Unusual Manifestations of Patent Ductus Arteriosus in Infancy*

KENNETH CRUZE, M.D.,† LARRY P. ELLIOTT, M.D.,**
GEROLD L. SCHIEBLER, M.D.,** AND MYRON W. WHEAT, JR., M.D.†
Gainesville, Florida

The diagnosis of patent ductus arteriosus during infancy, although a common congenital malformation, is important for several reasons. It may enter into the differential diagnosis of those conditions associated with a continuous murmur or become complicated by congestive cardiac failure, and it is ordinarily amenable to surgical obliteration.** Some infants with a patent ductus arteriosus present with a clinical picture that is quite specific, having many of the classic features usually seen in the older patient. Other infants, however, have a clinical profile not conforming to the usual classic syndrome, the "atypical patent ductus arteriosus."

Certain unusual clinical features observed among six infants with isolated patent ductus arteriosus admitted to the University of Florida Teaching Hospital form the basis of this report. In addition, a

*Supported in part by Research Grant No. H-5407 from the National Institutes of Health, Public Health Service, Special Research Fellowship Grant No. HD 11,831, Heart Institute, National Institutes of Health, the Lisa Ann Levin Fund, and Developmental Physiology Training Program Grant 2A-5273.

From the Departments of Pediatrics** and Surgery,† College of Medicine, University of Florida.

Table 1—Pertinent Data—Seven Cases of Patent Ductus Arteriosus in Infancy

<table>
<thead>
<tr>
<th>Group</th>
<th>Case No.</th>
<th>Age (mo)</th>
<th>Sex</th>
<th>Surgery (S) or Necropsy (N)</th>
<th>Congestive Failure</th>
<th>Unusual Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>M</td>
<td>2.0 cm. PDA (S) larger than aorta</td>
<td>+</td>
<td>ECG and VCG showed isolated RVH (Fig. 1) with QRS axis +190° (Fig. 1) ECG shown QRS axis (−65°) resembling an endocardial cushion defect (Fig. 2)</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>5</td>
<td>M</td>
<td>2.0 cm. PDA (S)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>1</td>
<td>F</td>
<td>2.0 cm. PDA (N) Biliary Atresia</td>
<td>0</td>
<td>Murmur similar to VSD (Fig. 3) With C.F. classic continuous murmur of PDA</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>8</td>
<td>F</td>
<td>2.0 cm. PDA (S)</td>
<td>+</td>
<td>Murmur of mitral insufficiency (Fig. 4) Markedly enlarged LA on x-ray (Fig. 5)</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>10</td>
<td>F</td>
<td>7 mm. PDA (S)</td>
<td>0</td>
<td>Findings of coarctation of aorta, BP arms 100; legs 70. Strong brachials, weak femorals</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>8</td>
<td>F</td>
<td>2.0 cm. PDA (S) larger than aorta</td>
<td>0</td>
<td>With C.F. classic continuous murmur of PDA</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>33</td>
<td>F</td>
<td>2.5 cm. PDA (S)</td>
<td>0</td>
<td>No significant murmur (Fig. 6) Preoperatively: insignificant S.M., Loud D.M. (Fig. 7a) Postoperatively: loud S.M., Absent D.M. (Fig. 7b)</td>
</tr>
</tbody>
</table>

Key: + = present; 0 = absent; ECG = electrocardiogram; VCG = vectorcardiogram; BP = blood pressure (mm. Hg); LA = left atrium; VSD = ventricular septal defect; PDA = patent ductus arteriosus; RVH = right ventricular hypertrophy; D.M. = diastolic murmur; C.F. = congestive heart failure; S.M. = systolic murmur.

Copyright, 1963, by the American College of Chest Physicians

563
seventh case of a two-year-old child is included because of unusual auscultatory findings.

These seven cases were divided into three groups, depending on the type of unusual clinical feature which made us seriously question, or failed to suggest, the diagnosis of an isolated patent ductus arteriosus.

