ELECTROCARDIOGRAPHIC CLASSIFICATION AND ABBREVIATED LEAD SYSTEM FOR POPULATION-BASED STUDIES OF CHAGAS' DISEASE[1]

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A modification of the Minnesota Code to standardize recording of electrocardiographic data in population-based studies of Chagas' cardiopathy is presented and evaluated. A five-lead electrocardiographic system for rapid screening of large populations is also described.

Introduction

Epidemiologic studies offer important clues regarding the pathogenesis, evolution, and prognosis of Chagas' heart disease. In this context immunologic procedures provide an index of the prevalence of infection, while the electrocardiogram remains the basic tool for determining the prevalence of disease and for studying its natural history.

There is no generally accepted classification system with clearly-defined criteria for recording the electrocardiographic findings of population-based studies of Chagas' disease. Reports of epidemiologic surveys in the past often failed to include criteria for electrocardiographic interpretation *(1, 2, 3, 4)*, and different research centers have employed different standards *(5, 6, 7, 8)*. As a result, it is difficult to compare results of one study with those of another, and there is no guarantee of consistency within the same study.

In an attempt to standardize the recording of electrocardiographic data in our field studies, we developed a classification system for Chagas' cardiomyopathy. The Minnesota Code *(8, 9)* was chosen as the basis for this system because of its broad use in population-based studies *(10, 11)*, its easy employment by the electrocardiographer, and its organization in a form suitable for computer analysis. Although the Minnesota Code was designed for studies of coronary artery disease and does not permit coding of many of the complex arrhythmias and conduction defects characteristic of chronic Chagas' cardiomyopathy, it has been used in Chagas' disease studies *(7, 12)*. Nevertheless, modifications of the code have not been published, and the code's suitability for population-based studies of Chagas' disease has not been tested.

In this article we present and evaluate an amplification of the Minnesota Code for population-based studies of Chagas' heart disease. We also describe an abbreviated lead

system *(13, 14)* that we have used since 1973 to screen large populations. The system, which employs only leads I, II, aVL, V_1, and V_5, has been particularly useful in rural areas where electrocardiogram recording facilities are limited.

Electrocardiographic Classification System

Our modifications of the Minnesota Code are shown in detail in the Appendix. The original code's procedural rules *(9)* for measuring heart rate, intervals, and wave forms were not changed, and the basic sections of the original code were retained. However, a code was added to each section to document the absence of specific abnormalities or (in the case of sections 2 and 8) to record the normal axis and normal sinus rhythm. The modifications of the code were adapted from the diagnostic criteria of the New York Heart Association *(15)*, definitions proposed by an international task force *(16)*, and tables of normal parameters *(15, 17)*.

Sections 1 and 4 of the original code were not changed. In Section 2, the restriction not to code QRS axis deviation in the presence of ventricular conduction defects was removed in view of the frequent combinations of right bundle branch block and fascicular block in Chagas' disease *(18)*. Also, the criteria for axis deviation were modified to facilitate the coding of the fascicular blocks.

Qualifying statements were amended to permit coding of electrocardiograms for children, since the criteria of the original code apply only to adult men. Thus, we recommend that tall left precordial R waves (categories 3-1 and 3-3) not be coded for individuals under 35 years of age and that T-wave inversions in the right- and mid-precordial leads (5-1, 5-2, and 5-3) not be coded in individuals under 25 years of age because these patterns may represent normal findings. The upper limits of normal for PR interval and QRS duration were reduced for the purpose of coding conduction defects in younger individuals (Sections 6 and 7) *(15, 17)*.

