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IN THIS ISSUE

MEDICAL MEETINGS

EPIC-SEC (Emory Practical Intervention Course Southeastern Consortium)
Apr. 19-21, 2018; Atlanta, GA USA
www.epicsec.org

SCAI: 2018 Scientific Sessions
Apr. 25-28, 2018; San DIego, CA USA
www.scai.org/SCAI2018/

52nd Annual Meeting of the AEPC
May 9-12, 2018; Athens, Greece
http://www.aepc2018.org

International PDA Symposium
May 18-19, 2018; Memphis, TN USA
https://pdasymposium.org

Effective Prenatal Screening of CHD
May 31 – Jun. 1, 2018; London, UK
rbht.nhs.uk/healthprofessionals/clinical-departments/paediatrics/morphology/prenatal-screening-chd

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The Role of Echocardiography in the Evaluation of Preterm Infants with Patent Ductus Arteriosus

By P. Syamasundar Rao, MD

Introduction

Ductus arteriosus is a vascular structure that connects the main pulmonary artery with the descending thoracic aorta. In the fetus, the ductus arteriosus diverts deoxygenated blood from the pulmonary artery into the descending aorta and from there to the placenta for oxygenation.[1,2] It closes spontaneously at birth,[1,2] and is considered patent if it persists beyond 72 hours of life.[3] The incidence of Patent Ductus Arteriosus (PDA) is 0.05% in full-term infants,[4,5] and constitutes 10% of all Congenital Heart Defects (CHD). The incidence of PDA is high in preterm babies; the earlier the gestational age, the higher the incidence.[3-6] The ductus remains open in 90% of babies born at 24 weeks gestation, in 80% of babies born between 25 to 28 weeks gestation and in 10% of infants born between 30 and 37 weeks gestation.[6] The patency rates are also related to birth weight; 80% in babies weighing less than 1,200g and 40% in infants weighing less than 2,000g have PDAs.[4] The adverse effects of PDA in preterm babies have been addressed in previous reviews.[4,5,7,8] The clinical, roentgenographic and biomarker profiles are helpful in evaluating the significance of PDA in the premature; however, echocardiography appears to be the prime modality for detection and quantification of PDA in preterm infants. The purpose of this paper is to review the role of Echo-Doppler studies in the assessment of PDA in the premature infants.

"The incidence of PDA is high in preterm babies; the earlier the gestational age, the higher the incidence.[3-6] The ductus remains open in 90% of babies born at 24 weeks gestation, in 80% of babies born between 25 to 28 weeks gestation and in 10% of infants born between 30 and 37 weeks gestation.[6]"

Echocardiography

An echocardiogram is commonly performed in conjunction with Doppler studies and may be called an Echo-Doppler study. Such studies are recommended if there is a clinical suspicion of PDA. Indeed, it may be considered the investigative procedure of choice for diagnosis and quantification of PDA. An Echo-Doppler study is also useful in excluding any congenital cardiac defects. Rarely, a question of aortic coarctation may be raised, and most of the time can be

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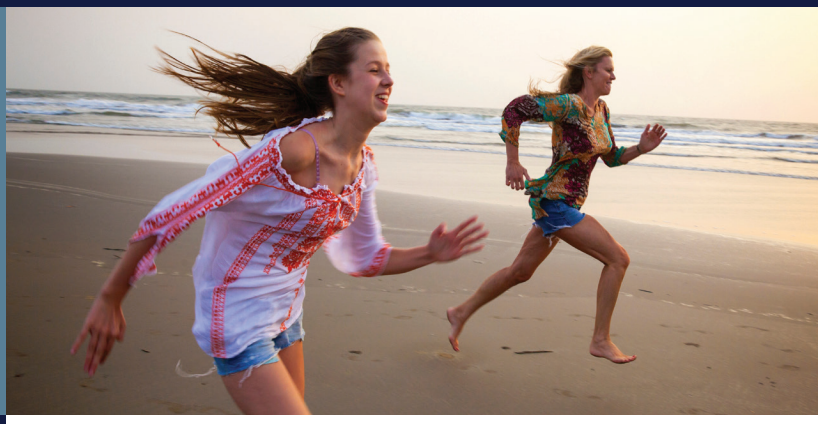

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- Severe RVOT obstruction, which cannot be dilated by balloon
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Potential device-related adverse events that may occur following device implantation include the following: stent fracture,* stent fracture resulting in recurrent obstruction, endocarditis, embolization or migration of the device, valvular dysfunction (stenosis or regurgitation), paravalvular leak, valvular thrombosis, pulmonary thromboembolism, hemolysis.