Group A includes two instances (Cases 1 and 2) in which the auscultatory findings suggested a patent ductus arteriosus, but the electrocardiogram and vectorcardiogram showed certain features which suggested the presence of an additional congenital malformation. Group B includes three instances (Cases 3, 4 and 5) in which the auscultatory-phonocardiographic findings simulated other common congenital malformations of the heart. Group C includes two instances (Cases 6 and 7) in which the auscultatory-phonocardiographic findings were unusual, and suggested no particular common congenital malformation.

A summary of the pertinent clinical data in our seven cases is given in Table 1.

CLINICAL OBSERVATIONS AND DISCUSSION OF UNUSUAL FEATURES

Group A

Case 1

A seven-week-old acyanotic boy with a weak cry was admitted with congestive cardiac failure. There was a systolic thrill maximal in the second to fourth left intercostal space. Auscultation showed a grade 4/6 systolic murmur maximal in the third to fourth left intercostal space at the sternal border, an accentuated pulmonic component of the second sound, a grade 2/6 decrescendo diastolic murmur maximal in the left subclavicular area, and a grade 2-3/6 mid-diastolic flow murmur at the apex. The peripheral pulses were bounding. Blood pressures (simultaneous flush technique) were 100 and 90 mm. Hg in the right arm, and right leg, respectively.

Roentgenologically there was increased pulmonary vascularity, biventricular hypertrophy, and left atrial enlargement. The electrocardiogram and vectorcardiogram showed isolated right ventricular hypertrophy with a mean QRS axis in the frontal plane of +190° (Fig. 1).

Although the auscultatory findings indicated a patent ductus arteriosus, the electrocardiographic findings were unusual for patent ductus arteriosus and suggested the presence of an additional cardiac malformation. In order to exclude an associated extracardiac anomaly, retrograde aortography was performed. A large patent ductus arteriosus and a normal aortic arch system were demonstrated.

Since operation, the infant has been asymptomatic. Only an insignificant grade 1/6 short systolic murmur remains and the electrocardiogram is evolving toward normal.

Comment: Electro-vectorcardiographic patterns of isolated right ventricular hypertrophy are a most unusual finding in the infant with isolated patent ductus arteriosus. This was noted only twice among 39 infants with patent ductus arteriosus studied by Krovetz and Warden.19 Why this

![Figure 1: Electrocardiogram and vectorcardiogram (Grishman cube method) in Case 1 showing isolated right ventricular hypertrophy.](image-url)
showed the changes commonly observed in defects of the endocardial cushion type. Because of this finding, it was felt preoperatively that the child might have an associated intracardiac malformation.

Although observed in other congenital anomalies,\textsuperscript{10,11} it is extremely rare for this electrocardiographic pattern to be present in an isolated patent ductus arteriosus. The only comparable case in the English literature is one reported by Ziegler.\textsuperscript{7}

In this case, the electrocardiographic pattern probably indicates an unusual degree of left ventricular hypertrophy, rather than an anomaly of the pathway of the bundle of His.\textsuperscript{12} This view was supported by the fact that postoperatively the QRS loop has shifted inferiorly, whereas in lesions of the endocardial cushion type, the QRS loop remains superiorly orientated.

**Group B**

**Case 3**

A 27-day-old underdeveloped, icteric girl was admitted because of progressive jaundice since birth and the recent onset of tachypnea. Blood pressure in the right arm was 170/70 and in the right leg 160/50 mm Hg. The peripheral pulses were bounding. A systolic thrill and a grade 4/6 regurgitant systolic murmur (Fig. 3) were heard maximally at the second to fourth left intercostal space at the sternal border. The two components of the second sound were narrowly split, and the pulmonic component accentuated. A grade 1/6 mid-diastolic flow murmur was noted at the apex. The electrocardiogram showed biventricular hypertrophy. Roentgenologically there was bi-

**Comment:** The unexpected finding in this case was an electrocardiogram which
ventricular hypertrophy, increased pulmonary vas-cosity and left atrial hypertrophy. The auscultatory findings were consistent with a defect in the ventricular septum.

Thirty-six hours after admission, the infant suddenly developed a severe bout of pulmonary edema. A repeat examination showed different findings. These included a systolic suprasternal notch thrill and a continuous crescendo-decres-cendo murmur and thrill maximal in the second left intercostal space. The child died six hours thereafter.

