Guideline

Guidelines for the Secondary Screening of Heart Disease in Schools: Electrocardiographic Findings of the Initial Screening (JSPCCS2019)

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The previous "Guideline for Secondary Screening of Heart Disease in Schools (2006 revised version)" has been widely used as a screening tool that utilizes the electrocardiogram (ECG) to detect heart disease in school students.[1] More than 10 years have passed since its publication. We need to revise it at this stage to reflect the current advancements in automated ECG diagnosing systems and changes in the growth of students' physiques.

As the first step for revising the guidelines, we collected ECG readings of approximately 50,000 healthy children in Japan to serve as a reference for the updated normal values.[2] This was performed by the Pediatric Electrocardiogram Research Committee (formerly the Committee for the Heart Disease Screening in School of the Japanese Society of Pediatric Cardiology and Cardiac Surgery) and other experts in this field. Then, the previous guidelines were revised to reflect the new reference for normal values. A large proportion of the new guidelines remain the same as the preceding comprehensive guidelines of school heart disease screening published by JCS 2016/JSPCCS 2016[3]; however, several parts have been consecutively discussed, modified, and added, in order to focus on new interpretation of ECG findings in school students.

The main points of revision are as follows:

1) In addition to the numerical value correction described above, the table of criteria which has been used to detect ventricular hypertrophy by a points system was incorporated into the screening criteria according to a code system.
2) Criteria and descriptive explanations for "Brugada-type ST-T abnormality," "ectopic atrial rhythm," and "Short QT interval" were included.
3) Annotations were added accordingly, labeled as "Note" or "Notes," to explain items *1 to *20 to ensure accuracy further.
4) In addition, we have added the terminology of diagnoses and findings in automated ECG diagnosis, as was presented by the Japanese Heart Rhythm Society in the Expert Consensus Statement in 2019.[4] We revised some of these terminologies and definitions while making sure that they are consistent with the Expert Consensus Statement.

The research process, the methods, and a proposal for revisions were presented at a joint meeting with the current School Health Screening Committee in 2019. Subsequent approval for publication of these guidelines in the Journal of the Society was provided.

Admitting that recording of ECG findings is desirable without a filtering system, it is usually necessary to filter noises and baseline oscillations out due to the large volume of ECGs recorded at schools. The ECG findings used in this study were based on filtered ECG records. The filtering maneuver may affect the QRS wave height.

In our study, we found that the R and S waves were reduced by approximately 10–15%, compared with the unfiltered example, after filtering electromyogram and hum noise.

The reference normal ECGs were obtained from students in the first grade of elementary school (6 grades, from 6 to 12 years old), junior high school (3 grades, 12 to 15 years old), and senior high school (3 grades, 15 to 18 years old). Therefore, our screening criteria are based on these references. Findings from each student are assessed according to the criteria for lower grades of elementary school students, for junior high school students, and for senior high school students. In the future, we aim to collect and analyze ECGs in fourth grade students of elementary school with the goal of developing and proposing criteria for screening heart disease in the upper grades of elementary school.

Found below are the explanations for screening categories A, B, and C. If there are two or more findings, the findings with higher categorization (in the order of A, B, and C) are prioritized.

Category A: Findings requiring secondary screening or further examination.

Category B: Findings not requiring secondary screening (if other abnormal findings are absent).

Category C: Findings not requiring heart disease screening at schools.

I. Q Wave

1. Broad Q wave

Category	Code No.	Findings
A	1-1-1	|Q|/R≥1/3 and Q≥0.03 sec (in any one of the leads I, II, V2 to V6)
	1-1-2	Q≥0.04 sec (in any one of the leads I, II, V1 to V6)
	1-1-4	QIII≥0.05 sec and |Q aVF| ≥0.1 mV
	1-1-5	Q aVF≥0.05 sec
B	1-1-3	Q aVL≥0.04 sec and R aVL≥0.3 mV
	1-2-2	0.03≤Q<0.04 sec (in any one of the leads I, II, V2 to V6)
	1-2-4	0.04≤QIII<0.05 sec and |Q aVF| ≥0.1 mV
	1-2-5	0.04≤Q aVF<0.05 sec
C	1-2-1	|Q|/R≥1/3 and 0.02≤Q and <0.03 sec (in any one of the leads I, II, V2 to V6)
	1-3-1	1/5≤|Q|/R<1/3 and 0.02≤Q<0.03 sec (in any one of the leads I, II, V2 to V6)
	1-3-3	0.03≤QaVL<0.04 sec and RaVL≥0.3 mV
	1-3-4	0.03≤QIII<0.04 sec and |QaVF| ≥0.1 mV
	1-3-5	0.03≤QaVF<0.04 sec

