ABSTRACT. Objective. To determine the basis for cardiac consultations for pediatric patients in an academic hospital setting.

Methods. The activities of the cardiology consultation service were tabulated for 12 months, from July 2001 to June 2002. Patients were identified from 4 sources, ie, a monthly log of patient encounters maintained by the consultation service, encounter forms submitted to the billing office, consultation notes maintained in a central file, and a departmental list of echocardiography studies. Patients who required clearance for noncardiac surgical procedures were generally evaluated in the cardiology clinic and not by the consultation service. Patient data were obtained from consultation and echocardiography reports and from hospital computer-based records for discharge summaries for inpatient admissions, emergency department encounter summaries, and laboratory reports. For each patient, consultations were tabulated as separate encounters if they occurred on different days in the emergency department, during separate admissions, or for different clinical concerns during a single admission.

Results. A total of 2071 consultations were performed for 1724 patients. The age at the time of consultation was 6.6 ± 9.5 years (median: 1.2 years; range: 1 day to 60.6 years). A total of 1507 patients (87.4%) had a single consultation; 217 patients (12.6%) had multiple encounters, ranging from 2 to 9, accounting for 564 consultations (27.2%). Clinical concerns included murmurs (18.5%), cardiac function (12.7%), arrhythmias (12.7%), intercurrent illnesses among cardiac patients (11.3%), cyanosis (6.3%), syndromes (5.7%), chest pain (5.2%), syncpe/dizziness (4.5%), subacute endocarditis (4.4%), follow-up evaluations of fetal diagnoses (4.3%), Kawasaki disease (3.4%), cor pulmonale (3%), recent cardiac surgery or catheterization (1.6%), cerebrovascular accidents (1.2%), and miscellaneous conditions. Four diagnoses accounted for 91% of cases; these patients were more likely to have symptoms associated with exercise. Although endocarditis was a frequent clinical concern (91 patients), only 3 cases were identified, involving 2 patients with structural heart disease and 1 neonate with an indwelling intracardiac catheter. Two other patients had central venous lines, intravascular thrombus, and fungemia. Kawasaki disease was the most common acquired condition leading to consultation. Cor pulmonale was most commonly screened among patients with congenital diaphragmatic hernia, chronic lung disease of prematurity, pneumonitis, reactive airway disease, or cystic fibrosis. Patients with recent cardiac surgery or cardiac catheterization typically had postpericardiotomy syndrome or complications associated with vascular access. Approximately 20% of cases of cerebrovascular accidents had a cardiac basis.

Conclusions. Although a variety of conditions were assessed, some were encountered more frequently. Future educational curricula developed for cardiac training of pediatric residents should appropriately emphasize conditions necessitating consultation. Pediatrics 2004; 114:e409–e417. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2003-0898-L; congenital heart disease, health education, patient care.
been determined. Education of medical students and residents in pediatric cardiology is challenging both because structural congenital heart disease is uncommon, affecting <1% of children, and because conditions potentially having a cardiac basis frequently have other causes.¹-⁵ To establish the appropriate emphasis for clinical instruction in pediatric residency training programs, I determined the basis for cardiac consultations in a tertiary academic pediatric hospital.

**METHODS**

**Study Population**

The activities of the cardiology consultation service were tabulated from July 1, 2001, to June 30, 2002. Patients were evaluated in the emergency department, neonatal and pediatric intensive care units, inpatient wards, and occasional outpatient settings at Children’s Hospital, Boston, and in the neonatal intensive care units and nurseries at Brigham and Women’s Hospital and Beth Israel-Deaconess Hospital. There is a general cardiology ward and a cardiac intensive care unit at Children’s Hospital, Boston, which are not staffed by the consultation service. Patients were identified from 4 sources, ie, a monthly log of patient encounters maintained by the consultation service, encounter forms submitted to the billing office, consultation notes maintained in a central file, and a departmental list of echocardiographic studies. Although cardiology consultation is generally required for echocardiography, our departmental policy has permitted independent ordering of echocardiographic tests by the oncology service, to evaluate cardiac function associated with chemotherapy protocols, and by the neonatology service, to screen for patent ductus arteriosus among premature infants.

