Innocent Cardiovascular Murmurs in the Adult

A 16-Year Follow-Up

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It is a popular belief that the innocent murmurs of childhood and adolescence "disappear" or are "outgrown" in early adulthood. Support for this view is found in the detailed longitudinal study of 200 normal persons examined over a 30-year period in the University of Colorado Child Research Council. In this study 1 McCammon found that of the 97 per cent of children who had a stethoscopically detectable murmur at one time or other, about 20 per cent had lost their murmur by the age of 10 years, an additional 50 per cent lost theirs between the age of 10 and 15 years, and about 20 per cent retained them after this age. The oldest patient to lose a murmur was 26 years of age. Marienfeld et al. 2 indicated only 20-per cent retention of innocent murmurs over a 20-year period.

Other studies reported 60- to 94-per cent incidences of retention of murmurs in patients re-examined during the middle and late teen years. 3-6

In the present study 100 adults who were recorded as having had innocent murmurs as children 16 or more years previously were re-examined. This study also afforded an opportunity to compare the results of clinical examination with tape-recorded heart sounds replayed through a loudspeaker, on an oscilloscope, and transcribed from the tape onto photographic paper.

Materials and Methods

The files of the Denver Rheumatic Fever Diagnostic Service contained over 1,000 patients with innocent murmurs in the year 1945. These were judged innocent after careful clinical, electrocardiographic, and fluoroscopic study of each patient. Request for follow-up examination was made to each of these patients and the first 100 replies were selected for this study. Re-evaluation of these patients consisted of a brief history, full clinical cardiovascular examination, a 13-lead electrocardiogram, cardiac fluoroscopy, and recording of the heart sounds on magnetic tape. The clinical examination consisted of a right arm blood pressure, examination of the peripheral arterial and jugular venous pulses, inspection and palpation of the precordium, and auscultation over the precordial, supraclavicular, and carotid areas. Auscultation was performed in these areas under the following conditions in each patient: the supine position, normal breathing, at rest; the supine position, full inspiration, glottis open, at rest; the supine position, full expiration, glottis open, at rest; the erect position, normal breathing, at rest; and the supine position, normal breathing, following 10 sit-up exercises. In each patient and under each of these conditions the murmur was analyzed in terms of location of maximal intensity, radiation, timing, intensity, frequency, and quality. Heart sounds were recorded in the supine position in full expiration over four routine positions: right sternal margin at the second intercostal space, left sternal margin at the second intercostal space, left sternal margin at the fourth intercostal space, and apex. Sounds were also recorded over additional areas or in other positions when the clinical examination indicated. The tape-recording equipment consisted of a condenser-type microphone 3 coupled to a miniature tube used as a cathode follower, a no. 518 A Altec Lansing power supply, a Magnecord PT6-G amplifier matched to a PT6-AH single-track magnetic tape-recording unit. The magnetic tape was of the high-output type.

Audio reproduction was by means of a suitable playback amplifier and speaker system and was simultaneously visualized on the oscilloscope screen of a laboratory recorder. 1 When necessary for editing purposes or closer inspection, the heart cycle in question was recorded on this unit. Heart cycles illustrating certain points and free from other artifacts were selected in this manner, and loops were

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1 DR-8 Recorder—Electronics for Medicine, Inc., White Plains, New York.
made of the magnetic tape. Each loop usually contained three to five complete heart cycles (recording and playback speed 7½ inches per second). The loop was then played into a direct-writing envelope-selecting phonocardiographic instrument.† 

Each of the 100 tape recordings was examined without knowledge of the patient's name or clinical findings. The various characteristics of heart sounds and murmurs were noted first by listening alone and then by oscilloscopic viewing. These observations were then compared to the observations made at the clinical examination.

### Results

The study population consisted of 44 women and 56 men. The mean age for women was 25.9 years, with a range of 18 to 34 years; that for men 28.6 years, with a range of 20 to 34 years.

In every patient an innocent cardiac murmur was audible at this examination, and no evidence of heart disease was discovered in any of the 100 patients.

### Physical Examination

One patient was said to have had idiopathic pericarditis in 1960 but no sequelae were noted at this examination. One patient was found to have a systemic blood pressure of 170/100 mm. Hg. The femoral pulses were full and without lag, and there was no evidence of cardiac enlargement. Funduscopic examination was within normal limits.

### Heart Sounds

In 17 patients there was no splitting of the main components of the first heart sounds as judged by either stethoscopic auscultation, or reproduction from tape through the speaker or on the oscilloscope. The first heart sound was visibly split on the oscilloscope in 83 patients but in only 15 of these was the split audible.

Second heart sounds were normally split with inspiration in 99 instances, and one patient had a paradoxical splitting for no apparent reason.

Third heart sounds were visible in 32 patients and of these 22 were also audible.

### Murmurs

A murmur was audible by stethoscopy in each of the 100 patients. The location of the point of maximum intensity of the murmur (supine, normal breathing, at rest) is noted in table 1.