2. QS pattern

Category	Code No.	Findings
A	1-1-6	QS pattern when initial R-wave is present in adjacent right precordial leads (in any one of the leads V2 to V6)
	1-1-7	QS pattern (all leads V1 to V4 or all leads V1 to V5)
	1-1-8	QS pattern (lead V6)
	1-2-3	QS pattern (lead I or II)
	1-2-7	QS pattern (all leads V1 to V3)
	1-3-6	QS pattern (leads III and aVF)
C	1-3-2	QS pattern (leads V1 and V2)

3. Deep Q wave

Category	Code No.	Findings
A	1-4-1	|QV5|<|QV6| and |QV6| ≥0.5 mV
B	1-2-6	|Q| ≥0.5 mV (lead III or aVF)

4. Other Q wave findings

Category	Code No.	Findings
A	1-5-1	qR(S) pattern (lead V1)*1

Note

*1: When there are unusual findings in the Q wave listed as code nos. 1-2 and 1-3, the ST portion and findings in the T wave (code nos. 4 and 5) must be noted. When abnormalities coexist in both, myocardial ischemia and myocardial disease must be meticulously ruled out.

II. QRS Electrical Axis

Abnormal electrical axis

Category	Code No.	Findings
B	2-1-0	−90°＜QRS axis≦−30°
	2-4-1	−180°＜QRS axis≦−90°*2
	2-1-1	−30°＜QRS axis≦0° (only for students in lower grader of elementary school and students in junior and senior high school students are classified into category C.) for)
	2-2-1	＋135°≦QRS axis≦180°
	2-2-2	＋120°≦QRS axis＜＋135°
C	2-3-0	＋90°≦QRS axis＜＋120°
	2-5-0	Indeterminate axis (90° in the frontal plane)*3

Notes

*2: In case with severe QRS electrical axis deviation, anterior left bundle branch block or posterior left bundle branch block may be suspected. In such a circumstance, attention must be paid to further findings such as the presence of right bundle branch block or PR interval prolongation.

*3: An indeterminate electrical axis means that the angle of the electrical axis to the reference line cannot be measured because the amplitudes of the R and S waves are equivalent (the electrical axis is perpendicular to the frontal plane).

III. R Wave and S Wave

1. Right ventricular hypertrophy

Category		Lower grade in elementary school	Junior and senior high schools	
			Males	Females
A	qRS, qR, or R type in V1	＋	＋	＋
	High R wave in right precordial leads			
	RV1	≧2.0 mV	≧2.0 mV	≧1.5 mV
	R＜R' in V1 and R'V1 is:	≧1.0 mV	≧1.0 mV	≧1.0 mV
	R＞|S| in V1 and RV1 is:	≧1.5 mV	≧1.5 mV	≧1.0 mV
B	Deep S wave in left precordial leads			
	|SV6|	≧1.0 mV	≧1.0 mV	≧1.0 mV
	R≦|S| and |SV6| in lead V6 is:	≧0.5 mV	≧0.5 mV	≧0.5 mV
	Right axis deviation of QRS electrical axis*4	≧120°	≧120°	≧120°

As data collection from students in higher grades of elementary schools has been insufficient, these values in lower grade students are to be referenced for them.

2. Right ventricular overload/right ventricular high voltage (items with R and S wave probable right ventricular hypertrophy and their code nos.)

