The Ballistocardiogram in Acute Rheumatic Fever

By William B. Abrams, 1st Lt., MC, AUS, and George L. Chesley, Capt. MC, AUS

Sixty-four ballistocardiograms were obtained on a portable equalized electromagnetic ballistocardiograph from 18 young adult males with acute rheumatic fever. Thirteen of these subjects had clinical findings suggestive of heart involvement and five did not. Abnormal records were obtained from only one patient in each group. It appears, therefore, that abnormal ballistocardiograms are not often found in acute rheumatic fever even when evidences of cardiac involvement are present.

In a previous communication the ballistocardiograms obtained from 319 healthy young adult males on an equalized electromagnetic ballistocardiograph were described. The present report deals with the ballistocardiograms similarly obtained from 18 young adult males with acute rheumatic fever, 13 of whom had clinical evidences of heart involvement. Starr, Dock, Epstein and Hoffman have reported cases of active rheumatic carditis in which the ballistocardiograms were abnormal.

Materials and Methods

All patients were on the medical service of a military hospital and were under the direct care of one of the authors. The diagnoses of acute rheumatic fever were based on the clinical findings listed in table 1. Six of the patients had had an upper respiratory illness within the three weeks prior to the onset of the presently discussed illness, and four individuals gave a history of a previous attack of rheumatic fever. None of the subjects received penicillin or immunization injections or admitted to a urethritis during the month prior to the onset of the illness. All 18 patients had fever. All but one subject had a migratory polyarthritis which in every case subsequently cleared completely. All but one individual had an elevated erythrocyte sedimentation rate. The patient without arthritis had a tachycardia and a transient second degree auriculoventricular heart block on the electrocardiogram. Valvulitis and/or myocarditis was inferred from the presence of changing significant heart murmurs in 10 cases. Unstable electrocardiographic abnormalities also suggested myocardial involvement in seven of these subjects and in three others. The electrocardiographic changes noted were: first degree A-V block in four cases, second degree block in two cases, and abnormalities of the T waves in five cases. Pericarditis was inferred in one patient from typical serial electrocardiographic changes. This subject also had a diastolic murmur heard along both sides of the upper sternum. Nine of the 13 individuals with these evidences of cardiac involvement, and one other patient, had a prominent tachycardia.

We believe the symptoms, signs, and electrocardiographic findings described above justified the diagnosis of acute rheumatic fever in all patients with at least a mild degree of heart involvement in 13 subjects despite the fact that none of the patients came to autopsy to provide pathologic confirmation.

The ballistocardiograph used was a portable electromagnetic model as described by Dock. Electrical equalization was effected by placing a 20 microfarad capacitor across the coils. The basic characteristics of this instrument as well as the technic and precautions employed in obtaining the records were described in the previous report. Patients who could not come to the fluoroscopic table were placed on the floor in order to obtain a solid base. Freedom of movement was determined by a shoulder tap. There was no attempt at calibration because of the lack of a valid method in living subjects. When evaluating the records, therefore, changes in amplitude without changes in form were not considered significant.

The commonly accepted criteria of normality and abnormality were applied in the interpretations of these records. The most common abnormalities were recently reviewed by Brown, Rinzer, and Benton. Of the 71 records obtained, 7 could not be interpreted because of distortion from tachycardia or somatic tremor.

Results

The results are summarized in table 2.

A. Thirty-three ballistocardiograms were obtained from the 13 subjects considered to have heart involvement during the acute phase

From the United States Army Hospital, Fort Campbell, Ky.
of the disease. Thirty-one of these records were clearly normal (fig. 1). One record, obtained from a subject with mitral stenosis resulting from a previous rheumatic episode (case 10), was considered to show the grade 1 changes of Brown\textsuperscript{a} (fig. 2A). Tracings obtained from this individual when the rheumatic process appeared to be subsiding and later inactive were similar (fig. 2B). Lastly, one record was considered suspicious because of low amplitude (case 7, fig. 2C). It could not be considered abnormal, however, because there were no abnormalities of form and, as mentioned above, quantitative interpretations of records made on this type of ballistocardiograph are open to question.

Of the seven tracings obtained during the period when the evidences of rheumatic fever and carditis seemed to be subsiding, only the record of case 10 referred to in the preceding paragraph, was abnormal. Six normal records were obtained from three other individuals.

