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Original Article

Prevalence of undiagnosed congenital cardiac defects in older children*

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Abstract *Background:* Certain congenital cardiac defects may go undetected for several years due to lack of symptoms and signs. Our purpose was to determine the prevalence of such defects among children greater than one year of age. *Methods:* The study was performed on subjects diagnosed with systemic hypertension, aged from 1 to 19 years, with a mean of 12.4 years, in whom we performed echocardiography, using a standard protocol, to establish any end-organ damage or to reveal any congenital cardiac defects. *Results:* We found a congenital cardiac defect in 5 (3.5%) of the 143 children evaluated. Of these, 4 had not previously been detected, specifically Ebsteins malformation of the tricuspid valve, with moderate regurgitation, a coronary arterial anomaly, a bicuspid aortic valve, and prolapse of the mitral valve permitting regurgitation. In the other patient, we found a non-significant tiny muscular ventricular septal defect. *Conclusions:* Our transthoracic echocardiographic investigation revealed previously unsuspected congenital cardiac defects in 4 of 143 older children, with 3 of these requiring further management by a paediatric cardiologist. A similar prevalence has also been reported in older children evaluated echocardiographically for other diseases such as insulin-resistance and leukemia. Hence, it is possible that the prevalence of congenitally malformed hearts is higher than previously reported. When clinically indicated, clinicians should more readily consider obtaining an echocardiogram to help in the identification of such malformations.

Keywords: Ebstein's malformation; bicuspid aortic valve; mitral valvar prolapse

THE PREVALENCE OF CONGENITALLY MALFORMED hearts is reported to be about 4 to 5 cases per 1000 live births.[1–10] Some studies, however, have reported a higher incidence of about 12 to 14 cases per 1000 live births.[11,12] The majority of defects are diagnosed in early childhood due to the presence of a murmur, cyanosis, or congestive heart failure. A number of significant lesions, nonetheless, can go undetected for several years.[13] Most patients with congenitally malformed hearts may not have a family history. Many may be completely asymptomatic, with normal physical examinations, and have normal chest X-rays and electrocardiograms.[13] Echocardiography, which has been available since the 1980s, has dramatically improved the ability to diagnose such lesions. At present, for economic and practical concerns, not all children undergo screening for silent defects. Hence, echocardiograms performed in large populations for another cause can give an insight into the true prevalence of the congenitally malformed heart. Hypertensive children are reported to have a high prevalence of left

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ventricular hypertrophy secondary to chronic hypertension. We enrolled such hypertensive children prospectively to search for any end-organ damage. We performed a transthoracic echocardiogram using a protocol for recognition of the congenitally malformed heart in our hypertensive population, evaluating both for left ventricular hypertrophy and presence of congenital cardiac defects. Our aim was to determine the prevalence of undetected defects among hypertensive children greater than one year of age.

Methods

Institutional approval: The protocol was approved by the Committee for the Protection of Human Subjects at the University of Texas. All subjects and parents gave informed assent and consent, respectively, for this study. We were careful in maintaining full confidentiality, safeguarding the rights and welfare of human subjects, and informing subjects, in a confidential manner, of the results obtained from the study.

Population: This was a prospective study. We evaluated patients known to have hypertension and aged from 1 to 19 years. The subjects were enrolled from those referred to the our hypertension programme after detection of elevated blood pressure by a primary care provider on several preceding occasions, and from those who were identified by systematic school-based screening for hypertension between the ages of 11 and 18 years in urban Houston public schools. Parents were notified in advance, by letter sent from each school, regarding the screening programme. Forms were provided for parents to sign and return if they did not wish their child to participate. At each screening, three measurements of blood pressure while seated were made at least one minute apart using oscillometric monitors. Students found to have an average blood pressure above the gender, age, and height-percentile specific 95th percentile value for blood pressure underwent a 2nd set of measurements 1 to 2 weeks later. Students found to have a blood pressure above the 95th percentile at the 2nd screening underwent a third set of blood pressure measurements, again after an interval of 1 to 2 weeks. Students found to have elevated measurements on all three occasions were considered to be hypertensive. Families of hypertensive children were informed of the persistent elevation of blood pressure, and invited to participate in a clinic-based study of hypertensive end-organ injury in children.