Category	Code No.	Findings
A	3-2-0	qR(S) pattern (lead V1) (same as code No. 1-5-1) or R pattern
	3-2-2	RV1≧2.0 mV
	3-2-4	RV1≧1.5 mV (in female students from junior and senior high school)
	3-2-7	R＜R' in V1 and R'V1≧1.0 mV
	3-2-3	R＞|S| in V1 and RV1≧1.5 mV
	3-2-5	R＞|S| in V1 and RV1≧1.0 mV (in female students from junior and senior high schools)
B	3-5-1	|SV6| ≧1.0 mV
	3-5-2	R≦|S| and |SV6| ≧0.5 mV in lead V6

3. Left ventricular hypertrophy

Category		Lower grade in elementary school	Junior and senior high schools	
			Males	Females
A	Strain pattern of ST-T in left precordial leads*4, *7	+	+	+
	High R wave in left precordial leads			
	RV5	≥4.0 mV	≥4.5 mV	≥3.5 mV
	RV6	≥3.0 mV	≥3.5 mV	≥2.5 mV
	Deep S wave in right precordial leads			
	|SV1|+RV5	≥6.0 mV	≥6.5 mV	≥5.0 mV
	|SV1|+RV6	≥5.0 mV	≥5.5 mV	≥4.5 mV
	Deep Q wave in left precordial leads:|QV5|<|QV6| and |QV6|	≥0.5 mV	≥0.5 mV	≥0.5 mV
B	High R wave in leads II, III, or aVF			
	R II and R III	≥2.5 mV	≥2.5 mV	≥2.5 mV
	RaVF	≥2.5 mV	≥2.5 mV	≥2.5 mV
	Left axis deviation of QRS electrical axis*4	≤0°	≤−30°	≤−30°

As data collection from students in higher grades of elementary schools remains insufficient, these values in lower grade students are to be referenced for them.

4. Left ventricular overload/left ventricular high voltage (items with R and S wave probable left ventricular hypertrophy and their code nos.)

Category	Code No.	Findings	
A	3-1-4	RV5≥4.5 mV	Males in junior and senior high schools
	3-1-1	RV6≥3.5 mV	
	3-3-3	|SV1|+RV5≥6.5 mV	
	3-3-0	|SV1|+RV6≥5.5 mV	
	3-1-6	RV5≥3.5 mV	Females in junior and senior high schools
	3-1-3	RV6≥2.5 mV	
	3-3-5	|SV1|+RV5≥5.0 mV	
	3-3-2	|SV1|+RV6≥4.5 mV	
	3-1-5	RV5≥4.0 mV	Lower grade in elementary school
	3-1-2	RV6≥3.0 mV	
	3-3-4	|SV1|+RV5≥6.0 mV	
	3-3-1	|SV1|+RV6≥5.0 mV	
B	3-1-8	R II and R III≥2.5 mV	
	3-1-9	RaVF≥2.5 mV	

Notes

*4: On top of the heading 3 describing hypertrophy on R and S waves, the items marked with *4 in the table far above are those that determine ventricular hypertrophy on other than R or S waves. The QRS electrical axis must be incorporated with other findings for judgement.

*5: Left ventricular hypertrophy is difficult to confirm in those with WPW syndrome or with left bundle branch block.

*6: The amplitude may be slightly lower in female students in senior high school than in those in junior high school. This is because diverse body weight (obesity/thinness) and/or breast development.

*7: Strain pattern of ST-T: High R wave in leads V5 or V6 with negative or biphasic T wave (− to +). ST segment is often down-sloping or flat.

IV. ST Junction and ST Segment

1. ST depression

Category	Code No.	Findings
A	4-1-1	ST-J depression≥0.2 mV and flat or down-sloping ST segment (in any one of the leads I, II, aVL, aVF, or V1 to V6)
	4-1-2	0.1≤ST-J depression<0.2 mV and flat or down-sloping ST segment (in any one of the leads I, II, aVL, aVF, or V1 to V6)
	9-2-4	Strain pattern of ST-T in left precordial leads*7
B	4-2-1	0.05≤ST-J depression<0.1 mV and flat or down-sloping ST segment (in any one of the leads I, II, aVL, aVF, or V1 to V6)
	4-3-1	ST-J depression<0.05 mV, down-sloping ST segment, and depression of ≥0.05 mV from baseline at ST segment or the lowest point of T wave (in any one of the leads I, II, aVL, or V2 to V6)
	4-4-1	ST-J depression>0.2 mV and up-sloping ST segment (in any one of the leads I, II, aVL, aVF or V1 to V6)
C	4-4-2	ST-J depression>0.1 mV and up-sloping ST segment (in any one of the leads: I, II, aVL, or V1 to V6)

2. ST elevation

Category	Code No.	Findings
A	9-2-2	Brugada-type ECG: coved-type*8, 10
	9-2-3	Brugada-type ECG: saddleback-type ST elevation*9, 10
C	9-2-1	ST elevation≥0.2 mV (in any one of the leads II, III, aVL, or V5 to V6): ignore this finding when 6-4: WPW syndrome or 7-1: left bundle branch block is present

Notes

*8: Brugada-type ST-T abnormality (coved-type): ST elevation≥0.2 mV at the J point in right precordial leads (in any of the leads V1, V2 or V3) and coved-type (type 1) ST-T change are recognized.