Second degree A-V block in the original code was divided into types I and II in the modified code (6-2 and 6-3). Section 7, "Ventricular Conduction Defects," was expanded to encompass the combinations of ventricular conduction defects common in Chagas' cardiomyopathy. Section 8, "Arrhythmias," was expanded to include a wide spectrum of rhythm disturbances, with particular emphasis on ventricular ectopic activity. The Lown-Wolf classification of ventricular extrasystoles *(19)* was incorporated into the code, and the severity of these was graded according to frequency, multiformity, repetitive pattern, and degree of prematurity. Although it has been demonstrated in patients with coronary heart disease that advanced grades of ventricular extrasystoles carry an enhanced risk of sudden death *(20)*, such prognostic information is not yet available for patients with Chagas' disease. It is hoped that use of such a classification system in longitudinal population-based studies will help clarify the prognostic significance of arrhythmias for Chagas' disease patients. In Section 9, "Miscellaneous," categories for artificially-paced rhythms are included.

Reliability and Sensitivity

Methods

The reproducibility of results derived from coding electrocardiograms according to this classification system was tested by comparing the observations of two independent readers, both internists. The electrocardiograms examined consisted of 100 from hospitalized or ambulatory patients from the Hospital Professor Edgard Santos in Salvador, Bahia, with positive complement fixation tests for *T. cruzi* and 110 from all individuals over five years of age living on a single *fazenda* (plantation) in Castro Alves, Bahia *(21)*. Forty-one per cent of the latter group showed serologic evidence of Chagas' infection.

Recording of twelve-lead tracings followed the methods of Rose and Blackburn *(9)*. A

.thirty-second lead II or V_1 rhythm strip was recorded for all individuals in the rural area. Readings were made without the benefit of clinical information. To compare the sensitivity of the five-lead system with that of the twelve-lead system, each reader analyzed all tracings with only five leads showing; then, one or two weeks later, he reread the same tracings with all 12 leads showing but without knowledge of his previous interpretation.

Results

Tables 1 and 2 compare the coded interpretations of the two readers.

The different frequency of abnormalities found in the hospital (Table 1) and rural area (Table 2) groups reflected the characteristics of the two populations. The large numbers of axis deviations, conduction defects, and arrhythmias in the hospital patients were consistent with their 100 per cent seropositivity, high prevalence of apparent heart disease, and greater mean age (42.7 years). The rural group had a lower degree of seropositivity, exhibited few cases of clinically apparent heart disease, and included many children (the

population's mean age was 28.0 years); as expected, the prevalence of conduction defects and arrhythmias was low.

The two readers agreed upon their coding of 82 per cent of the twelve-lead ECGs from the hospital group, upon 94.5 per cent of the tracings from the rural area, and upon 88.6 per cent of the total. Concordance was slightly greater with the five-lead tracings. Interobserver variation in ECG interpretation of similar or even greater degree has been documented by several workers *(22, 23)* including Blackburn, who used the Minnesota Code *(8)*.

Ten per cent of the disagreements represented differences of interpretation, most commonly in differentiating ventricular ectopic impulses from aberrantly conducted supraventricular impulses. More than half of the disagreements were due to small differences in measuring intervals of wave dimensions—differences that nevertheless resulted in the assignment of different codes. Some oversight on the part of one or the other reader accounted for other disagreements. To minimize such errors, we now require that our readers record the frequency, PR interval, and QRS duration for each tracing, and that the two

Table 1. Hospital electrocardiogram interpretations of the two readers using five-lead and twelve-lead systems. A total of 100 electrocardiograms obtained from hospital patients were examined.

Item	Code	Results with the twelve-lead system			Results with the five-lead system		
		No. of abnormalities coded		No. of disagree-ments	No. of abnormalities coded		No. of disagree-ments
		Reader 1	Reader 2		Reader 1	Reader 2	
Normal tracing[a]		14	13		15	15	
Q and QS items	1	22	22	6	9	6	4
Axis	2	51	52	2	51	52	2
High R waves	3	8	7	1	8	7	1
S-T depression	4	6	7	2	6	7	2
T-wave items	5	32	33	3	30	30	2
A-V conduction	6	18	17	3	18	17	3
Ventricular conduction	7	57	57	1	57	57	1
Arrhythmias[b]	8	45	44	4	37	36	4
Miscellaneous	9	16	16	0	17	17	0
Total disagreements				22 (in 18 ECGs)			19 (in 15 ECGs)

[a]Including 8-0-2, 8-7-1, 8-8-1.
[b]Excluding 8-0-2, 8-7-1, 8-8-1.