*The term "stent fracture" refers to the fracturing of the Melody TPV. However, in subjects with multiple stents in the RVOT it is difficult to definitively attribute stent fractures to the Melody frame versus another stent.

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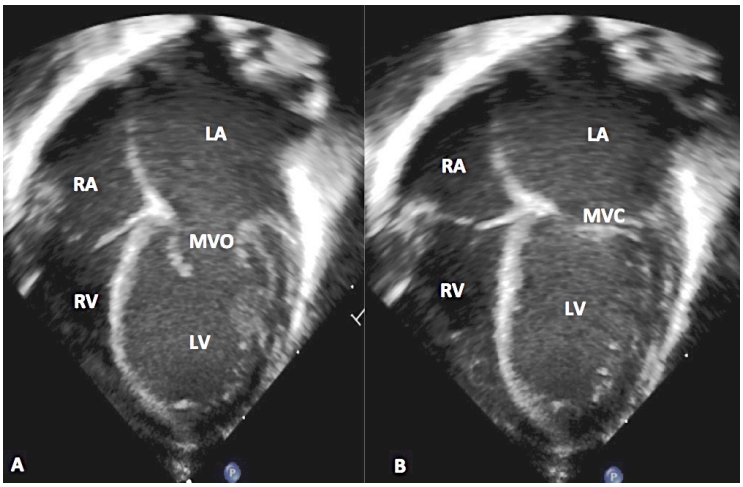

Figure 1. Echocardiographic frames from an apical four-chamber view demonstrating enlarged left atrium (LA) and left ventricle (LV). The mitral valve (MVO) is open in A and closed (MVC) in B. But, this enlarged LA and LV appearance is subjective. RA, right atrium; RV, right ventricle.

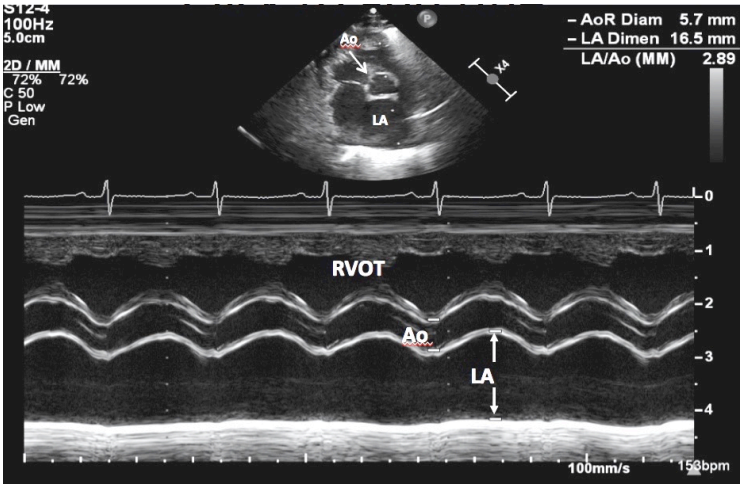

Figure 2. M-mode tracing in the parasternal short axis view demonstrating measurements of the aorta (Ao) and left atrium (LA) (arrows). Note that the LA/Ao ratio is increased (2.89:1). RVOT, right ventricular outflow tract.

confirmed/excluded by carefully reviewing the 2-dimensional (2D) and color, pulsed and continuous wave Doppler recordings with occasional need for angiography.[9] Echo-Doppler studies along with clinical data are useful in assessing the severity of PDA, including identification of hemodynamically significant Patent Ductus Arteriosus (hsPDA), which in turn help in managing the premature babies.[4,10-12]

Echo-Doppler Protocol

Two-dimensional (2D), M-mode and Doppler examination is performed in parasternal long and short axis, apical four- and two-chamber, subcostal and suprasternal notch views. Pulsed, continuous wave and color Doppler in multiple views should be recorded with particular attention to the definition of the size of the PDA and its hemodynamic effects. Recording maximal Doppler flow velocity magnitudes across the ductus is also undertaken. Doppler recordings that are useful in estimation of pulmonary arterial pressures should also be made. Finally, recording the patterns of descending aortic diastolic flow should also be undertaken in order to demonstrate normal anterograde diastolic flow, absent diastolic flow or retrograde diastolic flow, as the case may be. Important aspects germane in the evaluation of PDA will be reviewed.

