks (LBBB and RBBB), left anterior and left posterior fascicular blocks, nonspecific intraventricular blocks, and ventricular preexcitation (3). The purpose of the present report is to define the normal QRS duration, review the recommendations made in 1985, recommend alterations and additions to those recommendations, and provide recommendations for children and adolescents.

Normal QRS Duration

The QRS duration depends on the method of measurement, age, and gender. Global intervals, from the earliest onset to the latest offset of the waveform in all leads (generally taken from a spatial vector magnitude or superimposed complexes), are the desirable standard. Global intervals, by definition, will be longer than measurements from single leads. QRS duration may increase with increasing heart size. In addition, the QRS complex is wider in the precordial than in the limb leads. There are also age- and gender-dependent differences in children and adolescents. In children less than 4 years of age, a QRS duration of 90 ms or more is considered to be prolonged, and in those whose ages are 4 to 16 years, a QRS duration of 100 ms or more is considered to be prolonged (4). In adult males, the QRS duration may be up to 110 ms (5). In 725 normal males more than 18 years of age, QRS duration ranged from 74 to 114 ms, with an average of 95 ms (6).

Because global data and data detailing the effects of age, gender, and race are still evolving (7–10), the committee recommends that for the present, a QRS duration of greater than 110 ms in subjects older than 16 years of age be regarded as abnormal. The data for both children and adults may have to be revised in the near future.

Review of Prior Recommendations With Revisions Proposed by the Committee

The committee recommends that the definitions and criteria for mean frontal plane electrical axis and axis deviation, R-wave peak time (defined as the interval from the onset of the QRS complex to the peak of the R wave in leads that do not have a small initial R wave, in preference to the term *intrinsicoid deflection*), complete and incomplete RBBB, complete and incomplete LBBB, left anterior and left posterior fascicular block, nonspecific intraventricular block, ventricular preexcitation, and the Wolff-Parkinson-White pattern and syndrome defined in 1985 (3) be retained, with the inclusion of appropriate values for pediatric subjects, including mean frontal plane axis and axis deviation. These definitions and criteria, with the revisions proposed by the committee, are presented below.

Table. Mean Frontal Plane Axis

Age	QRS Axis Normal Values	Abnormal Values	Description
Adult	−30° to 90°	<−30°	Left-axis deviation
		−30° to −45°	Moderate left-axis deviation
		−45° to −90°	Marked left-axis deviation
		90° to 120°	Moderate right-axis deviation
		120° to 180°	Marked right-axis deviation
8 to 16 y	0° to 120°	>120°	Right-axis deviation
5 to 8 y	0° to 140°	>140°	Right-axis deviation
		<0°	Left-axis deviation
1 to 5 y	5° to 100°	>100°	Right-axis deviation
1 mo to 1 y	10° to 120°	>120°	Right-axis deviation
		<10° to −90°	Left-axis deviation
Neonate	30° to 190°	>190° to −90°	Extreme right-axis deviation
		<30° to <−90°	Left-axis deviation

Mean Frontal Plane Axis

The mean frontal plane electrical axis, determined by the vector of the maximal (dominant) QRS deflection, depends on age and body habitus (Table). It shifts to the left with increasing age. In adults, the normal QRS axis is considered to be within −30° and 90°. Left-axis deviation is −30° and beyond. Moderate left-axis deviation is between −30° and −45°. Marked left-axis deviation is from −45° to −90° and is often associated with left anterior fascicular block. Moderate right-axis deviation in adults is from 90° to 120°, and marked right-axis deviation, which is often associated with left posterior fascicular block, is between 120° and 180°. In the absence of a dominant QRS deflection, as in an equiphasic QRS complex, the axis is said to be indeterminate.

In children, there is normally a rightward QRS axis at birth that shifts gradually leftward throughout childhood. In the neonate, the mean electrical axis in the frontal plane is between 60° and 190° and is termed "extreme right axis" when it is between −90° and 190°. Normally, the axis then shifts to the left, and by ages 1 to 5 years, it is generally between 10° and 110° (4). Between 5 and 8 years of age, the normal QRS axis may extend to 140°, and between ages 8 and 16 years, the range of QRS axis extends to 120°. Leftward QRS-axis shifts are present in congenital defects with underdevelopment of the right ventricle, such as tricuspid atresia, and with abnormal location of the conduction system, such as complete atrioventricular septal defect.

Complete RBBB

1. QRS duration greater than or equal to 120 ms in adults, greater than 100 ms in children ages 4 to 16 years, and greater than 90 ms in children less than 4 years of age.

2. rsr′, rsR′, or rSR′ in leads V_1 or V_2. The R′ or r′ deflection is usually wider than the initial R wave. In a minority of patients, a wide and often notched R wave pattern may be seen in lead V_1 and/or V_2.
3. S wave of greater duration than R wave or greater than 40 ms in leads I and V_6 in adults.
4. Normal R peak time in leads V_5 and V_6 but greater than 50 ms in lead V_1.

Of the above criteria, the first 3 should be present to make the diagnosis. When a pure dominant R wave with or without a notch is present in V_1, criterion 4 should be satisfied.