To be considered for further analysis, subjects were required to have shown casual elevations of blood pressure above the 95th percentile on at least two previous occasions, and to be taking no concurrent medication with the potential to raise blood pressure, such as prednisone or methylphenidate. Infants and preterm children were excluded from the study. Demographic and anthropometric data were collected on all subjects at entry, and included age, gender, height, weight, and ethnicity, the latter being self assigned.

All subjects underwent casual measurements of blood pressure in the clinic, including ambulatory monitoring for 24 hours as part of the protocol. A casual hypertensive state was confirmed in all subjects at the 1st visit to the hypertension clinic by averaging the last 3 of 4 blood pressure measurements performed by manual auscultation with a mercury sphygmomanometer by trained personnel using methodology recommended by the American Heart Association. Manual auscultatory measurements were used for analysis of clinic blood pressure. All subjects also underwent ambulatory monitoring using Spacelabs oscillometric monitors (Spacelabs, Inc., Redmond, WA). Measurements were performed every 20 minutes for 24 hours. Subjects with systolic or diastolic pressures over 24 hours greater than the 95th centile for children, or a blood pressure load, calculated as the proportion of values exceeding the 95th centile for the 24-hour period of greater than 25%, were considered to have ambulatory hypertension. Subjects with casual hypertension and a load less than 25% were excluded, and considered to have "white coat hypertension", that is hypertension noted in the clinical setting, but with normal results on ambulatory blood pressure monitoring. Once hypertension was confirmed, all subjects underwent further evaluation for secondary causes of hypertension and end-organ damage, including a transthoracic echocardiogram.

The echocardiographic studies were performed on all patients diagnosed with hypertension based on the results of their casual and ambulatory measurements. The heart was imaged by trained paediatric sonographers via 2-D, Doppler, and M-mode imaging using a standard protocol to rule out congenital cardiac disease, with emphasis on the evaluation for left ventricular hypertrophy. All examinations included 2-D imaging in the parasternal long axis and short axis views to evaluate for coronary arterial anomalies. The studies were acquired and recorded either digitally or on a videocassette for later review. A single board-certified paediatric cardiologist interpreted these studies over a period of 2 years. All studies were evaluated for the presence of congenital cardiac disease, excluding those with known cardiac disease. A patent foramen ovale, or small interatrial communication of less than 3 millimetres, or trivial mitral, tricuspid or pulmonary valvar insufficiency with normal valvar structure, were all deemed examples of physiologic insufficiency.[14] Any congenital

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cardiac defect detected in a previously undiagnosed child where the echocardiogram was solely obtained for the evaluation of end-organ damage secondary to hypertension was considered a sufficient criterion to label the child as one with a previously undetected congenital cardiac malformation. Such a defect was considered significant if it required further evaluation and management by a paediatric cardiologist.

Results

We enrolled 143 children with systemic hypertension, 77 of whom were males, with a mean age of 12.4 ± 4.3 years, ranging from 1 to 19 years, and with a median of 14 years. They all underwent an echocardiogram to evaluate for congenital cardiac defects. Such defects were detected in 5 (3.5%) of the 143 children evaluated. We found defects such as Ebstein's malformation of the tricuspid valve with moderate regurgitation, a coronary arterial anomaly, a bicuspid aortic valve, and mitral valve prolapse with mild mitral regurgitation. We also found one example of a tiny muscular ventricular septal defect. Other incidental findings included 1 patient with non-compaction of the left ventricle, confirmed by magnetic resonance imaging, another with mild mitral regurgitation, 6 with trivial aortic insufficiency, and 2 with trivial pericardial effusions. Patency foramen ovale was seen in 7 (5%) of the children. Coronary arterial anomalies, and patent foramen ovale foramen, may not have been detected in some patients, especially older children, due to limited acoustic windows.