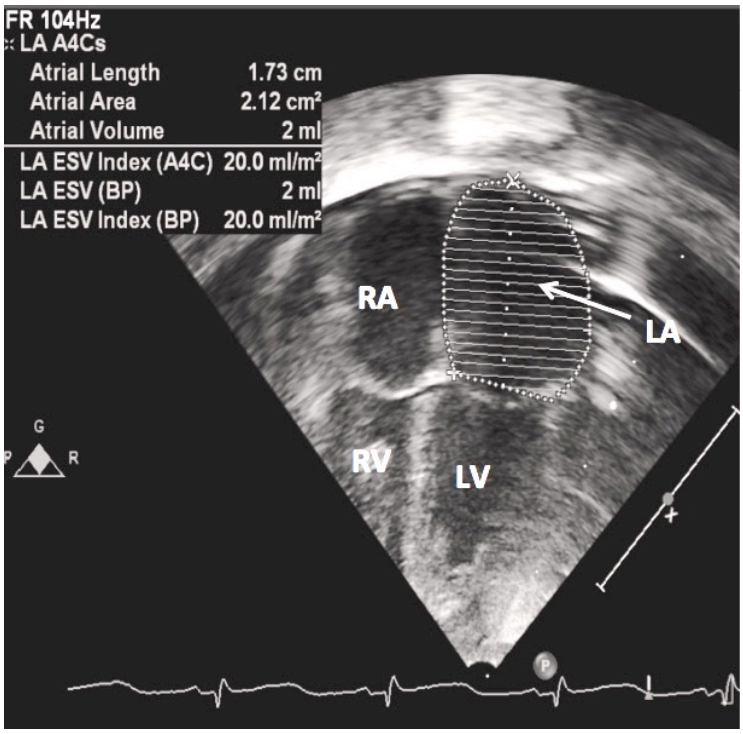

Figure 3. Echocardiographic frames in an apical four chamber view showing mapping of the left atrial (LA) area. While the calculations are not difficult to make (insert to the left upper corner), there are no established normal values for several preterm infant groups. LV, left ventricle; RA, right atrium; RV, right ventricle. The LA is also mapped in apical two-chamber view, but is not shown in the figure.

Left Atrium

The left atrial (LA) size may be subjectively estimated in an apical four-chamber view (Figure 1), but such an evaluation is not optimal. The size of the LA may be measured on M-mode recording in parasternal short axis view as shown in Figure 2; this may be compared with normal standards. However, the normal values for several weight categories in the preterm infants have not been set up. The left atrial volume may be estimated using the biplane area-length method in apical 4-chamber (Figure 3) and apical 2-chamber views. But again, normal values do not exist for some weight categories in the premature infants. The LA to the aortic root (LA/Ao) ratio (Figure 2) was shown to be useful in measuring the degree of shunting across the PDA.[13] LA:Ao ratio is less than 1.2:1 in a normal infant. In small PDAs, this ratio is between 1.2:1 and 1.4:1. In moderate-sized PDAs, the ratio is likely to be between 1.4:1 and 1.6:1 while in large PDAs, the ratio is expected be ≥1.6. While these ratios are usually dependable, false positives, as seen in babies with mitral valve insufficiency, and false negatives may occur in infants in whom fluid restriction has been undertaken.

Left Ventricle

The size of the left ventricle (LV) is recorded in parasternal long- and short-axis views (Figure 4) and LV internal dimension in end-diastole (LVIDd) and systole (LVIDs) are measured. These recordings are made at the tips of the mitral valve to ensure comparison with established norms. Normal values have not been established for some weight categories, and in such cases, visual estimate as in Figure 1 may be helpful.