Table 2. Rural area electrocardiogram interpretations of the two readers using five-lead and twelve-lead systems. A total of 110 electrocardiograms from residents of the rural study area were examined.

Item	Code	Results with the twelve-lead system			Results with the five-lead system		
		No. of abnormalities coded		No. of disagree-ments	No. of abnormalities coded		No. of disagree-ments
		Reader 1	Reader 2		Reader 1	Reader 2	
Normal tracing[a]		78	80		83	84	
Q and QS items	1	3	2	1	0	0	0
Axis	2	6	6	1	6	6	1
High R waves	3	8	8	0	8	8	0
S-T depression	4	0	0	0	0	0	0
T-wave items	5	1	1	0	0	0	0
A-V conduction	6	6	5	1	6	5	1
Ventricular conduction	7	8	8	0	8	8	0
Arrhythmias[b]	8	9	9	2	8	8	2
Miscellaneous	9	3	2	1	1	1	1
Total disagreements				6 (in 6 ECGs)			5 (in 5 ECGs)

[a]Including 8-0-2, 8-7-1, 8-8-1.
[b]Excluding 8-0-2, 8-7-1, 8-8-1.

readers code each tracing independently but review discrepant readings together to decide on a final coding.

The observed discrepancies do not lessen the usefulness of the code for studies of Chagas' cardiomyopathy. Twenty per cent of the disagreements involved minor differences in R-wave height, S-T depression, and T-wave inversions that by themselves would not contribute to the final classification of the tracing as unequivocally abnormal or consistent with Chagas' cardiopathy. One-third of the disagreements concerned the coding of Q and QS waves, items that are more important in the diagnosis of coronary disease than of Chagas' disease. In this study, pathological Q and QS waves in tracings of seropositive individuals occurred only in the presence of ventricular conduction defects. Hence, errors in coding Q and QS items were compensated for by the coding of ventricular conduction defects, where the discrepancy rate was low.

Table 3 lists the differences in the coding performed by both readers with the five-lead as compared to the twelve-lead ECG. Overall, the five-lead classifications were in agreement with the twelve-lead classifications in 87 per cent of the cases. The items missed in the five-lead tracings were Q and QS items, S-T depressions, T-wave items, and arrhythmias— all items recorded only by leads III, R, F, V_{2-4}, or V_6. None of the Q and QS items occurred in the absence of bundle branch or fascicular block in the seropositive group.

In the hospital group, extrasystoles were detected in seven cases by the twelve-lead ECG but not by the five-lead ECG. In an attempt to improve the sensitivity of the five-lead tracing for detecting arrhythmias, a thirty-second rhythm strip was included in the recordings taken in the rural area. In this group, however, the rhythm strip did not in any instance increase the sensitivity of the five-lead electrocardiogram with respect to the twelve-lead tracing. In other population-based surveys in endemic areas we have observed that a thirty-second rhythm strip detected ectopic activity not present on either the five-lead or twelve-lead recordings in less than 1 per cent of over 500 individuals.

Table 3. Differences in the results obtained with the five-lead system as compared to the twelve-lead system, showing the discrepancies recorded by both readers in examining 210 ECGs.