All children in whom a congenital cardiac defect was detected were further evaluated and treated by a paediatric cardiologist. All patients were clinically asymptomatic, without exercise intolerance, palpitations, chest pain or dizziness. The 15 year-old boy with the Ebsteins malformation had previously been evaluated by a paediatric cardiologist at 4 years of age for the presence of a murmur, and was told that the murmur was innocent. No echocardiogram had been performed at that visit. The current evaluation by a paediatric cardiologist revealed a soft, holosystolic murmur heard best at the right lower sternal border. The chest X-ray showed mild cardiomegaly. The electrocardiogram showed normal sinus rhythm, with right axis deviation and incomplete right bundle branch block. The echocardiogram confirmed the diagnosis of Ebsteins malformation, with moderate tricuspid valvar regurgitation. The patient was placed on an oral inhibitor of angiotensin converting enzyme. The child with the coronary arterial anomaly was 17 years old. The right coronary artery arose from the left coronary artery, and coursed between the great arterial trunks. He was advised to undergo cardiac catheterization, and to refrain from participation in sports, but moved to a different state prior to the catheterization. Another patient, not previously discussed, was found to have a coronary arterial fistula on the first echocardiogram, but a repeat echocardiogram after a year showed complete resolution of the fistula. This was confirmed by cardiac catheterization. The standard electrocardiogram and chest X-rays were abnormal only in the child with Ebstein's malformation. All children with congenitally malformed hearts were advised to undergo follow-up with a paediatric cardiologist.

Discussion

A congenital cardiac malformations is present in as many as one-quarter of all neonates seen with congenital malformations.[15] Many such patients are lost during fetal life and after birth[16–18] due to major anomalies, while some defects are missed after birth due to lack of symptoms and signs.[19] The incidence of congenital cardiac defects that will require expert cardiologic care is reported to be stable, at about 2.5 to 13 per 1000 live births.[20] It is a general belief that the majority of the defects that go undetected are ones without clinical significance.

With the availability of echocardiography, it has become easier to detect such defects.[11,20] With the development of fetal echocardiography,[21] and increasing use of transthoracic echocardiography, the true prevalence of this disease is coming to the fore.[7,19] Hence, recent studies have reported a higher prevalence than previously reported. As not every child undergoes a routine echocardiographic evaluation of the heart, it has been due to large studies involving other diseases for which children undergo such imaging that a surprising number of silent defects have been detected. A similar prevalence to that reported in this study, namely around 3.5%, has also been found in older children evaluated by an echocardiogram for other unrelated diseases such as insulin-resistance[19] and leukemia.[22] Hence, it is possible that congenital cardiac defects are more prevalent in liveborn children than previously reported.

What is more surprising is that not all undetected defects are benign, and therefore need further evaluation by a paediatric cardiologist,[19] including possible prophylaxis for infective endocarditis, and sometimes restriction from participation in sports and strenuous physical activities. Silent defects were detected in about 3% of our population older than one year of age. We also detected a very small muscular ventricular septal defect, but such lesions are usually asymptomatic,

and often undergo spontaneous closure. Other cardiac findings included non-compaction of the left ventricle, mild mitral regurgitation, a trace of aortic insufficiency, and trivial pericardial effusion. Patent foramen ovale was demonstrated in one-twentieth of the children by a transthoracic echocardiogram, albeit without any contrast study.

In the presence of a clinically diagnosed innocent heart murmur, an echocardiogram has been shown to be of low yield, with an additional 2 of 109 patients shown to have congenital cardiac defects that were missed by auscultation.[23] No matter how good is the evaluating clinician, there remain certain defects that can easily be missed by physical examination, chest X-ray, and electrocardiogram alone.[13,19,24,25] The results from our study suggest that paediatric cardiologists should have a lower threshold for obtaining an echocardiogram in the clinical setting, in this way identifying individuals who, over a lifetime, are at potential risk.

It is also important to note that a transthoracic echocardiogram not geared at looking for congenital cardiac defects can miss many of the lesions. Hence, a person trained in evaluation of the congenitally malformed heart should be performing the scan and evaluating the results. Our study indicates at the magnitude of the problem, and may help with developing resources and infrastructure for diagnosis and management of congenital cardiac disease. Numerous reports of previously undiagnosed defects, including congenitally corrected transposition, exist in the literature.[13,26,27] Undiagnosed defects serve as a risk factor for sudden death in older children and adults,[28,29] as a nidus for infective endocarditis,[30–32] and presage arrhythmias and late heart failure. The true morbidity and mortality due to congenital cardiac disease will only be determined when account is also taken of silent defects.

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