Examination at necropsy demonstrated a large patent ductus arteriosus and diffuse pulmonary lobular hemorrhage. Microscopic examination of the biliary tract showed a segmental biliary atresia just distal to the union of the cystic and common hepatic ducts.

**Comment:** This case has several unusual features. The initial auscultatory findings suggested a ventricular septal defect, a common occurrence in the infant with a large patent ductus arteriosus. When the infant developed severe pulmonary edema, however, the physical findings changed to those of a patent ductus arteriosus.

The clinical observation of pulmonary edema is worthy of reference since Keith, et al. have not observed this manifestation of cardiac failure in infants with a patent ductus arteriosus.

In an extensive review of infants with biliary atresia, associated anomalies were noted to be present in 10 to 15 per cent of the cases. In 30 cases of biliary atresia, Krovetz found six that had congenital heart defects. The most common associated cardiovascular anomaly was a ventricular septal defect. A patent ductus arteriosus in association with congenital biliary atresia was not observed, and thus this represents an unusual combination of congenital anomalies.

**CASE 4**

This eight-month-old girl was admitted for evaluation of a heart murmur and congestive...
cardiac failure present since six months of age. Examination showed the infant to have a weak, hoarse cry. Blood pressures (by the simultaneous flush technique) were 100 mm. Hg in the right arm and 80 in the right leg. The pulses were bounding. A systolic thrill and grade 4/6 regurgitant systolic murmur and a grade 3/6 diastolic flow murmur were heard maximally at the apex (Fig. 4). The systolic components were heard well at the lower left sternal border and left axilla. A prominent systolic ejection click was maximal in the fourth left intercostal space at the sternal border. The components of the second sound were accentuated and narrowly split. The electrocardiogram showed left atrial enlargement and left ventricular hypertrophy. Thoracic roentgenograms (Fig. 5) demonstrated biventricular enlargement, left atrial enlargement, and increased pulmonary vascularity.

Prior to right-sided cardiac catheterization, the diagnosis was mitral insufficiency and a ventricular septal defect. At cardiac catheterization the catheter was unexpectedly passed through a patent ductus arteriosus. The left-to-right shunt was determined to be confined to the pulmonary artery level and the pulmonary artery pressure was equal to the systemic pressure.

Since operation, the child has grown normally, her voice has returned to full strength, and she is completely asymptomatic. No thrill is palpable, but a grade 2/6 pansystolic regurgitant murmur of mitral insufficiency remains at the apex. The electrocardiogram and thoracic roentgenograms have shown a progressive decrease of left atrial enlargement and left ventricular hypertrophy.

**Comment:** Linde and Adams\(^{14}\) have described a triad of mitral insufficiency, patent ductus arteriosus and pulmonary hypertension. In each of their three cases, the mitral insufficiency was not obvious until after corrective surgery. In our case, however, the auscultatory - phonocardiographic findings suggested mitral insufficiency prior to surgery and these findings have persisted. As in their cases, however, the patient is doing well and there is no obvious functional impairment. The etiology of the mitral insufficiency is unknown, although Linde and Adams\(^{14}\) have suggested that (a) stretching of the atrioventricular annulus, (b) an embryologic relationship between patent ductus arteriosus and the mitral valve, (c) mitral valve disease secondary to rheumatic fever, (d) unrecognized subacute bacterial endocarditis, or (e) secondary endocardial fibroelastosis may play a role, alone or in combination.

**Case 5**

This girl, weighing only 3 lb. 3 oz. at birth, had a heart murmur noted at six weeks of age.

On examination at three months of age, the diagnosis of coarctation of the aorta was made on the basis of a grade 3/6 pansystolic murmur heard maximally in the back under the left scapula; a differential blood pressure (simultaneous flush method) of 100 mm. Hg in the right arm and 65-75 mm. Hg in the right leg; and bounding brachial pulses with very weak femoral pulses. The two components of the second sound were narrowly split and the pulmonic component accentuated.

The electrocardiogram showed left atrial enlargement and left ventricular hypertrophy. Thoracic roentgenograms showed cardiomegaly with normal pulmonary vascular markings.

