Use of Tape-Recorded Heart Sounds in Screening of Children for Heart Disease

By Jacques M. Smith, M.D., Robert A. Miller, M.D., Carl Marienfeld, M.D., Betty Hahnenman, M.D., and Joel Willard, B.S.

An automated tape-recording unit for use in screening large populations of school children for heart disease has been developed and field tested. A technician can produce good quality apex and base heart sound recordings from 250 children during an average school day. The physician can listen to these recordings at a rate of 140 children per hour, recalling for examination each child considered to have an abnormal recording. Since almost all heart disease in children has some acoustic manifestation, a screening technic based on the heart sounds seems to be a logical one. The studies done with this unit have demonstrated its ability to select children with heart disease from a large number of normal children. Agreement between readers is satisfactory, and the number of "false positives" is considered reasonable.

The recent dramatic progress in the diagnosis, treatment, and surgical correction of heart disease has stimulated renewed interest in the prevalence of cardiac problems in the school-age child. The practicing physician has become increasingly aware of congenital heart disease, so that at the present time these malformations are thought to constitute at least half and probably more than half of the total cases of heart disease in children.1, 2

Various cities in the United States maintain registries of heart disease in children, especially rheumatic heart disease; but in most instances these cases represent a relatively small proportion of the actual number of affected children.

There are over 25 published studies on the incidence of heart disease in school children (table 1), 5 of which have appeared since 1945.3-18 These studies are based on clinical examination by workers with widely varied training and experience. The older studies tend to show a higher over-all incidence of heart disease and a marked predominance of rheumatic heart disease. More recent studies show lower incidence and a more even distribution of the cases between congenital and acquired heart disease. The scope of all these studies was limited to relatively small numbers of children by the laborious and time-consuming technic of physical examination as applied to large numbers of individuals.

On the basis of the published data one may make 2 assumptions: 1. There are probably 4 or more cases of heart disease in every 1,000 school children. 2. In many of these cases neither the parents nor the family physician of these children is aware that they have heart disease.

The nature of heart disease in children is such that it almost always alters the characteristics of the normal heart sounds or produces a murmur. The very high incidence of significant murmurs in heart disease of childhood is in direct contrast to the situation in adults, in whom a large proportion of coronary and hypertensive heart disease occurs. It would seem, therefore, that the most logical approach to cardiac case-finding in children would lie in the field of auscultation. Phonocardiography or other graphic methods of registering the heart sounds of children have been shown to be unsatisfactory as a screening device for heart disease.20 The high incidence of innocent murmurs in childhood and the problem of extraneous noise

A project of the Children's Screening Committee of the Chicago Heart Association.

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Table 1.—Incidence of Heart Disease in School Children

<table>
<thead>
<tr>
<th>City</th>
<th>Total school population examined</th>
<th>Organic heart disease per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York City, 1915</td>
<td>278,174</td>
<td>1.50</td>
</tr>
<tr>
<td>New York City, 1918</td>
<td>250,000</td>
<td>1.60</td>
</tr>
<tr>
<td>New York City, 1918 to 1922</td>
<td>1,336,343</td>
<td>1.39</td>
</tr>
<tr>
<td>New York City, 1921</td>
<td>44,000</td>
<td>0.50</td>
</tr>
<tr>
<td>Chicago, 1923</td>
<td>158,826</td>
<td>0.90</td>
</tr>
<tr>
<td>Philadelphia, 1924</td>
<td>23,671</td>
<td>0.63</td>
</tr>
<tr>
<td>Chicago, 1924</td>
<td>153,671</td>
<td>1.50</td>
</tr>
<tr>
<td>Chicago, 1925</td>
<td>130,260</td>
<td>1.70</td>
</tr>
<tr>
<td>Boston, 1927</td>
<td>119,337</td>
<td>0.52</td>
</tr>
<tr>
<td>Philadelphia, 1929</td>
<td>10,333</td>
<td>0.91</td>
</tr>
<tr>
<td>Florida, Illinois and Missouri, 1929</td>
<td>17,974</td>
<td>1.00</td>
</tr>
<tr>
<td>Cincinnati, 1927</td>
<td>6,960</td>
<td>0.37</td>
</tr>
<tr>
<td>Rochester, Minn., 1931</td>
<td>1,328</td>
<td>0.70</td>
</tr>
<tr>
<td>New York City, 1931</td>
<td>2,691</td>
<td>1.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade in school</th>
<th>Children</th>
<th>New Haven, 1934</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>'Better School'</td>
</tr>
<tr>
<td>1</td>
<td>1,144</td>
<td>1.32</td>
</tr>
<tr>
<td>5</td>
<td>1,123</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Poorer School'</td>
</tr>
<tr>
<td>1</td>
<td>1,863</td>
<td>1.93</td>
</tr>
<tr>
<td>5</td>
<td>1,628</td>
<td>2.08</td>
</tr>
<tr>
<td>Philadelphia, 1937</td>
<td></td>
<td>Elementary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33,293</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.30*</td>
</tr>
<tr>
<td>High School</td>
<td>9,154</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.40*</td>
</tr>
<tr>
<td>San Francisco, 1938</td>
<td>13,338</td>
<td>0.37</td>
</tr>
<tr>
<td>Cincinnati, 1938</td>
<td>85,389</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.12*</td>
</tr>
<tr>
<td>Louisville, 1941</td>
<td>41,905</td>
<td>0.52</td>
</tr>
<tr>
<td>Denver, 1945</td>
<td>1,09</td>
<td></td>
</tr>
<tr>
<td>Iowa, 1946</td>
<td>5,058</td>
<td>0.47</td>
</tr>
<tr>
<td>San Francisco, 1948</td>
<td>57,768</td>
<td>0.44</td>
</tr>
</tbody>
</table>