In 27 patients the murmur had a wide radiation, being clearly audible from the aortic area to the apex. In many patients the radiation increased as the murmur became louder with the various maneuvers employed. There was not a uniform correlation, however, between the intensity and radiation of the murmur. Thus, one grade II+/VI murmur might be well localized to the third left interspace, whereas another might be a grade I/VI murmur heard over the entire precordium and up into the neck. In 36 patients the radiation was considered minimal (localized to one or two interspaces), and in 37 patients it was considered medium (two to four interspaces). A murmur was audible in the neck in 24 patients; it was not always possible to determine whether this was a separate

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†Cardioscript S/8 8-channel console recorder—Fritz Schwarzer GMBH, Watertown, Massachusetts.
carotid bruit or a murmur conducted from a point lower in the chest.

The intensity of the murmurs on a I to VI basis (supine, normal breathing, at rest) was found to be from II to less than III in 14 patients, from I to II in 61, and between 0 and I in six. In the 19 patients in whom a murmur

was not heard in the supine, normal breathing, resting condition, exercise made it audible in six, expiration or exercise in 11, and erect position or exercise in two. Thus in every patient in this study, a murmur was audible following exercise.

Various positions and maneuvers affected murmur intensity. The intensity was increased by exercise in 84 patients, by expiration in 54, and by the erect posture in six. It was diminished by inspiration in all patients, and by the erect posture in 53.

In all instances the murmurs were early or mid-systolic in timing (fig. 1). In 85 per cent of cases they were of the classic vibratory quality but in a few instances they were described as rough or blowing. There was no consistency in the minor changes in quality observed when the point of maximum intensity varied with the different maneuvers. No comparison of quality with the 1945 examination could be made owing to the uncertain understanding of the descriptive terms used by earlier investigators.

Comparison between the clinical auscultation and the tape play-back listening and oscillographic viewing revealed a very close correlation between the two technics. Clinically, murmurs were audible in each of the 100 patients and by tape recording they were present in 99. For reasons unknown, the murmur in one patient, grade I+/VI at rest and grade II/VI following exercise, was not reproduced on the tape. In the remaining 99 patients the timing and various other characteristics of the murmurs agreed very closely with those found on clinical examination.

Discussion

The incidence of audible innocent murmurs in childhood and adolescence has been variously recorded as from less than 10 per cent as reported in the early 1940's to 97 per cent in 1962. This variation probably reflects not only the better technics of examination and improved construction of the stethoscope but also the more important fact of whether the incidence was determined by cross-sectional or longitudinal study. Cross-sectional studies now
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report incidence of innocent murmurs in the range of 60\(^9\) to 70 per cent.\(^{19}\) It is the opinion of McCammon\(^1\) that practically all individuals, if examined often enough, will be found to have audible murmurs, and Groom et al.\(^{11}\) have shown convincingly that systolic murmurs can be demonstrated phonocardiographically in 100 per cent of normal individuals.

It is commonly believed that these innocent murmurs disappear with maturity.\(^1,\),\(^12,\),\(^13\) The recent report by Marienfeld et al. supports this belief in that only 20 per cent of murmurs were retained after a 20-year period.

The interval between the two examinations, and thus the age of the patient at second examination would appear not to have consistent influence on the incidence of murmurs. In a 6-year follow-up of 100 children\(^4\) the murmurs disappeared in 8 per cent of cases. In a 7- to 10-year followup of 108 cases they disappeared in six cases and in a 2- to 12-year follow-up of 102 patients\(^5\) 17 per cent disappeared. In the study of Perkins and Morris\(^3\) there was considerable difference between the two or more observers, the range of disappearance being reported as 6 to 15 per cent.

The study here reported differs markedly in that murmurs were heard in 100 per cent of the 100 individuals re-examined after a 16-year period and in whom, despite an expected abnormality of 2 per cent,\(^14\) no cardiac pathology was found. While this is unequivocal support for the clinical skill of the examiners 16 or more years ago, the discrepancy between these and other reported figures requires some explanation.

Marienfeld et al.\(^2\) accepted the phonocardiographic criteria of Harris et al.\(^15-17\) It is suspected that the initial selection of patients was on the basis of a left sternal border vibratory murmur only and that this was the murmur looked for during the re-examination. Less attention was, perhaps, paid to the murmurs toward the base and in the neck, where about half of the adult murmurs in the present study were found.

In this study any stethoscopically audible murmur was acceptable. Marienfeld's\(^15\) criteria included vibratory quality, grade II, mid-systolic timing, diamond outline, and duration of half of the mean duration of systole. Most of the murmurs in the present study were short, all were early to mid-systolic in timing, and many were grade I with qualities other than vibratory. Many of the murmurs would be classified by Marienfeld et al.\(^2\) as only "perceptible." The patients were examined in several positions, in different phases of respiration, and both before and after exercise. With the use of these broader criteria, higher incidence of murmurs in this study might be expected.\(^18\) Whether these murmurs are the same as those heard earlier or new ones is difficult to determine.