At ten months of age, the child had a severe bout of bilateral pneumonitis associated with congestive cardiac failure. At this time, the classic auscultatory findings of a patent ductus arteriosus were present. There was no differential in blood pressure between the arms and legs. Operation was performed without incident.

Seven months postoperatively the child had no cardiovascular symptoms, normal blood pressures in the arms and legs with only a residual grade 2/6 short decrescendo murmur in the second and third left intercostal space anteriorly and posteriorly. The electrocardiogram showed resolution of the left ventricular hypertrophy.

**Comment:** This infant with a patent ductus arteriosus presented with auscultatory features that suggested another defect — a coarctation of the aorta.

Laubry and Routier\(^{18}\) noted in certain cases of patent ductus arteriosus that the femoral pulses were distinctly weaker than the brachial pulses, but not to the degree seen in true coarctation of the aorta. Our case seems to fit into this category.

The literature indicates that the classic murmur of a patent ductus arteriosus disappears when there is congestive heart failure,\(^{20,21}\) or severe pulmonary hypertension and a predominant right-to-left shunt.\(^{22}\) In this case, however, as in Case 3, the auscultatory findings prior to congestive failure simulated those of another congenital cardiac malformation, and the classic murmurs were not present until congestive failure supervened. Why this occurs
Upon examination, the heart was overactive. The peripheral pulses were described as "full." Blood pressures (simultaneous flush technique) were 90 mm Hg in the right arm and 105 in the right leg. Auscultation showed the first sound to be followed by a very prominent systolic ejection click and an insignificant grade 1/6 short decrescendo systolic murmur in the second-third left intercostal space at the sternal border (Fig. 6). The second sound appeared narrowly split with the pulmonic component markedly accentuated.

The electrocardiogram showed biventricular hypertrophy. Thoracic roentgenograms showed biventricular hypertrophy, a large pulmonary artery, increased pulmonary vascularity and left atrial enlargement.

Division and ligation of the patent ductus arteriosus was performed without incident after retrograde aortography demonstrated a large patent ductus arteriosus. Upon discharge, this infant was noted to have a grade 3/6 holosystolic murmur maximal at the apex and a grade 2/6 systolic ejection murmur over the pulmonary area. At the present time, she is asymptomatic and her voice has returned to normal. The electrocardiographic and roentgenologic signs of biventricular hypertrophy have decreased.

Comment: The unusual facet in this case was the presence of a very large patent ductus arteriosus with no significant murmur. This absence of a significant cardiac murmur led to delay in the referral of the child. The absence of a murmur in an infant with a patent ductus arteriosus still amenable to surgical correction is very unusual.  

Group C

Case 6

An eight-month-old girl was admitted because of a heart murmur noted on the second day of life, slow growth, poor feeding and the persistence of a hoarse weak cry.
This case fits very well into the clinical triad described by Linde and Adams in which mitral insufficiency is noted after surgery in cases of patent ductus arteriosus with pulmonary hypertension.

CASE 7

A two-year-old white girl was admitted because a heart murmur had been noted at the age of six months after an alleged "fainting spell with cyanosis." Later the child developed dyspnea and easy fatigability on exertion, squatted when tired, and was prone to upper respiratory infections.

The child had bounding peripheral pulses with a blood pressure in the right arm of 110/60 mm. Hg and in the right leg, 145/80 mm. Hg. A first sound was followed by a prominent systolic ejection click and a grade 2/6 short decrescendo systolic murmur maximal in the second and third left intercostal space. The second sound was markedly accentuated, single, and easily palpable. A grade 4/6 decrescendo diastolic murmur, extending throughout diastole, was maximal in the left subclavicular area and second to third left intercostal spaces (Fig. 7A).

Thoracic roentgenograms showed slight cardiomegaly, an enlarged pulmonary artery and aorta, increased pulmonary vascularity and mild left atrial enlargement. The electrocardiogram showed evidence of biventricular hypertrophy and left atrial enlargement.

During right-sided cardiac catheterization, the catheter was passed through a patent ductus arteriosus. The main pulmonary artery and thoracic aortic pressures were equal, 105/70 mm. Hg.