*Possible heart disease.

The tape recording of the heart sounds has several distinct advantages over physical examination is mass-screening programs: 1. It does not require the presence of the physician. The recordings may be made by a trained technician. 2. Large numbers of children can be recorded on a single roll of tape, which in turn can be played back at the listener's convenience in a quiet room. 3. The listener can turn the volume up or down and can go back to a case that he is not sure about. 4. A permanent record of these heart sounds is available, so that in questionable cases a phonocardiogram may be made from the tape giving the advantages of both subjective and objective evaluations.

Normal auscultatory findings in children differ greatly from those in adults. Both heart sounds are louder and the incidence of functional murmurs is very high in children. Examiners not acquainted with this characteristic ability to 'hear better' are in danger of over estimating the auscultatory findings. At rest, a faint systolic murmur can be recorded by the phonocardiogram in all children. With sufficiently sensitive pick-ups one can record a systolic murmur in all normal 20-year-old subjects. Direct phonocardiography reveals a systolic murmur in or over the pulmonary artery in all cases. Mannheimer has shown in a study of normal children that about half of these innocent murmurs are too faint to classify even by phonocardiography. Most of the functional murmurs of reasonable loudness have the familiar musical, vibratory, twang-
ing string quality described by Still at the beginning of the century.25 The rest of these functional murmurs are those of the ejection type, soft systolic murmurs usually best heard in the second left interspace, well separated from the heart sounds, and associated with normal splitting of the second sound.24,26 These innocent murmurs become as familiar as old friends to experienced examiners of large numbers of normal children. The heart sounds and murmurs in congenital and acquired heart disease in almost every case differ remarkably from innocent murmurs in quality, frequency, amplitude, and timing.26-28 There is a small group of patients in which auscultation alone is insufficient to make a definite determination between innocent and pathologic murmurs.15,19 Also, a few cases of congenital and acquired heart disease have practically no auscultatory manifestations.

The use of heart sounds as screening material for the detection of heart disease in children, therefore, will create a group of "false positives," which include innocent murmurs of unusual quality or loudness, those in which the differentiation between organic and innocent murmurs cannot be determined from the sound, and those cases in which for various reasons the heart sounds themselves seem unusual. Also, a group of "false negatives," including such things as an occasional case of coarctation of the aorta without a murmur, some cases of myocarditis or hypertension, might be missed by auscultation alone.