Patients who required clearance for noncardiac surgical procedures were generally evaluated in the cardiology clinic and not by the consultation service. The study was approved by the Children’s Hospital Committee on Clinical Investigation.

**Data Tabulation**

Patient data were obtained from consultation and echocardiography reports and Children’s Hospital computer-based records for discharge summaries for inpatient admissions, department encounter summaries, and laboratory reports. Tabulated data included patient age, date, site, and basis of consultation, whether the patient was new or was known to the cardiology service, performance of echocardiography, electrocardiography, or chest radiography, and final diagnosis. For each patient, consultations were tabulated as separate encounters if they occurred on different days in the emergency department, during separate admissions, or for a different clinical concern during a single admission. Patient ages were tabulated as age at the first encounter for a given diagnosis. Chest pain was classified with previously reported criteria.²

**Statistical Analyses**

Patient ages are expressed as mean ± SD. Analyses of the occurrence of heart disease among patients with supraventricular tachycardia or atrial fibrillation/atrial flutter and among patients with syncope/dizziness associated with exertion were performed with Fisher’s exact test. Comparisons of the age at first encounter between patients with supraventricular tachycardia and those with atrial fibrillation/atrial flutter and between patients with supraventricular tachycardia with or without congenital heart disease were made with the Wilcoxon rank sum test.

**RESULTS**

**Number of Consultations**

During the study period, 2071 consultations were performed for 1724 patients. The age at the time of consultation was 6.6 ± 9.3 years (median: 1.2 years; range: 1 day to 60.6 years). A single consultation was performed for 1507 patients. Two hundred seventeen patients (12.6%) had multiple encounters, ranging from 2 to 9, accounting for 564 consultations (27.2%). The monthly total of consultations ranged from 154 to 201 (average: 173). Patients were evaluated most often in the neonatal intensive care unit, inpatient wards, or the emergency department, for known cardiac patients (Fig 1).

**Reasons for Consultations**

**Murmurs**

Evaluation of a murmur represented 18.5% of encounters (Tables 1 and 2). The median age was 6 days (range: 1 day to 18.5 years). Echocardiography was used for all patients except for ~50% of patients with pulmonary branch murmurs of infancy or other innocent murmurs and for 10% of patients with ventricular septal defects, each of which was judged to be small. For patients evaluated for a murmur, the most common diagnosis or clinical concern in the neonatal intensive care unit was patent ductus arteriosus (68%), in the well-child nursery was ventricular septal defect (64%), and on the medical ward was innocent murmur (62%).

![Fig 1. Numbers of consultations performed on a monthly basis at different sites. Numbers in parentheses indicate the total numbers of patients evaluated. “Other” sites included the preoperative clinic, post-anesthesia care unit, radiology department, and infusion center. ER indicates emergency department; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.](image-url)
TABLE 1. Sites and Bases for Consultations