Three normal ballistocardiograms were obtained after evidences of systemic and cardiac rheumatic activity were no longer present. One of these was the second tracing obtained from case 7 (fig. 2D). As noted above, the ballistocardiogram obtained from case 10 when the process became clinically inactive continued to show a grade 1 abnormality according to Brown\textsuperscript{a} (fig. 2B).

B. Twelve ballistocardiograms were obtained from the five subjects with acute migratory polyarthritis without evident cardiac involvement. Eleven of these were normal and one was interpreted to show the grade 1 abnormality of Brown (case 5, fig. 2E, left). Two normal tracings were also recorded from this individual during the acute phase of his illness (fig. 2E, middle), but a tracing obtained while the symptoms and signs were subsiding and one obtained when there were no detectable evidences of activity again showed only grade 1 abnormality (fig. 2E, right).

Five ballistocardiograms were obtained from three of these subjects while the clinical picture was considered to be subsiding. Of these, only the one mentioned above (case 5) was abnormal.

Of three ballistocardiograms obtained from

<table>
<thead>
<tr>
<th>Finding</th>
<th>Cases</th>
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<tbody>
<tr>
<td>1. Antecedent upper respiratory infection</td>
<td>6</td>
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<tr>
<td>2. History of previous rheumatic fever</td>
<td>4</td>
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<tr>
<td>3. Migratory polyarthritis</td>
<td>17</td>
</tr>
<tr>
<td>4. Fever</td>
<td>18</td>
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<tr>
<td>5. Elevated erythrocyte sedimentation rate</td>
<td>17</td>
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<tr>
<td>6. Chest pain</td>
<td>2</td>
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<tr>
<td>7. Tachycardia</td>
<td>10</td>
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<tr>
<td>8. Cardiac enlargement</td>
<td>1</td>
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<tr>
<td>9. Changing apical systolic murmur</td>
<td>8</td>
</tr>
<tr>
<td>10. Parasternal diastolic murmur</td>
<td>2</td>
</tr>
<tr>
<td>11. First degree A-V heart block</td>
<td>4</td>
</tr>
<tr>
<td>12. Second degree A-V heart block</td>
<td>2</td>
</tr>
<tr>
<td>13. Abnormal T waves</td>
<td>5</td>
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<tr>
<td>14. Serial ECG's suggestive of peri-carditis</td>
<td>1</td>
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<table>
<thead>
<tr>
<th>Group</th>
<th>Clinical Phase</th>
<th>Number of Patients</th>
<th>Number of BCG's</th>
<th>Normal BCG's</th>
<th>Abnormal BCG's (grade)</th>
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<tbody>
<tr>
<td>A. Acute rheumatic fever with heart involvement</td>
<td>Active</td>
<td>13</td>
<td>33</td>
<td>32</td>
<td>1 (1)</td>
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<tr>
<td></td>
<td>Subsiding</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>1 (1)</td>
</tr>
<tr>
<td></td>
<td>Inactive</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1 (1)</td>
</tr>
<tr>
<td>B. Acute rheumatic fever without evident heart involvement</td>
<td>Active</td>
<td>5</td>
<td>12</td>
<td>11</td>
<td>1 (1)</td>
</tr>
<tr>
<td></td>
<td>Subsiding</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>1 (1)</td>
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<tr>
<td></td>
<td>Inactive</td>
<td>2</td>
<td>3</td>
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<td>1 (1)</td>
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Two of these subjects after the rheumatic fever had apparently become inactive, only the record of case 5 mentioned above was abnormal.