Left Ventricular Function

In the past, a number of echocardiographic methods have been utilized to evaluate the function of the LV; these were reviewed

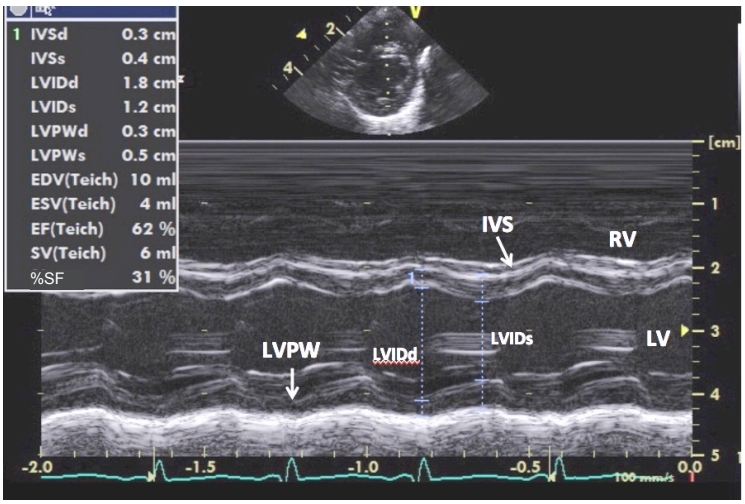

Figure 4. Echocardiographic frames from the parasternal short axis view demonstrating the left ventricular (LV) internal dimension in end-diastole (LVIDd) and systole (LVIDs). These measurements are used to calculate shortening fraction (%SF) as well as other parameters as indicated in the insert. IVS, inter-ventricular septum, LVPW, left ventricular posterior wall, RV, right ventricle.

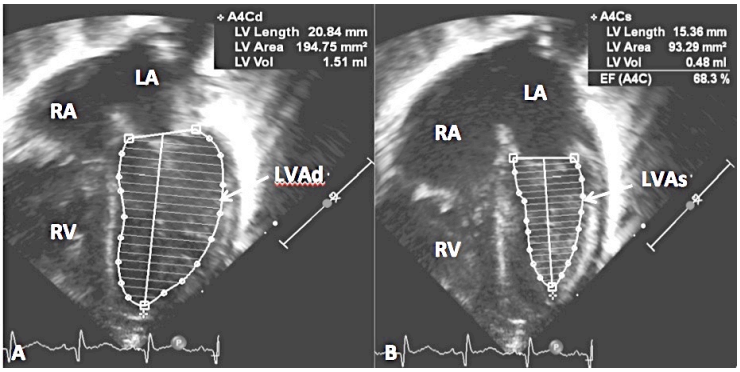

Figure 5. Echocardiographic frames from an apical four-chamber view demonstrating measurement of left ventricular area in diastole (LVAd) and in end-systole (LVAs) respectively in A and B. The area shortening of the LV is calculated using Simpson's rule (B). The LV area shortening is 68% (see insert in B); normal values are above 50%. LA, left atrium; RA, right atrium; RV, right ventricle.

elsewhere.[14-16] LV shortening fraction using M-mode echo (Figure 4) and Simpson's LV area shortening on 2D echocardiogram (Figure 5) are useful techniques in both the term and preterm neonate.

LV Shortening Fraction LV shortening fraction (Figure 4) was described in the early 1970s as a useful echo technique to assess LV function.[17] It is a commonly used technique and is useful for rapid estimation of global LV systolic function. It may be derived as follows:

$$SF = [(LVIDd - LVIDs)/ LVIDd] 100$$

Where SF is shortening fraction, LVIDd is left ventricular internal dimension in end-diastole and LVIDs is left ventricular end-systolic dimension.

The SF is independent of age and heart rate, but is load-dependent. The typical value is 33% ± 5%. In infants less than 5 days of age, and those with increased right ventricular systolic pressure, flattened interventricular septum may make the shortening fraction less reliable.