In the past few years it has become possible to reproduce heart sounds and murmurs as they are heard through the stethoscope.29 With this in mind, a study was begun in 1954 to investigate the feasibility of using high-fidelity tape-recording equipment in screening for heart disease in children. To investigate the ability of the readers to recognize abnormal auscultatory phenomena from tape recordings, a group of 100 patients was recorded. Some had congenital or acquired heart disease, and others had normal hearts; but in every case cardiac catheterization, x-ray of the chest, and electrocardiogram were done. The cases with known heart disease all had organic murmurs. With 4 readers listening to the recorded heart sounds, no case of heart disease was missed, and every "normal" recording was recognized. Next, the heart sounds of 1,200 children were recorded at the Cook County Children's Hospital and in 5 Chicago elementary schools. These recordings were reviewed by 3 physicians: a pediatric cardiologist, an adult cardiologist, and an internist. The prime object of this study was to determine the degree of agreement among the readers. The results are shown in table 2. Any 2 readings of the 1,200 recordings provided 1,200 comparisons. Since there were 3 pairs of readings, reader A and B, reader A and C, and reader B and C, a total of 3,600 comparisons was available from which to determine reader agreement. Actually, only 3,272 were analyzed for agreement and are shown on table 2. As can be seen, even with equipment considered at the time inadequate and with readers with quite different kinds of training, the degree of agreement was about as good as that demonstrated by pairs of readers of miniature chest x-rays.30 In an attempt to improve agreement among readers a teaching roll of heart sounds was developed. This preliminary study also pointed up the need for (1) modification of the equipment in order to speed up the

<table>
<thead>
<tr>
<th>Test</th>
<th>Both readings negative</th>
<th>One reading negative positive</th>
<th>Both readings negative</th>
<th>At least one reading positive</th>
<th>Reader agreement positive on positive x 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart sounds</td>
<td>2,923</td>
<td>264*</td>
<td>85*</td>
<td>349</td>
<td>24.3</td>
</tr>
<tr>
<td>Reading x-rays for tuberculosis</td>
<td>1,714</td>
<td>69</td>
<td>24</td>
<td>93</td>
<td>25.8</td>
</tr>
</tbody>
</table>

*Uncertain readings are included as positive.
recording rate, (2) simplification of the technical job of making the recordings so as to lessen technician fatigue, and (3) simplification of the administrative problems of mass-screening projects such as the identification of the patients and the maintenance of good records. This study also showed a need for improvement in the quality of the recorded sounds, specifically in the microphone, pointed up the problems of varying volume depending on the thickness of the chest wall, the size of the children, the need for reduction of room noise, and the difficulty of eliminating alternating current hum in the varying circumstances of recording in different locations.

METHODS AND MATERIAL

The recorder (figs. 1 and 2) was a Berlant BAX automatic, modified by replacing power supplies to use direct current from a battery pack for the "A" supply (15A), and an especially built highly filtered AC/DC power supply (15B) for the "B" source (1B). Additional modifications of the circuitry reduced noise and permitted operation of this recorder with associated equipment. The recording rate was 71/2 inches of tape per second, and the frequency response of the unit was plus or minus 3 db. from 30 to 10,000 cycles.

A Berlant 4-channel mixer (2), modified by the installation of remotely operated relays in each of the input channels, was used to control volume and to mix the incoming signals which identified the position of the microphone on the chest, the audio-announced identification number of the patient, and the heart sound signal. The frequency response of this mixer matched that of the recorder.

An automatic volume control (3) maintained the signal level of the amplified heart sounds within a pre-set range without the necessity for the operator to adjust constantly the recording volume.

The microphone (4) was a crystal type with a frequency response of plus or minus 1 db. from 26 to 1,500 cycles per second.

The microphone was encased in an aluminum cup-shaped holder (5) connected to a vacuum
storage tank (6). When the microphone and holder were placed against the chest, vacuum suction held the microphone in position at the predetermined pressure. It relieved the operator of the task of holding the microphone, eliminated the noise generated by the fingers of the operator and the movements of the skin of the subject, and served to block the majority of room noises. The microphone pressure control helped to eliminate the distortion caused by excessive pressure on the microphone diaphragm. The vacuum was released automatically, at the completion of a recording by a relay, a solenoid valve and a microswitch that locked into a specially built automation unit. A vacuum gage, power switch, and selector switch were provided so that the unit might be operated either manually or automatically.

The children being screened were identified in 2 ways. A Simplex electric numbering machine (7A) was used to stamp identifying numbers on the subjects' identification cards. It was modified to stack the cards automatically after they were stamped and to operate with a 16-mm. magnetic film (7B), a prerecorded series of consecutive identification numbers in the same sequence as those numbers stamped on the identification cards by the numbering machine. The listener, therefore, heard the patient identified by number and could be sure that that patient was correctly identified by a similarly numbered card.

A solenoid-operated Veeder-Root counter (7C) was interlocked with the numbering machine to provide the operator with a visual indication of the number of the case being recorded.