DISCUSSION

Since abnormalities of the ballistocardiograph are said to reflect disturbances of ventricular ejection, arterial resistance, and/or return flow and cardiac filling,\textsuperscript{10, 14, 15} it would seem that the inflammatory process did not significantly alter these factors in most of our patients. Abnormal ballistocardiograms were obtained from only 1 of 13 subjects with evidences of active rheumatic carditis and one of five individuals with acute rheumatic fever without evident heart involvement. Furthermore, the abnormal records obtained were of minimal degree and such tracings have been
FIG. 1. Representative ballistocardiograms from the 11 patients with acute rheumatic fever with heart involvement whose tracings were interpreted to be unquestionably normal. The electrocardiograms shown were obtained the same day as the respective ballistocardiograms. A, case 18: Left, ballistocardiogram (BCG); right, electrocardiogram showing a second degree A-V heart block and abnormal T waves. B, case 6: Left, ballistocardiogram; right, electrocardiogram showing abnormal T waves. C, case 14: Left, ballistocardiogram. The third complex shows a negative wave preceding the H wave which resembles that recently described by Davis and co-workers in association with mitral stenosis. This was noted on 7 of the 22 complexes on this strip. This patient had an apical systolic murmur. Right, electrocardiogram showing abnormal T waves. D, same case, three weeks later: The illness was still clinically active. Left, ballistocardiogram. The negative waves described above are not seen. Right, electrocardiogram showing a sinus tachycardia and abnormal T waves. E, case 2, ballistocardiogram; one electrocardiographic complex is also shown to demonstrate the first degree A-V heart block. F, case 1. G, case 3. H, case 8. I, case 17. J, case 11. K, case 16. The ballistocardiogram is normal despite a tachycardia. L, case 13. The ballistocardiogram is normal despite a tachycardia.
Fig. 2. Representative ballistocardiograms from the two patients with heart involvement and the one patient without evident heart involvement whose tracings were interpreted to be at variance. A, case 10: Two sections from the same strip. Note the complexes showing the small, high HIJ, deep K, prominent L configurations. Less than half the total number of complexes were so altered therefore it was of grade-1 abnormality. B, same case: Left, ballistocardiogram (BCG) taken six weeks later after the rheumatic fever became clinically inactive. The record is not significantly different. Right, electrocardiogram, typical of all of his, showing abnormal P waves. This patient had mitral stenosis from a previous rheumatic episode. C, case 7: Left ballistocardiogram showing low amplitude without abnormality of form. Right, electrocardiogram showing first degree A-V heart block. D, same case: Normal ballistocardiogram, left, and normal electrocardiogram, right, taken after the rheumatic fever became clinically inactive. E, case 5. Left, ballistocardiogram taken while the patient had active arthritis. Note the low amplitude complexes of the small, high HIJ, deep K, prominent L configuration. The record was of grade 1 abnormality. Middle, normal ballistocardiogram also taken during the active phase. Right, ballistocardiogram, similar to the first, taken after the rheumatic fever became clinically inactive.

recorded from perfectly normal young men. In both of these cases the same type of ballistocardiograms was obtained after the rheumatic process became clinically inactive. Another point is that one of these patients had mitral stenosis from a previous rheumatic episode and this condition is capable of altering the ballistocardiogram. Thus we do not feel that we can consider the ballistocardiographic findings in these patients to be related...
to the evident carditis in one, or to be suggestive of carditis in the other.

From the practical point of view these results do not suggest that the ballistocardiograph, when used according to the methods of this study, would be of diagnostic aid in cases of suspected rheumatic carditis. Although the cardiac involvement in our patients could be considered mild in most cases, it was nevertheless detectable clinically and on the electrocardiogram, but not on the ballistocardiogram. Furthermore, in our cases, the ballistocardiograms did not seem to reflect the degree of heart involvement since the most severely ill patient had four normal tracings.

SUMMARY AND CONCLUSIONS

1. Thirty-three ballistocardiograms were obtained from 13 young adult males with evidences of active rheumatic carditis. Thirty-one records were clearly normal. One record showed only a grade 1 abnormality, but a similar tracing was obtained after the illness became clinically inactive. One record showed low amplitude but could not be considered abnormal because there were no changes of form.

2. One grade 1 abnormal and 11 normal ballistocardiograms were obtained from five subjects with active migratory polyarthritis without evident heart disease. The patient with the variant tracing had similar records which were taken during the subsiding and inactive phases.

3. From the results of this study it would seem that the ballistocardiogram is normal in most mild cases of acute rheumatic fever even when unstable electrocardiographic abnormalities and changing heart murmurs indicate cardiac involvement.