<table>
<thead>
<tr>
<th>Basis for consultation</th>
<th>ED, Known</th>
<th>ED, New</th>
<th>NICU</th>
<th>Well Nursery</th>
<th>PICU</th>
<th>Medical Ward</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murmur</td>
<td>17</td>
<td>254</td>
<td>73</td>
<td>3</td>
<td>34</td>
<td>3</td>
<td>3</td>
<td>384</td>
</tr>
<tr>
<td>Function</td>
<td>35</td>
<td>4</td>
<td>20</td>
<td>53</td>
<td>150</td>
<td>2</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>106</td>
<td>43</td>
<td>20</td>
<td>8</td>
<td>15</td>
<td>8</td>
<td>8</td>
<td>262</td>
</tr>
<tr>
<td>Intercurrent illness</td>
<td>230</td>
<td>2</td>
<td>4</td>
<td>21</td>
<td>9</td>
<td></td>
<td></td>
<td>233</td>
</tr>
<tr>
<td>Cyanosis (postnatal diagnosis)</td>
<td>13</td>
<td>12</td>
<td>47</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Syndrome</td>
<td>97</td>
<td>2</td>
<td>4</td>
<td>15</td>
<td>118</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td>57</td>
<td>35</td>
<td></td>
<td></td>
<td>13</td>
<td>2</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>Syncope/dizziness</td>
<td>25</td>
<td>4</td>
<td></td>
<td>22</td>
<td>1</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subacute bacterial endocarditis</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>17</td>
<td>58</td>
<td></td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Fetal diagnosis follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrhythmia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyanotic heart disease</td>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthotic heart disease</td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal postnatal status</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>5</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Kawasaki disease</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>65</td>
<td></td>
<td></td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>PAH/cor pulmonale</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>37</td>
<td>14</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Recent cardiac surgery</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Recent catheterization</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>CVA/TIA</td>
<td>8</td>
<td></td>
<td>3</td>
<td>6</td>
<td>7</td>
<td></td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Other conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical clearance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Cardiomegaly</td>
<td></td>
<td></td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Abnormal ECG-nonarrhythm</td>
<td></td>
<td></td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>3</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALTE</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Thrombus</td>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Systemic hypertension</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Vascular ring</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Rheumatic fever</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>9*</td>
<td>4†</td>
<td>2‡</td>
<td>1§</td>
<td>2¶</td>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ALTE indicates apparent life-threatening episode; CVA/TIA, cerebrovascular accident/transient ischemic attack; ED, emergency department; NICU, neonatal intensive care unit; PAH, pulmonary artery hypertension; PICU, pediatric intensive care unit; ECG, electrocardiogram.
* Five central venous line malfunctions (for prostacyclin or antibiotic administration), 2 hemoptysis in patients with pulmonary vascular obstructive disease, hypercalcemia, and 1 femoral artery pseudoaneurysm (catheterization performed 1 year previously).
† Two thoracopagus conjoined twins, 1 sibling with congenital heart disease, and 1 rule out coarctation.
‡ Two siblings with congenital heart disease.
§ Rule out pulmonary embolism.
¶ Tachypnea.

TABLE 2. Consultations for Evaluation of a Murmur

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>ED, New</th>
<th>NICU</th>
<th>Well Nursery</th>
<th>PICU</th>
<th>Medical Ward</th>
<th>Other</th>
<th>Total</th>
<th>Echocardiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic stenosis</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial myxoma</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial septal defect, secundum</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrioventricular canal, transitional</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innocent or flow murmur</td>
<td>2</td>
<td>19</td>
<td>5</td>
<td>21</td>
<td>1</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitral stenosis</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patent ductus arteriosus</td>
<td>135</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>143</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>Rule out patent ductus arteriosus, not present</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral pulmonary stenosis</td>
<td>4</td>
<td>27</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>46</td>
<td>24</td>
</tr>
<tr>
<td>Pulmonary stenosis</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Truncus arteriosus</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
<td>5</td>
<td>21</td>
<td>47</td>
<td>1</td>
<td>2</td>
<td>76</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Ventricular septal defect/coarctation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolved before consultation</td>
<td>7</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations as in Table 1.

Function

Cardiac function evaluation accounted for 12.7% of consultations (Table 1). The patient age was 8.7 ± 8.5 years (median: 6.4 years). Common conditions prompting evaluation of cardiac function included oncologic disease (40.5%), congenital heart disease (13.6%), sepsis (10.6%), postoperative general surgical procedures (7.2%), neuromuscular disease (6.8%), arteriovenous malformations (3.8%), and hematologic disease (sickle cell disease or β-thalassemia).
There were 3 new diagnoses of structural congenital heart disease among neonates who were examined initially in the emergency department or pediatric intensive care unit; 2 had severe coarctation and the other an interrupted aortic arch.

### Arrhythmias

Evaluation of an arrhythmia accounted for 12.7% of consultations (Tables 1 and 3). Atrial arrhythmias represented 63% of consultations for the indication of arrhythmia. The most common arrhythmias requiring treatment were supraventricular tachycardia, atrial flutter, and atrial fibrillation. Compared with patients with atrial flutter/atrial fibrillation, patients with supraventricular tachycardia were younger (7.9 ± 8.5 years; median: 5.4 years; vs 26.1 ± 12.1 years; median: 22.7 years; \( P < .001 \)) and had a lower incidence of congenital heart disease (8% vs 78%, \( P < .001 \)). Patients with supraventricular tachycardia with congenital heart disease presented at older ages than did those without structural defects (median age: 15.1 years vs 3.1 years; \( P = .05 \)).