The listener was always aware of the position on the chest from which the recording was made by a one-half second, 1,000-cycle tone (8) recorded on the tape to indicate the apex recording. A similar 400-cycle tone (9) indicated the base of the heart. Two transistorized tone generators controlled by a microswitch in the automation unit provided the signals.

The automation unit (10), which was designed especially for the task, controlled the entire sequence of recording. The unit was activated by a foot switch (11). Ten microswitches activated by milled eams on a common shaft controlled the sequence of timing during the recording cycle. The technician placed the microphone in its vacuum holder over the apex of the heart, and stepped on the foot switch. The machine now automatically started the tape-drive mechanism on the tape recorder and activated the recording bias, turned off the vacuum pump motor, and opened the solenoid...
valve to furnish a vacuum for the microphone holder. It then selected the musical tone that identified the apex microphone position and fed the signal to the tape, activated the card numbering machine, and stamped the cards automatically with the identification number, then activated the 16-mm film play-back machine, which announced the same number on the tape. The microphone was now activated and recorded 11 seconds of heart sounds at the apex. The unit now automatically shut off the tape recorder and released the vacuum to the microphone holder. The technician saw that the microphone had been released from the chest and had only to pick it up and place it over the second left interspace, then stepped on the activating foot-switch again. The automation unit started the cycle again, this time, however, identifying the recording as coming from the base of the heart by the other musical tone. It then bypassed the subject-numbering machine, since this second recording was from the same person. The entire recording cycle, apex and base, was 25 seconds in length. The technician was supplied with monitoring speaker (12), a power amplifier (13) and a pair of Cambridge stethoscope-type earphones (14), so that he could check the quality of the recordings. The entire unit, with its battery power supplies (15A and 15B) and control panel (16) was housed in 2 specially designed portable consoles, each of which divided in half for easier portability.

The recording team consisted of the recording technician and an administrative aid. Arrangements were made for additional help with the dressing and supervision of the children from the school nurse or other volunteers. Prior to the day of the recording, information was supplied to the parents, informing them of the screening procedure and requesting permission to make the recordings on their children. For each schoolroom a master sheet was prepared, which included the names of all the children and indication whether permission had been granted for recording. Each child was given his identification card and his presence was noted on the master sheet. As the individual was to be recorded, he handed his identification card to the administrative aid, who placed it in the Simplex stamping machine, which automatically numbered his card during the recording procedure. The child undressed to the waist and lay down. The technician then placed the microphone over the apex of the heart and activated the automation unit. With the recording sequence it was possible to record 2 children per minute. However, 60 children per hour was a more reasonable rate and this should be modified to account for delays in bringing children to the equipment. Taking into account the necessary adjustments to meet school schedules, we have found that over an extended period of time a recording rate of about 250 to 300 children per school day was quite practical.

Play-Back Procedure

It has been found that a training period is necessary for the listener to become proficient. The training was provided by means of a training reel that allowed the listener to become familiar with the identifying tones of the microphone position, the quality of the heart sounds, murmurs, breath sounds, and the identification voice. In addition, it allowed him to listen to normal and abnormal heart sounds and murmurs in rapid sequence and to familiarize himself with the characteristics of these sounds as heard through a speaker or earphones. This training reel was made up of recordings selected from a group of 100 proved cases of congenital and acquired heart disease and from a group of normal children.

Following this period of training, the listener found that a recording of 11 seconds at the apex of the heart and 11 seconds at the base was of adequate length for screening purposes without causing undue fatigue. The normal screening rate for a trained listener was 140 patients per hour. For maximum efficiency, we have found that listening sessions should not exceed 1 hour. As he listened to the tape, the physician used an electric adding machine to record his results. The subjects identification number was indicated in the hundreds and thousands column. The presence or absence of murmurs or the inability of the reader to interpret the heart sounds because of technical difficulties was recorded in the tens column. The disposition of the case, that is, recall for examination, no recall, or inability to decide because of technical difficulties was recorded in the units column.

Findings (in tens column)
0—no murmur
5—technically unsatisfactory
9—a murmur present

Disposition (in units column)
0—no recall
5—no decision because of technical difficulties
9—recall

In addition to the "9," the subtract button was used to put a dash behind a recall indication. This helped to prevent errors by requiring the reader to perform 2 different and distinct acts in indicating a recall and also simplified the finding of recalls in a long column of figures.
TAPE-RECORDED HEART SOUNDS

Examples
279 00 (case 279, no murmur, no recall)
280 90 (case 280, murmur, no recall—reader considers murmur innocent)
281 99 (case 281, murmur, recall)
282 55 (case 282, recording technically unsatisfactory, no decision could be made)

It should be stressed that the physician listening to the tape was not trying to make a diagnosis. He was attempting, from a rapid sequence, to pick out those patients that should be recalled for examination.