Item coded with twelve-lead ECG	Item coded with five-lead ECG	No. of times each discrepancy occurred	
		Reader 1	Reader 2
1-1-1, 1-1-6, or 1-1-7	1-1-0 ⎫		
1-2-2 or 1-2-7	1-2-0 ⎬	16	18
1-3-2, 1-3-3, 1-3-4, or 1-3-6	1-3-0 ⎭		
2-5	2-6	1	0
4-2	4-3	1	1
5-2 or 5-3	5-0 or 5-3	4	5
8-1-1-1	8-1-1-0	2	2
8-1-2-1	8-1-2-0	6	6
8-1-3-1	8-1-3-0	1	1
8-1-4-2	8-1-4-1	1	1
9-0	9-1	1	1
9-5	9-0	2	1
Total discrepancies		35 (in 27 ECGs)	36 (in 26 ECGs)

Discussion and Conclusions

Our experience with the modified Minnesota Code has demonstrated that it is a useful and reproducible system for classifying electrocardiograms in cases of possible Chagas' disease. Its criteria for coding abnormalities are objective and thus eliminate subjective decisions from the data-collecting process. The format of the code is amenable to additions, subtractions, and modifications as required by the individual researcher. However, strict adherence to the code is desirable to allow comparability within and among studies.

Nevertheless, like the original Minnesota Code, the modified code contains criteria that may appear "arbitrary, and arrived at by compromises not likely to please anyone entirely" (9). Furthermore, it suffers from the variability and limitations in sensitivity common to the original Minnesota Code (9, 24) and other electrocardiographic codes (25).

We believe that the five-lead electrocardiogram is suitable for screening subjects in population-based studies of Chagas' disease. Appreciable savings of time, in both recording and analyzing abbreviated electrocardiograms, have been quantitated elsewhere (13). The five-lead tracing is nearly as sensitive and precise as the twelve-lead electrocardiogram for identifying the common and important abnormalities of chronic Chagasic cardiomyopathy, although extrasystoles are recorded less frequently. (Since extrasystoles often occur sporadically, their detection tends to depend on the duration of the recording—26.) However, the small increase in sensitivity afforded by a rhythm strip, as demonstrated here and elsewhere (20), does not justify the additional expense and time needed to include it as a screening tool in the field. Its best use would be to diagnose and grade arrhythmias occurring in individuals found to have an irregular heartbeat upon physical examination or upon interpretation of an initial electrocardiographic tracing.

ACKNOWLEDGMENT

SUMMARY

A lack of standardized criteria for electrocardiographic interpretation has made it difficult to compare studies of Chagas' heart disease from different geographic areas. To achieve uniform reporting of electrocardiographic data from our field project, we developed a coding system especially adapted for studies of Chagas' disease.

This system was devised by modifying the Minnesota Code to allow recording of the complex conduction disturbances and arrhythmias characteristic of Chagas' disease. The reproducibility of the system was tested by evaluating 100 electrocardiograms of hospital patients with Chagas' disease and 110 electrocardiograms of people living in an area with endemic Chagas' disease.

A five-lead recording system was also tested with a view to facilitating the screening of large populations. Its sensitivity in detecting the electrocardiographic abnormalities of chronic Chagas' heart disease compares favorably with that of the traditional twelve-lead recording.

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APPENDIX

Directions for Modifying the Minnesota Code for Use in Population-based Studies of Chagas' Disease[1]

1) Q and QS Patterns:

Add: 1-1-0, absence of any item 1-1 mentioned below

1-2-0, absence of any item 1-2 mentioned below

1-3-0, absence of any item 1-3 mentioned below

2) QRS Axis Deviation:

Remove: (Do not code in presence of low voltage QRS, code 9-1, or ventricular conduction defect 6-4, 7-1, 7-2, 7-4.)

Remove: 2-3, 2-4, 2-5

Add: 2-6, right axis deviation: QRS axis from +91° through -119°

2-7, extreme right axis deviation: QRS axis from -120° through -91°

2-8, normal axis: QRS axis from +90° through -29°

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[1]Definitions of terms and criteria are taken from the original Minnesota Code *(9)* and references *15* and *16*, with modifications by the authors of the present paper. The criteria for PR and QRS duration in children were modified on the basis of tables of normal values *(15, 17)*.