LV Area Shortening Another technique that is valuable in both the full term and premature babies[18] is area shortening of the LV using

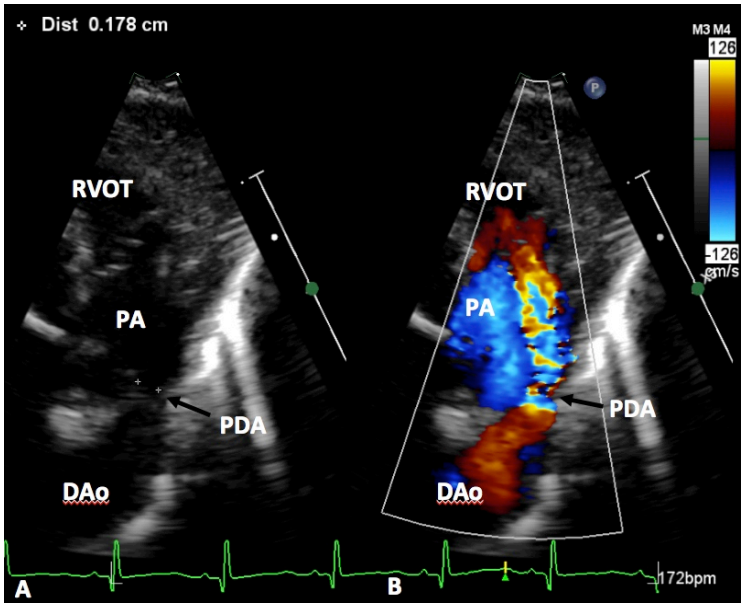

Figure 6. Echocardiographic frames from the parasternal short axis view demonstrating measurement of minimal diameter of the PDA. The color flow signal in B is deleted and 2-dimentional (2D) minimal ductal diameter measured in A. DAo, descending aorta; PA, pulmonary artery; RVOT, right ventricular outflow tract.

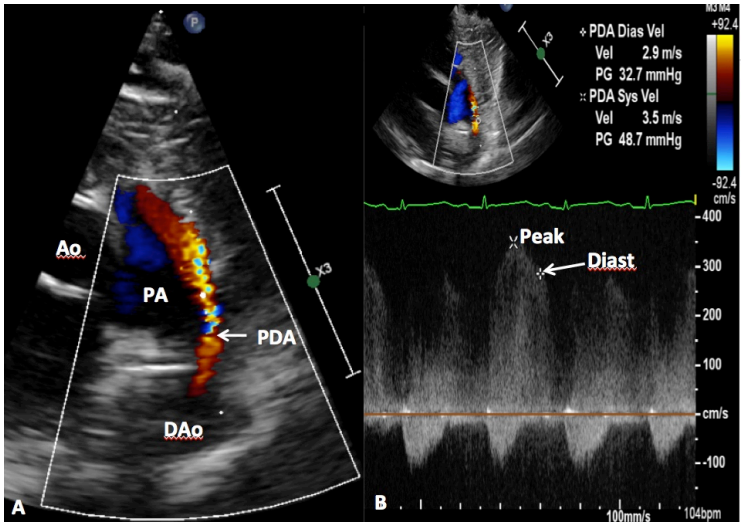

Figure 7. A. Echocardiographic frame from the parasternal short axis view illustrating PDA with left to right shunt. B. Continuous wave Doppler recording across the PDA demonstrates high Doppler velocity suggesting relatively low pulmonary artery pressure. Diastolic (Diast) (arrow) velocity (2.9 m/s) is used to calculate pulmonary artery (PA) diastolic pressure (See the text for further discussion). Ao, aorta; DAo, descending aorta.

Simpson's rule (Figure 5); the LV area shortening may be calculated:

$$AS = (LVAd - LVAs)/ LVAd$$

Where AS is area shortening, LVAd is LV area in diastole and LVAs is LV area in systole.

This technique of assessment of LV function is helpful, even if flat to paradoxical ventricular septal motion is present or LV dysynergy exists. But, it is also load-dependent. The standard norms are 50% to 60%.