Field Studies

A number of studies have been conducted for the purpose of testing the components of this equipment and the administrative efficiency of the operating procedure.

Field Study No. 1. At a local private institution, 99 children were examined (auscultation only) by each of 3 members of the screening team. Heart sounds of these same children were recorded in an area separate from the examining room. The recordings were studied twice by each of the 3 physicians, once using Cambridge stethoscope-type earphones for the play-back of the tape, and once using a speaker in a quiet room. The physicians worked independently and their findings were not revealed to each other during the studies.

Approximately 30 days after this recording session, each of the children was re-examined. This time, however, the 3 examiners acted as a consulting team examining the children together. In addition, they had the results of 70-mm. chest x-ray and the medical history of the child. On the basis of this examination, the physicians arrived at a "conference finding" for each child. These conference findings classified the children as having normal or abnormal heart sounds and constituted the standard against which the type recordings could be compared (table 3). The number of false positives was relatively small, and no case of actual heart disease was missed by the screening technic. The efficiency of the screening physician using tape recordings was equal to that from his auscultation.

Table 3.—Conference Findings in Ninety-nine Cases

<table>
<thead>
<tr>
<th>Reader</th>
<th>Live</th>
<th>Tape via speaker</th>
<th>Tape via phones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases recalled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>4</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

4 Definite heart disease, 2 cases requiring further observation, 93 no heart disease.

Field Study No. 2. In this study, a recording technic taped the heart sounds of 507 children from a local foundling home.

These tapes were listened to by 4 of us and, on the basis of the play-backs, 16 of the children were recalled. These were subsequently examined by 3 of us, and 1 child was found to have definite heart disease. Two other children had murmurs which we thought were probably not significant but would require additional laboratory and clinical observation.

It was not until after these studies were completed that the participating physicians were informed that this particular school carefully excludes children with heart disease. The one child, found by the screening technic to have significant heart disease, was a known case in which the school had made an exception. There are 2 observations that may be made from this study. The rate of false positives (15 out of 507 children) 2.6 per cent seems to be a reasonable figure. Although there was only 1 case of heart disease in the entire group, or an incidence of approximately 0.2 per cent, the case was not missed by the screening technic.

Field Study No. 3. The heart sounds of 1,020 children were recorded in a local elementary school. The tapes were read by 3 physicians and the results of these readings are shown in table 4. The children recalled by the screening program were subsequently examined by the same 3 physicians.

The significant findings in this project were that out of 1,020 children 40, or 4.0 per cent, were recalled. Of these children, 7 were found to have definite heart disease.
TABLE 4.—Results of Tape Recordings
Field Study No. 3

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total recorded on tape</td>
<td>1,020</td>
</tr>
<tr>
<td>Total recalled</td>
<td>40</td>
</tr>
<tr>
<td>Referred for follow-up care</td>
<td>10</td>
</tr>
<tr>
<td>1. Definite heart disease</td>
<td>7</td>
</tr>
<tr>
<td>2. Probably normal, but need</td>
<td>3</td>
</tr>
<tr>
<td>further observation</td>
<td></td>
</tr>
</tbody>
</table>

Three other children warranted further follow-up because a decision could not be made from the murmur alone.

Therefore, 17.5 per cent of the recalls were found to have definite heart disease, and a total of 25 per cent of the recalls warranted follow-up study by their physicians. Another important fact is that of the 7 children found to have heart disease, there was knowledge of this in only 2. Neither the parents nor the family physician knew of the existing heart disease in the other 5, even though a periodic physical examination is required of all students in the public schools. Furthermore, this incidence of 7 cases of heart disease per 1,000 is in agreement with published surveys. These figures vary from about 4 to 15 per 1,000 in the school age group.