3) High-Amplitude R Waves:

Add: Do not code 3-1 or 3-3 in individuals under 35 years of age

Add: 3-0, absence of any item 3 mentioned below

4) ST Junction (J) and Segment Depression:

Add: 4-0, absence of any item 4 mentioned below

5) T-Wave Items:

Add: Do not code T-wave items 5-1, 5-2, 5-3 in leads V_2, V_3, V_4 in individuals under 25 years of age

Add: 5-0, absence of any item 5 mentioned below

6) A-V Conduction Defect:

Add: 6-0, absence of any item 6 mentioned below

Substitute: 6-2, 6-3, 6-4, 6-5 with the following:

6-2, advanced second-degree AV block (includes Mobitz type II and incomplete atrioventricular block with 2:1 atrioventricular response): Intermittent failure of propagation of impulses to the ventricle following one or more conducted impulses showing constant conduction items. PR interval of normal beats is normal or prolonged.

6-3, second-degree A-V block, type I (Wenckebach): Intermittent failure of atrioventricular impulse conduction in which the blocked impulse is preceded by progressive prolongation of the PR interval relative to that of the first conducted impulse.

6-4, first-degree A-V block: Prolonged PR interval with a 1:1 conduction ratio in any leads of I, II, III, aVL, aVF:

Age group	Rate	Criteria for prolonged PR
≥15 years (adults)	≤100	≥0.22 seconds
	101-120	≥0.21 seconds
	>120	≥0.20 seconds
5-14 years (children)	≤100	>0.20 seconds
	101-120	>0.19 seconds
	>120	>0.18 seconds

6-5, Wolff-Parkinson-White pattern:

PR interval <0.12 seconds (adults) or <0.09 seconds (children); QRS>0.10 seconds (adults) or >0.09 seconds (children) and presence of delta-wave (slow slurring of initial part of QRS complex).

6-6, short PR interval:

PR interval <0.12 in adults and <0.09 in children measured in all complexes of any two of the following leads: I, II, III, aVL, aVF. Not coded in presence of 8-4-1, 8-4-2, 8-6-1, 8-6-2, 8-7-1.

7) Ventricular Conduction Defect:

In 7-1, 7-2, and 7-4 replace the phrase "QRS duration 0.12 sec. or more" with "QRS duration 0.12 sec. or more in adults or 0.11 sec. or more in children."

In 7-3 and 7-6 replace the phrases "QRS duration less than 0.12 sec." and "QRS duration at least 0.10 sec. and less than 0.12 sec." with the phrase "QRS duration at least 0.10 sec. and less than 0.12 sec. in adults, or at least 0.09 sec. and less than 0.11 sec. in children."

Add: 7-0, absence of all items 7 below

7-7, anterior fascicular block (AFB):

a) presence of 2-1

b) QRS duration less than or equal to 0.10 sec.

c) small (non-codable) Q waves in I, aVL, V$_5$, and V$_6$

d) S in II, III, and aVF with S greater than R in leads II and aVF

7-8, RBBB and AFB (takes precedence over 7-2 and 7-7):

a) presence of 2-1 or 2-7

b) meets requirements for 7-2

c) small (non-codable) Q in I and aVL

d) R wave in aVL equal to or greater than S wave

e) S wave in lead II greater than R wave

7-9, IRBBB and AFB (takes precedence over 7-3 and 7-7):

a) presence of 2-1 and 2-7

b) meets requirements for 7-3

c) small (non-codable) Q in I and aVL

d) R wave in aVL equal to or greater than S wave

e) S wave in lead II greater than R wave

7-0-0, absence of all items 7-0 below

7-0-1, posterior fascicular block (PFB):

a) presence of 2-6

b) QRS duration less than or equal to 0.10 sec.