*9: Brugada-type ST-T abnormality (saddleback-type): ST elevation≥0.2 mV at the J point in right precordial leads (in any of the leads V1, V2 or V3) and saddleback-type (type 2) ST-T change are recognized.

*10: When saddleback-type (9-2-3) of Brugada-type ST-T abnormality is found, secondary screening is required; it is possible for the type to change into the coved-type (9-2-2) depending on diurnal variation, daily variance, or other conditions.
Saddleback-type in Brugada-type ST-T abnormality would better been investigated further by recording an ECG with a right precordial lead placed one or two intercostal space(s) higher, in addition to regular 12-lead ECG. This is recommended to confirm whether or not the saddleback-type changed into the coved-type.

V. T Wave

Category	Code No.	Findings
A	5-1-1	Negative, or biphasic T wave with negative deflection≥0.5 mV (in any one of the leads I, II, aVL [R≥0.5 mV], aVF [mainly positive QRS], or V3 to V6) (in any one of the leads V4 to V6 in the precordial leads in elementary school students)
	5-2-1	Negative, or biphasic T wave with negative deflection≥0.1 mV and <0.5 mV (in any one of the leads I, II, aVL [R≥0.5 mV], aVF [mainly positive QRS], or V4 to V6) (T wave with negative deflection≥0.1 mV and <0.4 mV in lead V4 of lower grade in elementary school students are categorized as B)
	5-7-1	T wave alternance
B	5-3-1	Flat (0), negative, or biphasic (± type) T wave with negative deflection<0.1 mV (flat or down-sloping ST segment) (in any one of the leads I, II, aVL [R≥0.5 mV], V5, or V6) (female students in junior or senior high schools with this finding are categorized as C)
	5-6-1	Positive TV1, RV1≥ |SV1| (only in students in the first year of elementary school or younger)
C	5-4-1	Positive T wave, 1/20>T/R and R≥1.0 mV (in any one of the leads I, II, aVL, V5 or V6)
	9-5-1	T>1.2 mV (in any one of the leads II, III, aVF or V6) (Ignore this finding when 6-4: WPW syndrome, 7-1: left bundle branch block, or 7-2: complete right bundle branch block is present)

As data collection from students in higher grades of elementary schools remains insufficient, these values in lower grade students are to be referred for them.

VI. Atrioventricular Conduction

1. Complete atrioventricular block

Category	Code No.	Findings
A	6-1-0	Third degree (complete) atrioventricular block

2. Second degree atrioventricular block

Category	Code No.	Findings
A	6-2-0	Second degree atrioventricular block (higher degree)*11
	6-2-1	Second degree atrioventricular block (Mobitz type II)
	6-2-2	Second degree atrioventricular block (2:1 atrioventricular block)
	6-2-3	Second degree atrioventricular block (Wenckebach type)

3. PR (PQ) interval

Category	Code No.	Findings
A	6-3-0	PR interval>0.28 sec
	6-3-1	PR interval>0.24 sec (only in elementary school students; junior/senior high school students with the same finding are classified to category B)
B	6-3-3	PR interval≥0.20 sec (only in elementary school students)
C	6-5-1	PR interval<0.08 sec

4. WPW syndrome (ECG showing delta wave)

Category	Code No.	Findings
A	6-4-1	WPW syndrome
	6-4-3	Intermittent WPW syndrome

5. Aberrant conduction

Category	Code No.	Findings
C	6-6-0	Aberrant conduction

6. Artificial pacemaker

Category	Code No.	Findings
A	6-8-0	Artificial pacemaker

As data collection from students in higher grades of elementary schools remains insufficient, these values in lower grade students are to be referred for them.

Note

*11: Second degree atrioventricular block (higher degree) is a circumstance in which atrioventricular (AV) conduction is 1 in 3 or worse, and missing QRS wave for two or more consecutive atrial contractions.