Of the 17 patients evaluated for possible prolonged QT interval, 1 neonate had congenital prolongation of the QT interval. The other patients had prolongation of the interval resulting from medication effects (\( n = 4 \); clomipramine, nortriptyline, or pentamidine) or metabolic defects (\( n = 6 \); hypocalcemia in 5 cases and hypokalemia in 1 case) or had a normal interval (\( n = 6 \)). An associated disease was present for 1 patient each with first-degree atrioventricular block (anorexia nervosa), transient second-degree atioventricular block (Lyme disease), and neonatal complete heart block (maternal systemic lupus erythematosus).

### Intercurrent Illnesses

Evaluation of patients with known cardiac disease presenting with an intercurrent noncardiac illness (mainly viral syndromes) accounted for 11.3% of consultations (Table 1). The patient age was 5.3 ± 7.4 years (median: 2.0 years).

### Cyanosis

Cyanosis formed the basis of consultations for 6.3% of patients (Tables 1 and 4). Three-quarters of the patients were <1 week of age. Of 54 patients with structural cyanotic heart disease, 45 (83%) were diagnosed with fetal echocardiography. The mothers of these neonates had delivery scheduled at a nearby hospital. Intercurrent illnesses among patients with palliated cyanotic heart disease produced increasing cyanosis if there was fever for patients with systemic-pulmonary shunts or dehydration for those with intracardiac right-to-left shunts.
4.5% of consultations, 10% of all emergency department consultations for new patients (Tables 1 and 6). The patient age was 16.1 years (median: 19 years). 19% of emergency department consultations for new patients had a cardiac basis were more likely to have symptoms associated with exercise (P = .001). Of 13 patients who experienced syncope (n = 8) or dizziness (n = 1) during exercise or syncope shortly after completion of exercise (n = 4), 7 demonstrated a vasovagal basis, 4 had a cardiac condition, and 1 each exhibited a psychiatric or idiopathic cause.

**Syndromes**

The evaluation of cardiac involvement in syndromes prompted consultation for 5.7% of patients (Tables 1 and 5). The median age was 2 days. Three syndromes represented 57% of the consultations for this indication, ie, VACTERL association (vertebral anomalies, anal atresia, congenital heart disease, tracheoesophageal fistula, renal abnormality, and limb anomalies), trisomy 21, and infant of a diabetic mother.

**Chest Pain**

Chest pain accounted for 5.2% of consultations, 13% of all emergency department evaluations, and 19% of emergency department consultations for new patients (Tables 1 and 6). The patient age was 16.1 ± 7.4 years (median: 15.4 years). For this symptom, the 2 most common categories were musculoskeletal/costochondritic (42%) and idiopathic (22%) conditions. There was a cardiac or pericardial basis in 11% of cases; these patients either had a known cardiac history or had pericarditis presenting with systemic symptoms and abnormal cardiac auscultatory or electrocardiographic findings (6). Chest pain with exertion occurred for 2 patients, each with known heart disease. One patient with palliated cyanotic heart disease and normocytic erythrocytes experienced resolution of chest pain with reduction of hematocrit values from 71% to 63%. A chest radiograph was obtained in 92 episodes (86%) and contributed to the diagnosis for the 13 patients with pulmonary abnormalities and the 5 patients with pericarditis. An electrocardiogram was obtained in 106 episodes (99%) and differed from baseline tracings or was abnormal for 4 patients with pericarditis. Concern about possible pulmonary embolism was raised for 6 patients, but the results of imaging studies were normal.