c) small Q in II, III, aVF not meeting requirements for 1-1 or 1-2

d) large R waves in II, III, and F with R wave greater than S wave in lead II

e) R wave greater than S wave in V$_5$ and V$_6$

f) absence of 3-2

7-0-2, RBBB and RFB (takes precedence over 7-2 and 7-0-1):

a) meets requirements of 7-2

b) meets requirements of 7-0-1 ex-

cept that QRS duration meets requirements of 7-2

7-0-3, IRBBB and RFB (takes precedence over 7-3 and 7-0-1):

a) meets requirements of 7-3

b) meets requirements of 7-0-1 except that QRS duration meets requirements of 7-3

7-0-4, transient intraventricular defects (specify)

8) Arrhythmias:

Add: 8-0-0, absence of all items 8-0 below

8-0-1, sinus rhythm (code in presence of 8-7-1 and 8-8-1): Regular rhythm with P to P interval varying less than 0.16 sec. P wave upright in I, II, aVF, V$_5$, and V$_6$. P wave followed by ventricular deflections QRS-T, unless there is atrioventricular block.

8-0-2, irregular sinus rhythm (sinus arrhythmia): P to P intervals varying more than 0.16 sec. Fixed PR interval followed by QRS-T complex except in case of atrioventricular block.

8-1-1-0, absence of any items in 8-1-1 mentioned below

8-1-1-1, atrial extrasystole

8-1-1-2, junctional extrasystole

8-1-1-3, atrial and junctional extrasystoles (8-1-1-1 and and 8-1-1-2)

8-1-1-4, frequent atrial extrasystoles: 10 per cent or more of recorded cycles are atrial extrasystoles.

8-1-1-5, frequent junctional extrasystoles: 10 per cent or more of recorded cycles are junctional extrasystoles.

8-1-1-6, irregular, multiform, supraventricular rhythm (wandering atrial pacemaker):
Supraventricular rhythm with changing P-wave morphology, varying PR intervals, and rate less than 100 per minute.

8-1-1-7, combination of 8-1-1-6 and 8-1-1 item

8-1-1-8, multifocal atrial tachycardia:
Supraventricular arrhythmia with changing P-wave morphology, varying PR intervals, and rate exceeding 100 per minute.

8-1-2-0, absence of all items 8-1-2 mentioned below

8-1-2-1, infrequent ventricular extrasystoles (requires a code in 8-1-4): less than 10 per cent of recorded cycles or Lown Grades IA and B

8-1-2-2, frequent ventricular extrasystoles (requires a code in 8-1-4): 10 per cent or more of recorded cycles or Lown Grade 2

8-1-2-3, ventricular extrasystolic bigeminy (ventricular bigeminy) (requires a code in 8-1-4; takes precedence over 8-1-2-2)

8-1-3-0, absence of 8-1-3 mentioned below

8-1-3-1, repetitive ventricular extrasystoles—pairs (couplets, Lown Grade 4A)

8-1-4-1, unifocal ventricular extrasystole (Lown Grade 1 or 2)

8-1-4-2, multiform ventricular extrasystole (Lown Grade 3)

8-1-5-0, absence of 8-1-5 items mentioned below

8-1-5-1, early ventricular extrasystole (QRS of extrasystole occurring before termination of T wave of previous complex; Lown Grade 5)

8-1-6-0, absence of all 8-1-6 items mentioned below

8-1-6-1, A-V dissociation without antegrade block
a) atrial rate less than ventricular
b) P waves independent of QRS complex

8-1-6-2, complete sino-atrial exit block:
Failure of sinus impulse to reach or discharge the atria; P wave and QRS-T fail to appear at expected interval; resultant P-P pause an exact multiple of the dominant P-P interval.

8-1-6-3, incomplete sino-atrial exit block (sino-atrial exit block with Wenckebach phenomenon):
P to P intervals preceding the pause progressively shorten; the pause is less than a multiple of the basic P to P interval; and the P to P interval following the pause is longer than the preceding P to P interval.