DISCUSSION

Aside from any other uses of this tape-recording technic, its value in a case-finding program should be clear. In an era when every child with rheumatic heart disease should be on prophylactic antibiotics and every child with congenital heart disease is considered a potential surgical candidate, a practical case finding method is needed. The reports of Robinson,19 who found 4.4 cases of heart disease per 1,000 in the San Francisco schools, Rauh,15 who found 5 cases per 1,000 in the Cincinnati schools, Weiss,16 5 per 1,000 in Louisville, and Jackson,18 5 per 1,000 in a rural Iowa county are only a few of the mass of data testifying to the large numbers of children with heart disease in our school system. There are probably 2,500 to 5,000 school-age children with heart disease in Chicago alone. It is not feasible to have a trained cardiologist examine hundreds of thousands of normal children in order to screen for cases of heart disease. We can, however, bring the children to the cardiologist via the technic of high-fidelity tape-recorded heart sounds. With the installation of this recording equipment in a sound-proof trailer, it would seem quite practical to survey large populations of school children for heart disease, in a way quite comparable to the mass x-ray surveys for tuberculosis.

We are quite aware of the potential psychological problems that might be created by recalling a normal child for cardiac evaluation. It should be possible to keep this at a reasonable minimum with proper educational material for the parents, the teachers, and the children. The relatively low recall rate of false positives, approximately 30 cases per 1,000, will also tend to obviate this problem. More important, however, has been the gratifying experience of the screening physician in being able to free the normal child sentenced to limited activity because of erroneous diagnosis of heart disease.

The opportunity to “set straight” those children restricted because of loud functional murmurs previously considered organic, is an aspect of case-finding often overlooked.

SUMMARY

In an analysis for agreement of 3,272 comparisons between listeners of tape-recorded heart sounds, the degree of agreement was about as good as that demonstrated by pairs of readers in miniature chest x-rays. This pilot study was accomplished with equipment considered inadequate and with listeners of widely varied training.

A specially built, automated tape-recording unit has now been developed which makes screening for heart disease in large numbers of individuals practicable.

A technician can record approximately 250 children a day in the average Chicago public school. After a brief training period, the physician-listener can screen 140 children in an hour, recalling those who require a
physical examination. Field studies with this equipment have shown that the number of normal children recalled is low and that practically no heart disease with abnormal heart sounds and murmurs is missed. It is thought that this technic offers a practical way to screen large populations of children for heart disease.

ACKNOWLEDGMENT

The authors wish to express their appreciation for the valuable assistance and continuing interest of Mr. Louis deBoer, Executive Director of the Chicago Heart Association, who gave the original impetus to this project. We also wish to thank Dr. Arthur E. Rikli, Dr. John McDonough, Mr. Philip Enterline, and Miss Gloria Labbe of the Heart Disease Control Section, U. S. Public Health Service, for their advice and statistical help. Dr. Edward Press and Dr. Simon Rodbard also aided us in the early stages of this project.

SUMMARIO IN INTERLINGUA

In un analyse del correlation de judica-miento inter pares de auditores de 3,272 phonomagnetogrammas de sonos cardiac, le grado de accordo esseva simile a illo demonstrate per pares de interpretas de microroent-genogrammas thorac. Le hie-presentate studio, de character preliminari, esseva execute con equipamento considerate come in-adequate e con auditores de differentissime experiencia.

Un automatico apparato phonomagnetographic, specialmente construite pro le registration de sonos cardiac, es nunc disponibile, permettente le execution de tests discriminatori pro morbo cardiac in grande numeros de subjectos.

Un sol technico, usante le nove apparato, es capace a obtenr phonomagnetogrammas cardiac ab approximativamente 250 juveniles per die sub le conditiones de labor que es tipicamente incontrate in le scholas publice de Chicago. Post un curte periodo de trainamento, le medico-auditor pote examinar le registrationes de 140 juveniles in le curso de un hora, reclamante le subjectos pro qui un examine physic es indicate. Studios comparative, con le uso del nove apparatura sub le conditiones del practica quotidian, ha demonstrate le numero del subjectos normal reclamate es basse e que practically nulle caso de morbo cardiac con anormalitate del sonos cardiac e con murumures cardiac escappa al detection. Es opinate que iste technica representa un medio practic pro effectuar tests de discrimination pro morbo cardiac in grande populationes juvenil.

REFERENCES

15. Rauh, L. W.: The incidence of organic heart


CLINICAL EXPERIENCE
Others’ follies teach us not,
Nor much their wisdom teaches;
And most, of sterling worth, is what
Our own experience preaches.
—Tennyson: Will waterproof’s Lyrical Monologue.
Use of Tape-Recorded Heart Sounds in Screening of Children for Heart Disease

JACQUES M. SMITH, ROBERT A. MILLER, CARL MARIENFELD, BETTY HAHNEMAN and JOEL WILLARD

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