CASE HISTORIES

Case 1. An 18 year old white male was admitted to the hospital because of fever and a migratory polyarthritis involving the knees and ankles of four days duration. Examination of the heart revealed a tachycardia of 110 beats per minute. The initial erythrocyte sedimentation rate was 34 mm. in one hour, and the electrocardiogram showed a first degree A-V heart block and abnormal T waves. The evidences of rheumatic activity persisted for 14 days, and during this time one ballistocardiogram was taken (fig. 1F). Two others were taken during the subsiding and inactive phases. Diagnosis: Acute rheumatic fever with myocarditis and polyarthritis.

Case 2. A 19 year old white male entered the hospital because of fever and a migratory polyarthritis of seven days' duration involving the knees, ankles and shoulders. There was a history of a pharyngitis three weeks before. Examination of the heart revealed a grade 2 apical systolic murmur. The initial erythrocyte sedimentation rate was 46 mm. in one hour, and the electrocardiogram showed a first degree A-V heart block (fig. 1E). The evidences of rheumatic activity persisted for 30 days and during this time three ballistocardiograms (fig. 1E) were taken. Diagnosis: Acute rheumatic fever with valvulitis, myocarditis, and polyarthritis.

Case 3. A 17 year old white male was admitted to the hospital because of fever and a migratory polyarthritis of one and one-half days' duration involving the knees, ankles, elbows, and shoulders. Examination of the heart revealed a grade 1 systolic murmur at the apex and a grade 2 diastolic murmur along both sternal borders but loudest at the left lower sternal border. The initial erythrocyte sedimentation rate was 45 mm. in one hour, and the electrocardiogram showed a first degree A-V heart block. The evidences of rheumatic activity persisted for 21 days and during this time two ballistocardiograms (fig. 1G) were taken. Diagnosis: Acute rheumatic fever with valvulitis, myocarditis, and polyarthritis.

Case 4. A 20 year old white male was admitted to the hospital because of fever and a migratory polyarthritis involving the knees and wrists of two days duration. On examination the heart appeared normal. The initial erythrocyte sedimentation rate was 32 mm. in one hour, and the electrocardiogram was normal. The evidences of rheumatic activity persisted for 17 days and during this time four ballistocardiograms were taken. Diagnosis: Acute rheumatic fever with polyarthritis.

Case 5. A 17 year old white male entered the hospital because of fever and a migratory polyarthritis of 48 hours duration involving the knees and ankles. He gave a history of sore throat 10 days previously. Examination of the heart revealed normal findings. The initial erythrocyte sedimentation rate was 54 mm. in one hour, and the electrocardiograms were normal. The evidences of rheumatic activity persisted for 24 days and during this time three ballistocardiograms were taken, one of which was abnormal (fig. 2E). Three ballistocardiograms were taken, during the subsiding and inactive phases (fig. 2E, right). Diagnosis: Acute rheumatic fever with polyarthritis.

Case 6. A 17 year old white male was hospitalized because of fever and a migratory polyarthritis, involving the knees, ankles and elbows, of 48 hours duration. There was a history of rheumatic fever
three years previously. Examination of the heart revealed a tachycardia of 118 beats per minute and a grade 2 high pitched decrescendo diastolic murmur at the base of the heart. A protodiastolic gallop but no definite murmur was heard at the apex. The initial erythrocyte sedimentation rate was 32 mm. in one hour. X-ray films of the chest revealed the heart size to be at the upper limits of normal. The initial electrocardiogram showed S-T segment changes compatible with a diagnosis of acute pericarditis and the subsequent electrocardiographic evolution supported this diagnosis (fig. 1B). The evidences of rheumatic activity persisted for 30 days and during this time two ballistocardiograms were taken (fig. 1B). Diagnosis: Acute rheumatic fever with pancarditis and polyarthritis.

Case 7. An 18 year old white male was admitted because of choking sensations, palpitations and syncope of two days' duration. He had vague joint aching but no definite polyarthritis. On admission the temperature was 99.8°F, and examination of the heart revealed a tachycardia of 110 beats per minute and a grade 1 precordial systolic murmur best heard at the apex. The initial erythrocyte sedimentation rate was 47 mm. per hour, and the electrocardiogram showed a second degree A-V heart block. The evidences of rheumatic activity persisted for 14 days, and during this time one ballistocardiogram was taken (fig. 2C). Another record was taken after the rheumatic fever became inactive (fig. 2D). Diagnosis: Acute rheumatic fever with myocardiitis.