After operation, the child’s diastolic murmur disappeared although a grade 3-4/6 systolic flow murmur was present in the pulmonary area (Fig. 7B).

The child is now asymptomatic, although a grade 1/6 early systolic murmur and an accentuated pulmonic component of the second sound remain. Roentgenologically the heart has decreased in size and the electrocardiographic pattern of biventricular hypertrophy shows resolution toward normal.

Comment: The auscultatory findings in this case are very unusual since cases of patent ductus arteriosus with severe pulmonary hypertension usually show evidence of a systolic murmur only, without evidence of a diastolic murmur. This phenomenon has been shown to be correlated with pulmonary artery pressure. As the pulmonary artery pressure increases, the diastolic murmur tends to diminish or disappear—probably because flow through the patent ductus is diminished during diastole. Our case showed a converse situation. Only an insignificant systolic murmur was present preoperatively, with a very loud diastolic murmur as the most prominent auscultatory finding. No similar case was reported in the large series of patients with patent ductus arteriosus observed by Krovetz and Warden. This diastolic murmur may have been secondary to pulmonary insufficiency, flow across the patent ductus arteriosus in diastole, or both.

The prompt disappearance of the murmur after surgery suggests that the murmur may have been caused by blood flow across the ductus during diastole.

The other unusual aspect of this case is the history of squatting with exertion. This sign has not been previously associated with cases of patent ductus arteriosus in any of the standard references.

SUMMARY

Seven cases (five girls and two boys) with an isolated patent ductus arteriosus demonstrate a myriad of unusual clinical features early in life.

The auscultatory-phonocardiographic findings may be consistent with a patent ductus arteriosus, but the electrocardiogram may suggest a co-existing malformation. One electrocardiogram showed isolated right ventricular hypertrophy; the other mimicked the pattern usually associated with endocardial cushion defects—both highly unusual in cases with an isolated patent ductus arteriosus.

Other common congenital malformations may be suggested by the auscultatory-phonocardiographic findings, such as ventricular septal defect, mitral insufficiency, and coarctation of the aorta. Unemphasized previously is the finding that with the onset of cardiac failure the classic murmur of patent ductus arteriosus may become apparent.

The auscultatory-phonocardiographic findings may suggest no particular defect when an infant presents without a signi-
significant murmur or when an insignificant systolic murmur is accompanied by a loud pan-diastolic murmur.

These unusual observations make it mandatory to evaluate any symptomatic infant with a left-to-right shunt for a patent ductus arteriosus even though the clinical findings may not suggest this lesion. This diagnosis is probably made with the highest degree of certainty by retrograde aortography, utilizing a catheter positioned above the aortic valve. Such an examination also delineates lesions of the aortic sinuses, coronary arteries and the aortic arch system.

**Resumen**

En siete casos (cinco niñas y dos niños) con persistencia del conducto arterioso aislado se observaron innumerables características clínicas inusitadas.

Los hallazgos auscultatorios por fonocardiografía pueden ser compatibles con un conducto arterioso persistente, pero el ECG puede sugerir una malformación coexistente. Un ECG mostró hiperтроfia ventricular derecha aislada; el otro imitaba un cuadro generalmente asociado con los defectos del cojin endocardíco, ambos demostrados inusitados en casos de conducto arterioso persistente aislado.

Otras malformaciones congénitas comunes pueden ser sugeridas por los hallazgos de la fonocardiografía, tales como el defecto del tabique ventricular, la insuficiencia mitral y la coartación de la aorta.

No se ha enfatizado antes el hallazgo de que con el inicio de la insuficiencia cardíaca puede volverse aparente el soplo clásico del conducto arterioso persistente. Los hallazgos auscultatorios fonocardiográficos pueden no sugerir un defecto en particular cuando un niño presenta una falta de murmullo destacado o cuando éste es distólico e insignificante, acompañado de un intenso soplo pandiastólico.