**Syncope/Dizziness**

Evaluation of syncope or dizziness accounted for 4.5% of consultations, 10% of all emergency department evaluations, and 25% of emergency department evaluations for new patients. The patient age was 14.4 ± 5.4 years (median: 14.9 years). The most common causes were vasovagal (47 episodes, 50.5%) or orthostatic (23 episodes, 24.7%). For 5 patients, orthostasis was related to medication (clonidine, quetiapine fumarate, or furosemide). Six episodes (6.5%) had an idiopathic basis and 2 had other causes (hyperventilation or menorrhagia). Five patients (5.4%) each demonstrated a cardiac, neurologic, or psychiatric basis. Cardiac diseases included 2 new patients with congenital prolonged QT interval and 1 known patient each with primary pulmonary hypertension, severe subaortic stenosis, and bradycardia secondary to pacemaker dysfunction. Neurologic conditions included a seizure disorder, breath-holding spell, and migraine headache. Patients with a cardiac basis were more likely to have symptoms associated with exercise (P = .001). Of 13 patients who experienced syncope (n = 8) or dizziness (n = 1) during exercise or syncope shortly after completion of exercise (n = 4), 7 demonstrated a vasovagal basis, 4 had a cardiac condition, and 1 each exhibited a psychiatric or idiopathic cause.

**Subacute Endocarditis**

Evaluation for subacute endocarditis accounted for 4.4% of consultations (Tables 1 and 7). The patient age was 7.7 ± 7.3 years (median: 5.2 years). Of 91 consultations for this concern, there were 3 cases of subacute endocarditis (3.3%) (Table 7). Two events occurred among known cardiac patients, presenting to the emergency department with either fever and bacteremia or an indolent course of weight loss and anorexia. For each patient, the blood cultures yielded Streptococcus viridans. A premature neonate had an umbilical venous line, Staphylococcus aureus bacteremia, and right-sided intracardiac vegetations. Two patients had candidemia and intravascular thrombus associated with a central venous line.

Transthoracic echocardiograms were obtained in 79 consultations (87%) and transthoracic echocar-
diograms in 6 (6.7%). Thrombus or vegetation was noted only for the patients cited above. Echocardiography was deferred for 9 patients who had sterile blood cultures and for 3 others who had sterile cultures after removal of a central venous catheter and antibiotic therapy for bacteremia.

The most common clinical background was septicemia with an indwelling central venous catheter (36 episodes, 40%). A new murmur was present for 11 patients, 6 of whom had positive blood cultures. Echocardiograms were obtained for 10 of these patients. Each murmur was innocent, ie, 6 Still's murmurs, 4 flow murmurs associated with anemia, and 1 innocent pulmonary branch murmur of infancy.

**Follow-up Evaluations of Fetal Diagnoses**

Ninety neonates had consultations prompted by fetal echocardiographic diagnoses, representing 4.3% of consultations and 14.1% of consultations performed in the neonatal intensive care unit and nurseries (Table 1).

**Kawasaki Disease**

This clinical concern represented 3.4% of all consultations (Tables 1 and 2). The patient age was 4.3 ± 3.3 years (median: 3.7 years). Of the 70 encounters, 51 patients were diagnosed as having Kawasaki disease. The other 19 patients were diagnosed as having viral syndrome (15 patients), urinary tract infection or pyelonephritis (1 patient, 2 episodes), hypersensitivity reaction to dilantin, or necrotizing fasciitis.

**Pulmonary Artery Hypertension/Cor Pulmonale**

Concern about pulmonary artery hypertension accounted for 3.0% of consultations. The patient age was 3.7 ± 6.9 years (median: 92 days; range: 1 day to 2 years).
TABLE 7. Consultations to Rule Out Subacute Bacterial Endocarditis