Incomplete RBBB

Incomplete RBBB is defined by QRS duration between 110 and 120 ms in adults, between 90 and 100 ms in children between 4 and 16 years of age, and between 86 and 90 ms in children less than 8 years of age. Other criteria are the same as for complete RBBB. In children, incomplete RBBB may be diagnosed when the terminal rightward deflection is less than 40 ms but greater than or equal to 20 ms. The ECG pattern of incomplete RBBB may be present in the absence of heart disease, particularly when the V_1 lead is recorded higher than or to the right of normal position and r′ is less than 20 ms.

The terms rsr′ and normal rsr′ are not recommended to describe such patterns, because their meaning can be variously interpreted. In children, an rsr′ pattern in V_1 and V_2 with a normal QRS duration is a normal variant.

Complete LBBB

1. QRS duration greater than or equal to 120 ms in adults, greater than 100 ms in children 4 to 16 years of age, and greater than 90 ms in children less than 4 years of age.
2. Broad notched or slurred R wave in leads I, aVL, V_5, and V_6 and an occasional RS pattern in V_5 and V_6 attributed to displaced transition of QRS complex.
3. Absent q waves in leads I, V_5, and V_6, but in the lead aVL, a narrow q wave may be present in the absence of myocardial pathology.
4. R peak time greater than 60 ms in leads V_5 and V_6 but normal in leads V_1, V_2, and V_3, when small initial r waves can be discerned in the above leads.
5. ST and T waves usually opposite in direction to QRS.
6. Positive T wave in leads with upright QRS may be normal (positive concordance).
7. Depressed ST segment and/or negative T wave in leads with negative QRS (negative concordance) are abnormal (11,12) and are discussed in part VI of this statement.
8. The appearance of LBBB may change the mean QRS axis in the frontal plane to the right, to the left, or to a superior, in some cases in a rate-dependent manner (13,14).

Incomplete LBBB

1. QRS duration between 110 and 119 ms in adults, between 90 and 100 ms in children 8 to 16 years of age, and between 80 and 90 ms in children less than 8 years of age.
2. Presence of left ventricular hypertrophy pattern.
3. R peak time greater than 60 ms in leads V_4, V_5, and V_6.
4. Absence of q wave in leads I, V_5, and V_6.

Nonspecific or Unspecified Intraventricular Conduction Disturbance

QRS duration greater than 110 ms in adults, greater than 90 ms in children 8 to 16 years of age, and greater than 80 ms in children less than 8 years of age without criteria for RBBB or LBBB. The definition may also be applied to a pattern with RBBB criteria in the precordial leads and LBBB criteria in the limb leads, and vice versa.

Left Anterior Fascicular Block

1. Frontal plane axis between −45° and −90°.
2. qR pattern in lead aVL.
3. R-peak time in lead aVL of 45 ms or more.
4. QRS duration less than 120 ms.

These criteria do not apply to patients with congenital heart disease in whom left-axis deviation is present in infancy.

Left Posterior Fascicular Block

1. Frontal plane axis between 90° and 180° in adults. Owing to the more rightward axis in children up to 16 years of age, this criterion should only be applied to them when a distinct rightward change in axis is documented.
2. rS pattern in leads I and aVL.
3. qR pattern in leads III and aVF.
4. QRS duration less than 120 ms.

Ventricular Preexcitation of Wolff-Parkinson-White Type

Whether preexcitation is full or not cannot be determined from the body surface ECG, but the following criteria are suggestive of full preexcitation:

1. PR interval (assuming no intra-atrial or interatrial conduction block) less than 120 ms during sinus rhythm in adults and less than 90 ms in children.
2. Slurring of initial portion of the QRS complex (delta wave), which either interrupts the P wave or arises immediately after its termination.
3. QRS duration greater than 120 ms in adults and greater than 90 ms in children.
4. Secondary ST and T wave changes.

Terms Not Recommended

The term *Mahaim-type preexcitation* is not recommended because the diagnosis cannot be made with certainty on the basis of the surface ECG. The terms *atypical LBBB*, *bilateral bundle-branch block*, *bifascicular block*, and *trifascicular block* are not recommended because of the great variation in anatomy and pathology producing such patterns. The committee recommends that each conduction defect be described separately in terms of the structure or structures involved instead of as bifascicular, trifascicular, or multifascicular block.

The term *Brugada pattern* to describe a pattern that simulates incomplete RBBB in lead V_1 with ST-segment changes is not recommended for incorporation into automated interpretative algorithms because there are 3 different types of ST-segment changes (15,16) and because the pattern is not specific for the Brugada syndrome. The use of this term should be left to the discretion of the overreader.

The term *left septal fascicular block* is not recommended because of the lack of universally accepted criteria.

Additional Terms

Peri-infarction block (17,18): The term *possible peri-infarction block* is recommended when, in the presence of an abnormal Q wave generated by a myocardial infarction in the inferior or lateral leads, the terminal portion of the QRS complex is wide and directed opposite to the Q wave (i.e., a QR complex in the inferior or lateral leads).

Peri-ischemic block (19,20): This term is recommended when a transient increase in QRS duration accompanies the ST-segment deviation seen with acute injury.

Disclosures

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(*Continued*)

JACC Vol. 53, No. 11, 2009
March 17, 2009:976–81

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (1) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (2) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

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*Modest.

†Significant.

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KEY WORDS: ACCF Expert Consensus Documents ■ electrocardiography ■ electrophysiology ■ conduction ■ IVCD.