VII. Intraventricular Conduction

1. Left bundle branch block

Category	Code No.	Findings
A	7-1-1	Left bundle branch block: QRS duration≥0.12 sec, and VAT≥0.06 sec (in any one of leads I, II, aVL, V5, or V6) with no Q wave (only in junior high and senior high school students)
	7-1-2	Left bundle branch block: QRS duration≥0.10 sec, and VAT≥0.05 sec (in any one of leads I, II, aVL, V5, or V6) with no Q wave (only in the lower grade students of elementary school)
	7-1-3	Intermittent left bundle branch block
C	9-7-2	VAT V6≥0.06sec (ignore this finding when 6-4: WPW syndrome or 7-1: Left bundle branch block is present) (only in junior high and senior high school students)
	9-7-3	VAT V6≥0.05sec (ignore this finding when 6-4: WPW syndrome or 7-1: Left bundle branch block is present) (only in lower grade students of elementary school)

2. Complete right bundle branch block

Category	Code No.	Findings
A	7-2-1	Complete right bundle branch block: QRS duration≥0.12 sec, and R'>R and VAT≥0.06 sec (lead V1 or V2) (only in junior high and senior high school students)
	7-2-2	Complete right bundle branch block: QRS duration≥0.10 sec, and R'>R and VAT≥0.05 sec (lead V1 or V2) (only in lower grade students of elementary school)
	7-2-3	Intermittent complete right bundle branch block
C	9-7-5	VAT V1≥0.06sec (ignore this finding when 6-4: WPW syndrome, 7-2: complete right bundle branch block, or 7-3: incomplete right bundle branch block is present) (only in junior and senior high school students)
	9-7-4	VAT V1≥0.05sec (Ignore this finding when 6-4: WPW syndrome, 7-2: complete right bundle branch block, or 7-3: incomplete right bundle branch block is present) (only in lower grade students of elementary school)

3. Incomplete right bundle branch block*[12]

Category	Code No.	Findings
A	7-3-1	Incomplete right bundle branch block: The code 7-3-0 is recognized and R'V1≥|SV1| (only in junior and senior high school students)
	7-3-3	Incomplete right bundle branch block: The code 7-3-2 is recognized and R'V1≥|SV1| (only in lower grade students of elementary school students)
B	7-3-0	Incomplete right bundle branch block: QRS duration＜0.12 sec, and R＜R' (lead V1 or V2), or notch or slurring of the upward slope of the R wave in lead V1R is found (only in junior and senior high school students)
	7-3-2	Incomplete right bundle branch block: QRS duration＜0.10 sec, and R'＞R (lead V1 or V2), or notch or slurring of the upward slope of the R wave in lead V1R is found (only in lower grade students of elementary school)
C	7-5-0	QRS duration＜0.12 sec, R-R' type, and R'≤R (lead V1 or V2) (only in junior and senior high school students)
	7-5-1	QRS duration＜0.10sec, R-R' type, and R'≤R (lead V1 or V2) (only in lower grade students of elementary school)
	7-5-2	7-5-0 or 7-5-1, and R'V1≥0.5 mV and RV1≥ |SV1|

4. Intraventricular conduction disturbance*[13]

Category	Code No.	Findings
A	7-4-2	Intraventricular conduction disturbance: QRS duration≥0.13sec (only in male senior high school students)
	7-4-0	Intraventricular conduction disturbance: QRS duration≥0.12sec (only in female senior high school students and in both male and female junior high school students)
	7-4-1	Intraventricular conduction disturbance: QRS duration≥0.11sec (only in lower grade students of elementary school)

5. Left anterior fascicular block

Category	Code No.	Findings
A	7-7-0	Left anterior fascicular block: QRS duration＜0.12 sec, and |Q in lead I|≥0.025 mV, Q in lead I duration＜0.03 sec, and left axis deviation of −45° or more leftward
	7-7-1	Left anterior fascicular block: QRS duration＜0.10 sec, and |Q in lead I|≥0.025 mV, Q in lead I duration＜0.03 sec, and left axis deviation of −30° or more leftward (only in lower grade of elementary school students)

6. Bifascicular block

Category	Code No.	Findings
A	7-8-0	Bifascicular block: 7-2-1 and left axis deviation of −45° or more leftward (only in junior and senior high school students)
	7-8-1	Bifascicular block: 7-2-2 and left axis deviation of −30° or more leftward (only in elementary school students; junior and senior high school students with this finding are classified to category C)

7. Trifascicular block

Category	Code No.	Findings
A	7-9-0	Trifascicular block: 7-8-0 bifascicular block and PR＞0.28 sec (only in junior and senior high school students)
	7-9-1	Trifascicular block: 7-8-1 bifascicular block and PR＞0.24 sec (only in the lower grade of elementary school students)

As data collection from students in higher grades of elementary schools remains insufficient, these values in lower grade students are to be referred for them.