<table>
<thead>
<tr>
<th>Basis for consultation</th>
<th>ED, Known</th>
<th>ED, New</th>
<th>NICU</th>
<th>PICU</th>
<th>Medical Ward</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive BC</td>
<td>1*</td>
<td>1</td>
<td>7*</td>
<td>13†</td>
<td>35</td>
<td>57‡</td>
</tr>
<tr>
<td>Fever</td>
<td>5*</td>
<td>1</td>
<td>3</td>
<td>16†</td>
<td>42</td>
<td>24</td>
</tr>
<tr>
<td>New murmur</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>New S3</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Weight loss, anorexia</td>
<td>1†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Fatigue</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Embolic event</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Clinical conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repaired/palliated CHD</td>
<td>4*</td>
<td></td>
<td>3</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Unrepaired CHD</td>
<td>1†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oncologic diseases</td>
<td></td>
<td>3</td>
<td>16</td>
<td></td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>General surgery within previous 8 wk</td>
<td></td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Indwelling central venous catheter</td>
<td></td>
<td>5*</td>
<td>10†</td>
<td></td>
<td>33</td>
<td>48</td>
</tr>
<tr>
<td>Intravenous drug abuser</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Dental abscess</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

BC indicates blood culture; other abbreviations as in Tables 1 and 4.

* One patient with each symbol had subacute bacterial endocarditis; see text for details.
‡ Three organisms accounted for 39 (67%) of the 58 episodes of septicemia (57 presenting with septicemia and 1 presenting with constitutional symptoms and subsequently found to have bacteremia). Various species of *Candida* were isolated in 17 cases, *Staphylococcus aureus* in 14 episodes, and coagulase-negative *Staphylococcus* in 8. There were 5 cases of *Streptococcus viridans* and 2 cases each of *Pseudomonas aeruginosa* and group A *Streptococcus*. Ten other bacteria were isolated only once, for different patients.

25.6 years). The most common condition was congenital diaphragmatic hernia, which was found for 34% of patients evaluated for this concern. Other conditions prompting evaluation of pulmonary artery pressure included chronic lung disease associated with premature birth, pneumonitis or reactive airway disease, cystic fibrosis, pulmonary hypoplasia associated with chest wall deformity or cystic adenomatoid malformation, obstructive sleep apnea, pulmonary hemosiderosis, neurologic conditions associated with hypoventilation, and orthotopic lung transplantation.

Recent Cardiac Surgery or Cardiac Catheterization

Eight of 25 patients evaluated within 2 months after surgery had postpericardiotomy syndrome. Other issues addressed included surgical wound evaluation, pleural effusion, intervening viral illness, pain control, and bacterial pericarditis.

Evaluations after catheterization, with 1 exception, involved interventional procedures. One patient had transient fever after coil occlusion of collateral vessels, whereas the others had vascular access problems consisting of pain (local hematoma, infected hematoma, or arterial pseudoaneurysm) or coolness of an extremity.

Cerebrovascular Accidents/Transient Ischemic Attacks

Evaluation of a cardiac source for loss of neurologic function accounted for 1.2% of consultations (Table 1). A cardiac basis was identified for 5 of the 24 patients evaluated for this concern, ie, intracardiac thrombus for 2 patients with a single ventricle and bidirectional flow across a patent foramen ovale for 3 patients, including a neonate with a thrombus at the tip of a central venous line and 2 adolescents. An additional adult patient had pulmonary vascular obstructive disease, polycythemia (hematocrit: 62%), and microcytic anemia (mean corpuscular volume: 69 FL). The other 18 patients had a variety of conditions, ie, protein C, protein S, or antithrombin III deficiencies, carotid artery dissection, moyamoya disease, sickle cell disease, encephalitis, coagulopathy associated with intraventricular hemorrhage, severe hyponatremia caused by psychogenic polydipsia, or idiopathic causes.