Estas observaciones desacostumbradas hacen obligatorio investigar en un niño con una intercomunicación de izquierda a derecha, con motivo de un conducto arterioso persistente, aunque los hallazgos clínicos no sugieran esta lesión. Este diagnóstico probablemente es hecho con el mayor grado de certidumbre por la aortografía retrógrada usando un catéter colocado arriba de la válvula aórtica. Tal examen también delinea las lesiones de los senos aórticos, las coronarias y el sistema del arco aórtico.

**Resumen**

Dans 7 cas (5 filles et 2 garçons) avec persistance isolée du canal artériel ont été trouvés une quantité de signes cliniques inhabituels dans la première enfance.

Les trouvailles auscultatoires et phonocardiographiques peuvent évoquer un canal artériel persistant, mais l'électrocardiogramme peut suggérer une malformation coexistante. Dans un cas l'électrocardiogramme montrait une hypertrophie ventriculaire droite isolée; l'autre simulait des tracés habituellement rencontrés dans les défauts des couches enocardiocapaux—l'un et l'autre fait étant inhabituel dans les canaux artériels isolés.

L’auscultation et la phonocardiographie pourraient suggérer le diagnostic d’autres cardiopathies congénitales communes, telles qu’une communication interventriculaire, une insuffisance mitrale, et une coartation aortique. Une signe non indiqué jusqu’ici est le fait que, lorsque la défaillance cardiaque commence, le souffle clássique du canal artériel peut devenir apparent. L’auscultation et la phonocardiographie peuvent ne suggérer aucune cardiopathie particulière lorsque le nourrisson n’a pas de souffle net ou lorsqu’un souffle systolique insignifiant est accompagné par un gros souffle holodiastolique.

Ces signes inhabituels font que le diagnostic de persistance du canal artériel doit être évoqué chez tous les nourrissons ayant un shunt gauche-droite, même si les signes cliniques ne suggèrent pas cette lésion. On peut arriver à ce diagnostic avec un très haut degré de certitude par une aortographie retrograde, en utilisant un cathéter situé au-dessus des valvules aortiques. Un tel examen montre d’ailleurs également des lésions possibles des sinus aortiques, des artères coronaires et des arcs aortiques.

**Zusammenfassung**

Sieben Fälle (5 Mädchen und 2 Jungen) mit einem isolierten offenen ductus arteriosus wiesen eine Vielzahl ungewöhnlicher klinischer Eintümmlichkeiten in ihrem frühen Leben auf.

Die auskultatorisch-phonocardiographischen Befunde können vereinbar sein mit einem offenen ductus arteriosus, aber das Elektrokardiogramm kann für eine gleichzeitig bestehende Mißbildung sprechen. Ein EKG zeigte eine isolierte Hypertrophie des rechten Ventrüekels; das andere imitierte einen Typ, der gewöhnlich vor kommt bei endocardialen Defekten-beides in hohen Maße ungewöhnlich bei Fällen mit einem isolierten offenen ductus arteriosus.

Andere häufige congenitale Fehlbildungen kann man vermuten auf Grund der auskultatorisch-phonocardiographischen Befunde, so z.B. einen Ventrüekel-Septum-Defekt, Mitralinsuffizienz und Coarctation der Aorta. Nicht besonders hervorgehoben zu werden braucht die Feststellung, daß
PATENT DUCTUS ARTERIOSUS IN INFANCY

mit dem Einsetzen der Herzensuffizienz das klas-
sische Geräusch des offenen ductus arteriosus
zum Vorschein kommt.

Die auskultatorisch-phonoangiographischen
Befunde lassen keinen besonderen Defekt ver-
muten, wenn das Kind vorgestellt wird ohne ein
nennenswertes Geräusch, oder wenn ein unbe-
trächtliches systolisches Geräusch auftritt in Ver-
bindung mit auffallendem pandiastolischem Ge-
räusch.

Diese ungewöhnlichen Beobachtungen machen
es zur Auflage, jedes Kind mit verdächtigen
Symptomen und mit einem Links-Rechts-shunt
kritisch zu beurteilen auf einen offenen ductus
arteriosus, auch wenn die klinischen Befunde
diese Läsion nicht nahelegen. Diese Diagnose
läßt sich wahrscheinlich mit dem höchsten Grad
an Sicherheit stellen durch die retrograde Aorto-
graphie, wenn man ein oberhalb der Aorten-
klappe eingestellten Katheter verwendet. Eine
derartige Untersuchung stellt auch Veränderun-
gen der Aortensinus, der Coronar-arterien und
des Aortenbogensystems dar.