Notes

*12: Students with these findings (code nos. 7-3 or 7-5) should be examined carefully for heart sounds (phonocardiogram).

*13: Intraventricular conduction disturbance is a supraventricular rhythm, including sinus rhythm, with the QRS width increased but its waveform not fulfilling the definition of a left bundle branch block or right bundle branch block.

VIII. Rhythms

1. Premature supraventricular contractions

Category	Code No.	Findings
A	8-1-4	Multiform premature supraventricular contractions
B	8-1-1	Monomorphic premature supraventricular contractions (sporadic cases are classified to category C)

2. Premature ventricular contractions

Category	Code No.	Findings
A	8-1-2	Monomorphic premature ventricular contractions
	8-1-3	Combination of 8-1-1: Monomorphic premature supraventricular contractions and 8-1-2: Monomorphic premature ventricular contractions
	8-1-5	Polymorphic Premature ventricular contraction
	8-1-6	Premature ventricular contraction couplet
	8-1-7	R on T type premature ventricular contraction

3. Ventricular tachycardia

Category	Code No.	Findings
A	8-2-1	Ventricular tachycardia

4. Idioventricular rhythm

Category	Code No.	Findings
A	8-2-2	Idioventricular rhythm*14

5. Atrial fibrillation

Category	Code No.	Findings
A	8-3-1	Atrial fibrillation

6. Atrial flutter

Category	Code No.	Findings
A	8-3-2	Atrial flutter

7. Atrial flutter/fibrillation

Category	Code No.	Findings
A	8-3-3	Atrial flutter/fibrillation

8. Supraventricular tachycardia

Category	Code No.	Findings
A	8-4-1	Supraventricular tachycardia

9. Sinus arrest or sinoatrial block

Category	Code No.	Findings
A	8-5-1	Sinus arrest or sinoatrial block

10. Ectopic atrial rhythm

Category	Code No.	Findings
B	8-6-4	Ectopic atrial rhythm*[15]

11. Atrioventricular Junctional rhythm

Category	Code No.	Findings
A	8-6-0	Accelerated Junctional rhythm, heart rate (≥60bpm)*[16]
B	8-6-1	Atrioventricular Junctional rhythm*[16]

12. Atrioventricular dissociation

Category	Code No.	Findings
B	8-6-2	Atrioventricular dissociation (exclude complete atrioventricular block)*[17]

13. Escape beats or escape rhythm

Category	Code No.	Findings
B	8-6-3	Escape beats or escape rhythm

14. Sinus tachycardia*[18]

Category	Code No.	Findings
A	8-7-1	Heart rate (≥200bpm)
	8-7-2	Heart rate (≥180bpm)
B	8-7-3	Heart rate (≥150bpm)
	8-7-4	Heart rate (≥140bpm) (only in junior and senior high school students, elementary school students with the same finding are classified to C)
C	8-7-5	Heart rate (≥130bpm)
	8-7-6	Heart rate (≥100bpm)

15. Sinus bradycardia*18

Category	Code No.	Findings
B	8-8-1	Heart rate＜40 bpm
	8-8-2	Heart rate＜45 bpm (only in elementary school students; junior and senior high school students with this finding are classified to C)
C	8-8-3	Heart rate＜50 bpm
	8-8-4	Heart rate＜60 bpm

16. Other arrhythmias

Category	Code No.	Findings
A	8-9-9	Arrhythmias not otherwise specified
C	8-9-1	Sinus arrhythmia

As data collection from students in higher grades of elementary schools remains insufficient, these values in lower grade students are to be referenced for them.

Notes

*14: Idioventricular rhythm is a condition in which the control site of the heart beating (a pacemaker) is moved to a tissue other than the sinus node and considered to be found within the conduction system at the ventricular level.