Other Conditions

A variety of other conditions were evaluated (Table 1). Eight of 20 patients (40%) who underwent consultations because of cardiomegaly on chest radiographs had heart disease. The cardiologist and radiologist judged the cardiac silhouette to be normal in an equal number, 5 of whom had a large thymus. For 4 other patients, echocardiograms showed normal cardiac dimensions. Infants with an apparent life-threatening event had normal QT intervals and no other identifiable cardiac disorders; 5 patients demonstrated an idiopathic basis, whereas the others had apnea, periodic breathing, breath-holding, gastroesophageal reflux, or seizure disorder. Systemic hypertension was associated with renal disease for 4 patients, agitation, headache, or postoperative pain for 5, and medication (fludrocortisone and midodrine) for 1. Evaluation for a vascular ring was prompted mainly by the symptom of stridor, which was caused for 2 patients each by tracheomalacia and laryngomalacia and for 1 patient each by left main bronchus stenosis, subglottic hemangioma, innominate artery compression, and unilateral vocal cord paresis; 1 patient with an incidental finding of a right aortic arch had a loose vascular ring with an aberrant left subclavian artery. Of 7 patients evaluated for rheumatic fever, 2 with chorea and mitral regurgitation were diagnosed with this condition. Two other patients with movement disorders had either Guillain-Barré or antiphospholipid syndrome. The other 3 patients did not fulfill Jones
criteria, including 2 with fever and an innocent murmur.

**DISCUSSION**

This review documents for the first time the issues prompting cardiac consultation in an academic pediatric hospital setting. Although a variety of conditions were assessed, some diagnoses were encountered more frequently and should be given emphasis in future curriculum development for cardiac training for pediatric residents.

Evaluation of a murmur was the most frequent basis for consultation. Cardiac auscultation skills in various training programs, including pediatrics, have been documented to be poor. Four conditions (patent ductus arteriosus, ventricular septal defect, innocent murmur, and pulmonary branch murmur of infancy) accounted for 91% of diagnoses for patients with murmurs. Initially developing stethoscope skills among pediatric residents for the detection of these conditions should fulfill clinical needs frequently. Developing skills for the diagnosis of an innocent murmur should have additional benefits in reducing parental morbidity if confirmation by a cardiologist is subsequently sought, because the ability of the pediatrician to provide greater reassurance has been shown to reduce parental anxiety associated with referral.

Assessment of function was frequently requested for a variety of clinical conditions. Newly developed dysfunction among infants after discharge from the birth hospital can represent duct-dependent lesions that elude detection while the duct is widely patent. The majority of arrhythmias were atrial in origin. The most common arrhythmia was supraventricular tachycardia, which usually was associated with a structurally normal heart. Atrial fibrillation/atrial flutter occurred among older patients, who typically had congenital heart disease; the chronic effects of pressure or volume overload or surgical scars contribute to the development of these 2 arrhythmias, which are commonly seen among patients, as in our study group, who have undergone atrial baffle repair of dextrorotation of the great arteries (Mustard or Senning procedures), modified Fontan procedures because of a functional single ventricle, or repair of tetralogy of Fallot. Young adults with repaired congenital heart disease are becoming a larger patient group, because of improved survival rates, and are cared for at pediatric hospitals; therefore, familiarity with these arrhythmias is important. Ventricular arrhythmias were infrequent and mainly consisted of ventricular premature beats. Prolonged QT syndrome usually was associated with a metabolic abnormality or medication-related side effect, rather than with congenital prolongation. Heart block was uncommon and was associated with anorexia nervosa, Lyme disease, or maternal systemic lupus erythematosus.

Diagnoses made with fetal echocardiography were a frequent basis for neonatal consultation. Cyanotic lesions were over-represented among the prenatally diagnosed patients, in comparison with the occurrence in the general population, because delivery of these infants was arranged at a nearby hospital. Such a policy can decrease morbidity and mortality rates. Patients with palliated cyanotic heart disease experienced increased cyanosis with intercurrent illness in the presence of dehydration, because of increased oxygen extraction and lower venous oxygen saturation, in conditions with right-to-left intracardiac shunting or in the presence of fever, because of decreased shunt perfusion produced by lower systemic vascular resistance, in conditions with systemic-pulmonary artery shunting. The oxygen dissociation curve is steep for arterial oxygen pressure values of <50 mm Hg, so that a small decrease in oxygen tension produces a large decrease in oxygen saturation.

Chest pain and syncope were frequently evaluated in the emergency department, and each was typically associated with a benign condition. A serious organic cause for chest pain was unusual without associated symptoms of illness, positive physical examination findings related to the cardiac or respiratory systems, or symptoms during exertion. The occurrence of syncope during or shortly after exertion also was commonly observed among patients with cardiac conditions.