Case 8. A 17 year old white male was admitted to the hospital because of fever and a migratory polyarthritis involving the ankles and knees of 24 hours duration. He gave a history of having had pharyngitis two and one-half weeks previously and also of having had rheumatic fever at age 10 and chorea at age 14. Examination of the heart revealed a tachycardia of 110 beats per minute. The initial erythrocyte sedimentation rate was 34 mm. in one hour and the electrocardiogram showed abnormal T waves. The evidences of rheumatic activity persisted for 30 days and during this time four ballistocardiograms were taken (fig. 1H). Two of these were unreadable because of tremor. Diagnosis: Acute rheumatic fever with myocardiitis and polyarthritis.

Case 9. A 21 year old white male entered the hospital because of fever and a migratory polyarthritis involving the ankles and knees of seven days duration. Examination of the heart revealed normal findings. The initial erythrocyte sedimentation rate was 66 mm. in one hour, and the electrocardiogram was normal. The evidences of rheumatic activity persisted for two weeks and during this time one ballistocardiogram was taken. Diagnosis: Acute rheumatic fever with polyarthritis.

Case 10. An 18 year old white male was admitted because of fever, left anterior chest pain and a migratory polyarthritis of two days duration. Examination of the heart revealed a grade 4 systolic murmur and a crescendo presystolic murmur at the apex. The patient gave a history of having rheumatic fever at the age of 4 years. The initial erythrocyte sedimentation rate was 30 mm. in one hour. X-ray films of the chest revealed generalized cardiac enlargement with a straight left heart border and a prominent pulmonary conus arteriosus. The electrocardiograms showed abnormal P waves (fig. 2B, right). The evidences of rheumatic activity persisted for 25 days, and during this time one ballistocardiogram (fig. 2A) was taken. Two others were taken during the subsiding and inactive phases (fig. 2B, left). Diagnosis: Recurrence of active rheumatic fever with myocardiitis and polyarthritis in a patient with mitral stenosis and cardiac enlargement from a previous episode.

Case 11. A 19 year old white male was hospitalized because of fever and a migratory polyarthritis, involving ankles and knees, of two days' duration. The patient had had an upper respiratory infection two weeks previously. Examination of the heart revealed a tachycardia of 116 beats per minute. The initial erythrocyte sedimentation rate was 45 mm. in one hour and the electrocardiograms showed prolonged P-R intervals. The evidences of rheumatic activity persisted for 21 days and during this time three ballistocardiograms (fig. 1J) were taken. Four more were taken during the clinically subsiding and inactive phases. Diagnosis: Acute rheumatic fever with myocardiitis and polyarthritis.

Case 12. A 21 year old white male was admitted to the hospital because of fever and a migratory polyarthritis involving the knees and ankles of two days' duration. He had had a sore throat one week previously. Examination of the heart revealed a tachycardia of 110 beats per minute. The initial erythrocyte sedimentation rate was 34 mm. in one hour, and the electrocardiograms were normal. The evidences of rheumatic activity persisted for 21 days, and during this time one ballistocardiogram was taken. Four more were taken during the subsiding and inactive phases. Diagnosis: Acute rheumatic fever with polyarthritis.

Case 13. An 18 year old white male was admitted to the hospital because of fever and a migratory polyarthritis of two days' duration. He gave a history of sore throat one week previously and rheumatic fever 10 months previously. Examination of the heart revealed a grade 2 systolic murmur at the apex, which was transmitted to the left axilla. The initial erythrocyte sedimentation rate was 38 mm. in one hour and the electrocardiogram was normal except for prolongation of the Q-T intervals. The evidences of rheumatic activity persisted for 21 days and during this time one ballistocardiogram (fig. 1L) was taken. Diagnosis: Acute rheumatic fever with valvulitis, myocardiitis and polyarthritis.
Case 14. A 20 year old white male was hospitalized because of fever, migratory polyarthritis of 48 hours' duration, and pleuritic type pain in his left anterior chest of 18 hours' duration. On admission, the temperature was 103.4 F. and the patient appeared extremely toxic. Initial examination of the heart revealed only a tachycardia of 120 beats per minute. Several days later, however, a grade 2 systolic murmur at the apex was heard. The initial erythrocyte sedimentation rate was 50 mm. in one hour. X-ray films of the chest revealed a probable pneumonia of the basilar division of the left lower lobe. Urinalysis revealed 2 plus albumin, occasional red blood cells and occasional coarse granular casts. The electrocardiograms revealed abnormal T waves (fig. 1C and D). The evidences of rheumatic activity persisted for 30 days and during this time four ballistocardiograms (fig. 1C and D) were taken. Two more were taken during the subsiding phase. Diagnosis: Acute rheumatic fever with valvulitis, myocarditis, polyarthritis and possibly rheumatic pneumonia and glomerulonephritis.