The incidence in the various sites has changed considerably, most notably in the fewer murmurs heard best near the apex. Previously published data\(^1,\),\(^2,\),\(^9,\),\(^13\) have suggested that many childhood murmurs do disappear; while the present study cannot contradict this view, it does suggest that either more murmurs are retained or they are replaced by different adult murmurs. Perhaps with the more detailed type of examination used in the present study more murmurs would be heard at all ages. At any rate innocent murmurs would seem much more common in the adult than has been previously suspected.

Comparison of Auscultation and Tape-Recorded Phonocardiography

In the present study the clinical stethoscopic analysis of the murmurs, which were all less than grade III/VI in intensity, coincided almost exactly with the phonocardiographic analysis in respect to their intensity, timing, and frequency. The majority (85 per cent) had a vibratory quality and were seen best in the medium and low frequency channels.

The area in which the largest number of murmurs was heard was the third left intercostal space, which, with those heard in the fourth interspace made up 58 per cent of the total. These murmurs were mainly mid-systolic in timing and usually of a diamond shape similar to the vibratory murmur of childhood (fig. 1a).

The next most common murmur was the so-called pulmonary ejection murmur\(^19\) which
was heard in 31 per cent of patients (fig. 1b). This is somewhat higher than the incidence quoted by others for children and therefore supports the view that an increase in the basal position is observed through adolescence. The fact that sound spectrograms of these murmurs have shown a peak frequency of 370 c.p.s. may explain further the low incidence of adult murmurs reported by Marienfeld et al., who used an 80- to 180-c.p.s. selection.

The phonocardiograms of this pulmonary murmur indicated an earlier timing and in many there is no visible gap between the sound and the murmur. It is not surprising that the first sound and murmur would blend visibly as their frequency components are very similar. Over 70 per cent of individuals have first sound components in the 250- to 500-c.p.s. range, which encompasses the 370-c.p.s. range of these murmurs. That these frequencies are not merely prolonged extensions of the first sound is shown by the fact that the total duration of sound and "after sound" waves are longer than the usually accepted 0.165-second duration of the first sound in adults. Both the timing and the incidence of these murmurs are in keeping with the observations of McKusick. Despite this phonocardiographic picture, with the stethoscope there was usually a clear distinction between the sound and the murmur.

Much more attention is now being paid to aortic and carotid arterial murmurs extensively studied by Bruns and Van der Hauwaert. The importance of arterial auscultation in the adult has been stressed by Peart and Rob. Indeed Stuckey has suggested that the vibratory innocent murmur in children might be aortic in origin. These innocent arterial bruits (fig. 1c) are said to become more common with advancing age, an incidence of 37 per cent being observed in normal individuals in their fifties. The incidence of 10 per cent in the young adult patients in this study is, therefore, expected. If the statement that "the normal adult does not have murmurs within the heart" is true, it must be assumed that all the murmurs detected in this study are vascular in origin. This is a hypothesis that requires further substantiation, however.

The experience of this study would suggest that, with recording equipment carefully selected in terms of frequency fidelity, a very close correlation can be obtained between the stethoscopic and the tape-recorded findings. The main problems encountered were the loss of some of the lower frequencies and slight distortion of quality on audio playback. Confidence in the visual reproduction from tape was obtained by recording a few murmurs directly onto the phonocardiographic recorder and comparing these tracings with the same patient's tracing on the same recorder but taken from the tape. That no significant difference in the tracings was found indicates good fidelity of the tape within the frequency range of the instruments and microphones used.

There is little doubt that today clinicians are hearing murmurs much more frequently. It, therefore, becomes more necessary to understand their incidence and characteristics in order to avoid the erroneous diagnosis of cardiovascular disease. How blood rapidly traverses the heart with so little noise has puzzled clinicians for many years. While phonocardiography has revealed that murmurs are always present in children, a thorough and painstaking examination is still required to detect them with the stethoscope. Even more is this true for the adult.

Summary

One hundred young adults who were known to have had innocent murmurs as children were re-examined 16 or more years after the murmur was detected. In all individuals a murmur was again heard. Whether or not this was the same murmur could not be determined. While most (85 per cent) had the vibratory quality similar to the childhood vibratory innocent murmur, 87 per cent were audible at or above the third left intercostal space, a higher proportion than is usually found in children. The murmurs could be divided into three main groups: those maximum at the lower left sternal border (58 per cent), the pulmonary area (31 per cent), and the aortic area and...
neck (10 per cent). Only one was maximum at the apex. No true cardiorespiratory murmurs were heard.

In this study the cardiac sounds and murmurs were faithfully reproduced by the tape-recording equipment employed, thus supporting the view that this technic could be used in heart-screening programs but offers no advantage over simple auscultation.

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