Syndromes have been reported for 8.5% of patients with congenital heart disease. Recognition of syndromes permits thorough patient evaluation, including early detection of heart disease, which may not produce clinical symptoms as long as pulmonary vascular resistance is elevated in the early neonatal period. The 3 syndromes evaluated most frequently are associated commonly with congenital heart disease, Endocarditis was uncommon and occurred among patients with known congenital heart disease or indwelling venous catheters. Risk factors for thoracic echocardiographic evidence of endocarditis that were identified in each of 2 pediatric reports included positive blood cultures, physical findings of new or changing heart murmur, and congestive heart failure. Indications in neonates may be different. Our experience shows that the feature of a new murmur should be defined as a new regurgitant murmur, because a hyperdynamic condition associated with febrile illness can produce innocent murmurs.

Kawasaki disease was the most common acquired disease leading to consultation. Approximately one-quarter of patients evaluated for Kawasaki disease were determined to have other conditions. Considering the diagnosis of Kawasaki disease for children with some features of the illness is warranted, because atypical presentation has been associated with coronary involvement.

Various conditions were encountered less frequently. Evaluation of pulmonary hypertension mainly involved conditions associated with pulmonary disease. Doppler echocardiography can be used to estimate the level of pulmonary systolic pressure and to monitor the hemodynamic effects and dosing of nitric oxide or supplemental oxygen in these conditions. Consultation after cardiac surgery...
chiefly involved evaluation for postpericardiotomy syndrome, whereas assessment after catheterization mainly involved vascular access concerns among patients who had undergone interventional procedures (a risk factor for complications). Although neurologic deficits usually had a noncardiac cause, our patient group confirmed risks associated with cyanotic heart disease, Fontan procedure, thrombosis related to the use of an indwelling central venous catheter, patent foramen ovale, and polycythemia associated with microcytosis. Cardiomegaly was not present for 60% of patients evaluated for this condition. Failure to distinguish a large overlying thymus gland from true cardiac enlargement occurred relatively frequently. Systemic hypertension was associated with renal disease, the most common cause in pediatrics. Stridor, which can be produced by vascular compression of the airways, was associated mainly with airway disease among our patients.

CONCLUSIONS

Although numerous conditions were evaluated by the cardiac consultation service, some were encountered more frequently and should be given emphasis in curricula developed for pediatric residency training programs. Future investigations will be needed to determine the effectiveness of acquiring skills for the diagnosis of cardiac symptoms and disease during pediatric residency.

ACKNOWLEDGMENT

I thank the fellows and attending physicians who helped staff the cardiology consultation service during the study period.

REFERENCES

7. Mangione S, Nieman LZ. Cardiac auscultation skills of internal medicine and family practice trainees: a comparison of diagnostic proficiency. JAMA. 1997;278:717–722

Downloaded from by guest on May 3, 2017
Conditions Leading to Pediatric Cardiology Consultation in a Tertiary Academic Hospital
Robert L. Geggel
Pediatrics 2004;114;e409
DOI: 10.1542/peds.2003-0898-L

Updated Information & Services
including high resolution figures, can be found at:
/content/114/4/e409.full.html

References
This article cites 34 articles, 12 of which can be accessed free at:
/content/114/4/e409.full.html#ref-list-1

Citations
This article has been cited by 4 HighWire-hosted articles:
/content/114/4/e409.full.html#related-urls

Subspecialty Collections
This article, along with others on similar topics, appears in the following collection(s):
Medical Education
/cgi/collection/medical_education_sub
Hospital Medicine
/cgi/collection/hospital_medicine_sub
Cardiology
/cgi/collection/cardiology_sub

Permissions & Licensing
Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
/site/misc/Permissions.xhtml

Reprints
Information about ordering reprints can be found online:
/site/misc/reprints.xhtml
Conditions Leading to Pediatric Cardiology Consultation in a Tertiary Academic Hospital

Robert L. Geggel

Pediatrics 2004;114:e409
DOI: 10.1542/peds.2003-0898-L

The online version of this article, along with updated information and services, is located on the World Wide Web at:
/content/114/4/e409.full.html