Case 15. An 18 year old white male entered the hospital because of fever and a migratory polyarthritis involving the knees, ankles and wrists. He had been hospitalized 17 days previously because of arthralgia, but because symptoms subsided promptly with rest and because the erythrocyte sedimentation rate was normal he had been discharged. Forty-eight hours before this admission he developed a definite polyarthritis. Examination of the heart revealed normal findings. The initial erythrocyte sedimentation rate was 32 mm. in one hour, and the electrocardiogram was normal. The evidences of rheumatic activity persisted for two weeks and during this time three ballistocardiograms were taken. One more was taken during the subsiding phase. Diagnosis: Acute rheumatic fever with polyarthritis.

Case 16. A 20 year old white male was admitted because of fever and a migratory polyarthritis, involving the knees and ankles, of four days' duration. Examination of the heart revealed a tachycardia of 110 beats per minute and a grade 2 systolic murmur at the apex. The initial erythrocyte sedimentation rate was 15 mm. in one hour, and the electrocardiogram revealed abnormal T waves. The evidences of rheumatic activity persisted for three weeks and during this time two ballistocardiograms were taken (fig. 1K), one of which was distorted by somatic tremor. Diagnosis: Acute rheumatic fever with valvulitis, myocarditis, and polyarthritis.

Case 17. A 23 year old white male entered the hospital because of fever and a migratory polyarthritis involving the knees and ankles of three days' duration. He gave a history of pharyngitis two weeks previously. On admission examination of the heart revealed only a tachycardia of 110 beats per minute. However, after several days a grade 2 systolic murmur at the apex was heard. The initial erythrocyte sedimentation rate was 38 mm. in one hour, and the electrocardiogram showed abnormal T waves. The evidences of rheumatic activity persisted for six weeks and during this time eight ballistocardiograms (fig. 1F) were taken. Diagnosis: Acute rheumatic fever with valvulitis, myocarditis, and polyarthritis.

Case 18. A 20 year old white male was admitted to the hospital because of fever and a migratory polyarthritis involving the ankles and knees of six days' duration. He gave a history of having laryngitis and pharyngitis three weeks previously. On admission examination of the heart revealed only a tachycardia of 100 beats per minute. However, after several days a grade 2 systolic murmur at the apex was heard. The initial erythrocyte sedimentation rate was 40 mm. in one hour, and the electrocardiograms revealed second degree A-V heart block (fig. 1A). The evidences of rheumatic activity persisted for three weeks and during this time four ballistocardiograms were taken (fig. 1A). Diagnosis: Acute rheumatic fever with valvulitis, myocarditis and polyarthritis.

Acknowledgments

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SUMARIO ESPAÑOL

1. Treinta y tres balistocardiogramas se obtuvieron en 13 adultos jóvenes varones con evidencia de carditis reumática activa. Treinta y un trazados fueron claramente normales. Un trazado mostró anormalidad grado 1, pero un trazado similar se obtuvo luego que la enfermedad se convirtió clínicamente inactiva. Un trazado mostró amplitud baja pero no se pudo considerar anormal debido a la ausencia de cambios en configuración.

2. Un balistocardiograma anormal grado 1 y 11 balistocardiogramas normales fueron obtenidos en cinco sujetos con poliartritis activa migratoria sin evidencia de enfermedad cardíaca. El paciente con el trazado variante tuvo similares trazados que fueron tomados durante las fases de mejoría y de inactividad.

3. De los resultados de este estudio es aparente que el balistocardiograma es normal en la mayoría de los casos leves de fiebre reumática aguda aún en presencia de cambios electrocardiográficos inestables y soplos cardíacos indicando afectación del corazón.
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