8-1-6-4, sinus arrest:
Cessation of impulse formation of the sino-atrial node; P wave and accompanying QRS-T complex fail to appear at the expected time; resultant pause usually shorter than two normal P-P intervals and not an exact multiple of the P to P cycle length; may be followed by escape discharges or rhythm.

8-2-0, absence of 8-2-1

8-2-1, ventricular tachycardia (Lown Grade 4B): Three or more consecutive extrasystoles at a rate exceeding 100/min.

8-3-0, absence of all 8-3 items mentioned below

8-3-1, atrial fibrillation: Absent P waves; baseline consists of irregular wave forms which continuously change in shape, duration, amplitude, and direction; ventricular response totally irregular except in the presence of complete AV block.

8-3-2, atrial flutter: Atrial activity represented by regular biphasic oscillations (flutter waves) which are uniform in shape and occur at rates between 200 and 400 per min.; absence of isoelectric line between deflections; 2:1 or higher degree A-V block may be present.

8-4-0, absence of all 8-4 items mentioned below

8-4-1, atrial rhythm: Rate less than 100 with form of P-wave differing from that of normal sinus beat (P wave may be negative in II, III, and aVF, and positive in aVR).

8-4-2, atrial tachycardia: Atrial rate greater than 100, usually between 140 and 200; P-wave form different from P wave of sinus rhythm; PR normal or prolonged, QRS complex normal or slightly aberrant; isoelectric baseline between P waves; atrioventricular conduction 1:1 or with an ad-

vanced degree of A-V block (usually 2:1 conduction).

8-4-3, supraventricular rhythm: Rate less than 100 per minute, rhythm regular, QRS complexes of normal duration (except if a period of normal sinus rhythm shows bundle branch block), and no atrial waves seen.

8-4-4, supraventricular tachycardia: Rate exceeding 100 per minute, rhythm regular, QRS complexes of normal duration, and no atrial waves seen.

8-5-0, absence of all 8-5 items mentioned below

8-5-1, ventricular fibrillation: QRS and T waves not identifiable, recorded deflections continuously change in shape, duration, magnitude, and direction.

8-5-2, ventricular asystole: Cessation of ventricular electrical activity.

8-5-2, ventricular rhythm: Rate under 70 with regularly occurring, wide QRS complexes not preceded by P waves. P waves may be absent or there may be complete AV block.

8-5-2, accelerated ventricular rhythm: Ventricular rhythm with rate between 70 and 100.

8-5-4, any combination of the above

8-6-0, absence of all 8-6 items mentioned below

8-6-1, atrioventricular junctional rhythm: Regular with rate 100 per minute or less; P wave may occur before (with PR inter-

val less than 0.12 seconds), during, or after the QRS complex, and is inverted in II, III, and aVF. (If the P wave occurs during the QRS complex and is not seen, code as 8-4-3.)

8-6-2, atrioventricular junctional tachycardia:
Rate exceeding 100 per minute; rhythm regular with P wave occurring before (with PR interval less than 0.12 seconds), during, or after the QRS complex. P wave inverted in II, III, and aVF.

8-7-0, absence of 8-7-1

8-7-1, sinus tachycardia:
Sinus rhythm with rate over 100 per minute.

8-8-0, absence of 8-8-1

8-8-1, sinus bradycardia:
Sinus rhythm with rate under 50 per minute.

8-9-0, absence of 8-9-1

8-9-1, arrhythmia not mentioned above

9) Miscellaneous Items at Rest:

Remove: 9-0, 9-4-1, 9-4-2, 9-5

Add:
9-0, absence of any item 9 below
9-4, functioning artificial pacemaker
9-5, malfunctioning artificial pacemaker
9-6, T-wave amplitude greater than 12 mm in any leads of I, II, III, aVL, aVF, V_1-V_6. (Do not code in the presence of codes 6-4, 7-1, 7-2, or 7-4.)
9-9, any combination of items above