REFERENCES

1 ZIEGLER, R. F.: "The Importance of Patent
Ductus Arteriosus in Infants," Am. Heart J.,
43:553, 1952.

Ductus Arteriosus in the Absence of a
Continuous Murmur," Circulation, 6:110,
1952.

3 SCOTT, H. W., JR.: "Surgical Treatment of

4 ADAMS, P., JR., ADAMS, F. H., VARCO, R. L.,
Arteriosus in Infancy," Pediatrics, 12:664,
1953.

5 CLATWORTHY, H. W., JR. AND MACDONALD,
V. G., JR.: "Optimum Age for Surgical Clo-
sure of Patent Ductus Arteriosus," J.A.M.A.,

6 RUDOLPH, A. M., MAYER, F. E., NADAS, A. S.
AND GROSS, R. E.: "Patent Ductus Arteriosus:
A Clinical and Hemodynamic Study of 23 Pa-
tients in the First Year of Life," Pediatrics,

7 SCOTT, O. AND GEARY, G. F.: "Patent Ductus
Arteriosus in Infancy," Arch. Dis. Child., 35:

8 OCHSNER, J. L., COOLEY, D. A., McNAMARA,
D. G. AND KLINE, A.: "Surgical Treatment of
Cardiovascular Anomalies in 300 Infants
Younger than One Year of Age," J. Thor.

Ductus Arteriosus. An Analysis of 515 Sur-

10 KROZETZ, L. J., LESTER, R. G. AND WARDEN,
H. E.: "Diagnosis of Patent Ductus Arteriosus

11 BURCHELL, H. B., DU SHANE, J. W. AND BRAN-
DENBURG, R. O.: "The Electrocardiogram of
Patients with Aortoventricular Cushion Defects
(Defects of the Atriocentral Canal)," Am.

12 GRANT, R. P., SANDERS, R. J., MORROW, A. G.
AND BRAUNWALD, E.: "Symposium on Diag-
nostic Methods in the Study of Left to Right

13 NEUFELD, H. N., DU SHANE, J. W., WOOD,
E. H., KIRKLIN, J. W. AND EDWARDS, J. E.: "OrIGIN of Both Great Vessels from the Right
Ventricle. I. Without Pulmonary Stenosis,

14 NEUFELD, H. N., TITUS, J. L., DU SHANE,
J. W., BURCHELL, H. B. AND EDWARDS, J. E.: "Isolated Ventricular Septal Defect of the
Persistornt Common Atriocentral Canal Type,

Hypertension Simulating Ventricular Septal
Defect; Diagnostic Criteria in Ten Surgically

16 KEITH, J. D., ROWE, R. D. AND VLAD, P.: Heart
Disease in Infancy and Childhood, Mac-

II. Analysis of the Therapeutic Problem,

18 LINDE, L. M. AND ADAMS, F. H.: "Mitral In-
sufficiency and Pulmonary Hypertension Ac-

19 LAUBRY, C. AND ROUTIER, D, quoted in DON-
ZELOT, E. ET D'ALLAINES, F. in Truite des
Cardiopathies Congenitales, Masson et Cie,

20 KEYS, A. AND SHAPIRO, M. J.: "Patency of the
Ductus Arteriosus in Adults," Am. Heart

and its Surgical Treatment," Brit. Heart J.,
7:1, 1945.

22 SHEPHERD, J. T., WEIDMAN, W. H., BURKE,
E. C. AND WOOD, E. H.: "Hemodynamics in
Patent Ductus Arteriosus Without a Murmur,

23 KEITH, J. D., ROWE, R. D. AND VLAD, P.: Heart
Disease in Infancy and Childhood, Mac-

24 TAUSIG, H. B.: Congenital Malformations of
the Heart, Vol. II. Specific Malformations,

25 NADAS, A. S.: Pediatric Cardiology, W. B.