PDA Diameter

Color flow Doppler imaging is a useful technique in identifying the PDA and in determining its size. It is also useful in estimating the degree of ductal shunting. Color Doppler is exceptionally sensitive and may detect even a tiny PDA with color flow image appearing in the main pulmonary artery near the origin of left pulmonary artery. Because the degree of left-to-right shunt across the PDA is mainly determined by its narrowest diameter, minimal ductal diameter determined by angiography[19] has been used to categorize the sizes of the ductus. But, it has been observed that echocardiographic assessment of angiographic minimal ductal diameter is not precise.[20] However, echo is the technique of clinical relevance for the preterm infants. Color flow Doppler imaging of the ductus should be performed in multiple views in order to identify narrowest diameter; the color is deleted (Figure 6) and 2D diameter measured. Both the color flow and 2D diameters are used to measure the ductal size. Illustrations of small (Figure 7), medium (Figure 8) and large (Figure 9) PDAs are shown. The higher the Doppler flow velocity, the lower is the pulmonary artery pressure and smaller the ductus.

Studies in the mid-1990s suggested that the narrowest PDA diameter larger than 1.5 mm is seen with a later need for PDA treatment (sensitivity of 81% and a specificity of 85%).[21,22] In a study published in 2013, a PDA diameter of 1.5 mm or larger was also found to predict development of symptomatic ductus with high sensitivity (91%) and specificity (100%).[23] A more recent study indicated that PDA size ≥2 mm and peak-systolic-to-end-diastolic Doppler velocity ratio ≥ 2 on Days 3 and 7 of Life are seen with need for PDA treatment subsequently.[24] Because the size of the patient and the extent of maturation differ, the absolute ductal diameter may not, by itself, be a dependable marker of its size. Therefore, normalization of ductal size, for example, mm/Kg or mm/BSA [body surface area] may help establish significance of ductal diameter. A PDA diameter of 1.4 mm/kg was indicative of significant ductus in one study;[25] however, the number of babies examined in this paper was small. The ratio of minimal ductal diameter to width of the left pulmonary artery at its origin (PDA: LPA ratio) was recommended as a method of quantification of the size of the ductus;[26] this ratio is <0.5 in small PDAs, between 0.5 and 1.0 in moderate PDAs and ≥1.0 in large PDAs.

Pulmonary Artery Pressure

Echo-Doppler studies are valuable in estimating the pulmonary artery pressures in most infants; these methods were examined in detail elsewhere.[27] Doppler jets across tricuspid and pulmonary valve should be recorded in multiple views in all infants; the Doppler jet velocity (V) is used to calculate pressure difference (ΔP) between the cardiac chambers by using a modified Bernoulli equation:

Gradient (ΔP) = 4V2

Simultaneous measurement of arm systolic blood pressure is useful in assessing the magnitude of elevation of pulmonary artery pressure.

Tricuspid Insufficiency Jet Physiologic tricuspid insufficiency is present in most babies; this Doppler signal should be recorded in multiple views. The maximum peak velocity should be noted. The right ventricular (RV) outflow tract is examined to exclude pulmonary stenosis. If there is no RV outflow tract obstruction, the RV and pulmonary artery systolic pressures may be assumed to be similar. The peak velocity of the tricuspid regurgitant jet (V) is utilized to estimate pulmonary artery systolic pressure (Figure 10):

PAP = RVP = 4V2 + 5 mmHg

Where PAP is pulmonary artery systolic pressure, RVP is right ventricular systolic pressure and V is regurgitant tricuspid jet

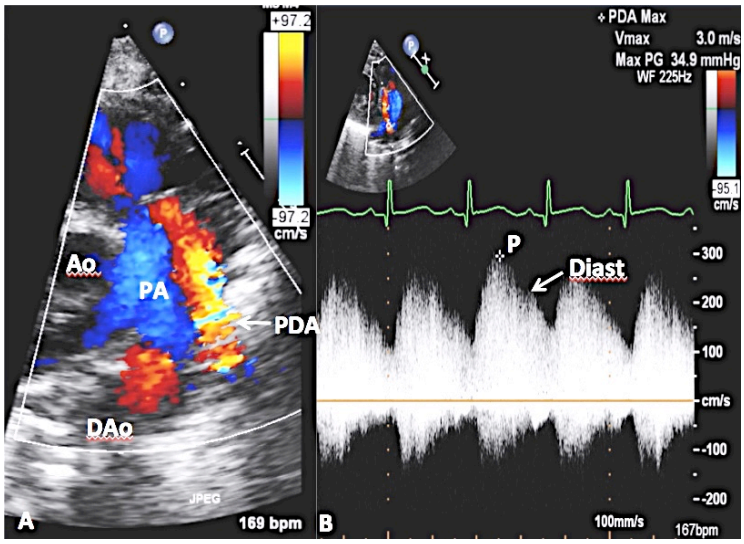

Figure 8. This figure is similar to Figure 7 from a different preterm baby demonstrating a moderate sized PDA. The estimation of pulmonary artery (PA) diastolic (Diast) (arrow) pressure may be made in a manner similar to that shown in Figure 7. The estimated PA pressure is likely to be higher than that shown in Figure 7. Ao, aorta; DAo, descending aorta; P, peak velocity.