*15: Ectopic atrial rhythm is a condition in which the control site of the heart beating (the pacemaker) is moved to a tissue other than the sinus node and considered to be found within the conduction system at the atrial level (the lower part of the right atrium, the coronary sinus, the left atrium, or other regions in the atrium).

*16: Atrioventricular junctional rhythm is a condition in which the control site of the heart beating (a pacemaker) is moved to a tissue other than the sinus node and considered to be located around the atrioventricular node. The P wave is negative in leads II, III, and aVF, and the pattern is found either immediately before the R wave (PR time less than 0.09 sec. for lower grade students in elementary school, less than 0.1 sec. for junior and senior high school students), simultaneously (P wave is invisible hidden by R), or immediately after the R wave (retrograde P). If the P wave is not seen, it is necessary to check for sinus dysfunction. Junctional excitation is usually less frequent than sinus node firing and typically occurs at a rate of 30–60/min. When junctional excitation is more frequent than 60/min, it is called accelerated atrioventricular junctional rhythm.

*17: Atrioventricular dissociation is a condition in which atrial excitation fails to activate the ventricles during the refractory period below the AV node; electricity conduction resumes once the refractory period has passed. Complete atrioventricular block, in which atrial excitation does not activate the ventricles regardless of the refractory period, is therefore excluded.

*18: Tachycardia or bradycardia should be regarded as phenotypes of disorder of the conduction system.

IX. Others

1. Low voltage

Category	Code No.	Findings
B	9-1-0	Low voltage: QRS＜0.5 mV (all leads I, II, and III) or QRS＜1.0 mV (all leads V1 to V6)

2. Atrial load

Category	Code No.	Findings
B	9-3-1	P≧0.30 mV (in any one of the leads II, III, aVF, or V1)
	9-3-3	P duration≧0.12 sec (in any one of the leads I, II, or aVL) (only in junior and senior high school students)
	9-3-4	P duration≧0.10 sec (in any one of the leads I, II, or aVL) (only in elementary school students)
	9-3-5	9-3-3 or 9-3-4, and biphasic P wave and duration of positive part＜duration of negative part (in lead V1 or V2)
C	9-3-2	P≧0.25 mV (in any one of the leads II, III, aVF, or V1)

3. Dextrocardia

Category	Code No.	Findings
A	9-6-1	Dextrocardia

4. QT prolongation*19

Category	Code No.	Findings
A	9-7-1	Criteria for QT prolongation using automatic ECG analysis in school screening: QT prolongation is defined as a QTc of ≥0.45 sec, obtained using the Fridericia correction. This is in agreement with the committee of this guideline for this time, as there is no data available from automatic measurement. (The reason for "≥0.45" sec is that QTc obtained in automatic ECG analysis is often approximately 20 msec longer than that that obtained using the tangent method.) When QT prolongation is suspected in automatic analysis, ECG should be reviewed manually using the tangent method (see the following table). The morphology of T wave should be considered as well. Table: Criteria of QT prolongation by the tangent method Both male and female in the first grade of elementary school ≥0.43 sec Both male and female in the first grade of junior high school ≥0.44 sec Students in the first grade of senior high school ≥0.44 sec in males, ≥0.45 sec in females No data are available for other grades. Refer to the above values for other grades.

5. Short QT

Category	Code No.	Findings
A	9-7-6	QTc value (obtained using Bazett's formula) ≤0.32sec (tentative criteria)*20

6. Reexamination is required

Category	Code No.	Findings
A	9-8-0	Unreadable ECG due to baseline drift, alternate current interference, artifacts from electromyogram, or other technical errors

7. Negative U wave

Category	Code No.	Findings
B	9-2-2	Negative U wave

Notes

*19: When QT prolongation (9-7-1) is fulfilled, attention must be paid to the following characteristic T waves: notched T waves, alternating T waves, broad based T waves, late appearing T waves, etc.

*20: There are a variety of opinions on the criteria of short QT syndrome, and no worldwide consensus has been made. The following standard values were reported by means of the tangential method with correction using the Bazett method. Male students: ≤0.325 sec, ≤0.315 sec, and ≤0.305 sec in the first grade of elementary school, of junior high school, and of senior high school, respectively. As for female students: ≤0.320 sec in the first grade of elementary, junior high, and senior high schools (Hazeki D, et al. Circ J, 2018; **82**(10): 2627–2633).

References

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