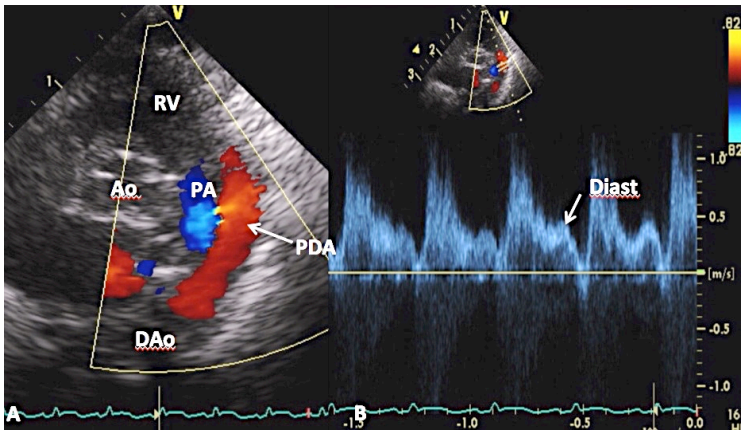

Figure 9. This figure is also similar to Figures 7 and 8 from a different preterm baby showing a large PDA. The estimation of pulmonary artery (PA) diastolic (Diast) (arrow) pressure may be similar to Figures 7 and 8 and is likely to be higher than those in Figures 7 and 8. Note laminar flow across the PDA. This along with low PDA Doppler velocity (< 0.5 m/s) indicates near systemic PA pressures. Ao, aorta; DAo, descending aorta; RV, right ventricle.

velocity. The pressure in the right atrium is assumed to be 5 mmHg. Recording adequate envelope of the tricuspid insufficiency jet is vital to give confidence to this method of PA pressure determination.

Pulmonary Insufficiency Jet. Physiologic pulmonary insufficiency jet (Figure 11) may be used to estimate pulmonary artery diastolic pressure:

PA diastolic pressure = 4V2 + 5 mmHg

Where PA is pulmonary artery and V is pulmonary insufficiency jet velocity. Right ventricular end-diastolic pressure is assumed to be 5 mmHg.

Patent Ductus Arteriosus Jet. As mentioned in the preceding section, PDA Doppler velocity should be recorded in multiple views;

this helps in assessing the pulmonary artery diastolic pressure (Figures 7, 8 and 9):

PA pressure = BP – 4V2

Where PA is pulmonary artery, BP is arm blood pressure (or pressure recorded via an indwelling umbilical artery catheter) and V is PDA flow velocity.

If the PDA Doppler velocity is high (Figure 7), the PA pressure is likely to be low; whereas, a low PDA velocity (Figure 9) implies high PA pressure. If the PDA Doppler velocity is mild to moderately elevated the PA pressure is mildly increased (Figure 8).

If no adequate recording of Doppler jets in the right heart could be secured, indirect signs may be used: right atrial and right ventricular dilatation, right ventricular hypertrophy, pulmonary artery dilatation and flattening of the interventricular septum may indicate increased PA pressures, but the degree of elevation may not be predicted. "Spike and dome" appearance of the PA Doppler flow velocity curve and short acceleration time (<100 msec) indicate elevated PA pressure.

Descending Aortic Flow Pattern

The finding of retrograde descending aortic flow in early diastole with continuation into the diastole was noted in babies who had aortic run-off lesions including PDA in early 1980s.[30] In one study it was suggested that absent anterograde diastolic or retrograde diastolic flow in the descending aorta in an infant with minimal PDA diameter ≥1.5 mm may signify hsPDA.[31] The pattern of descending aortic diastolic flow may also indicate the amount of left-to-right shunt:[26]

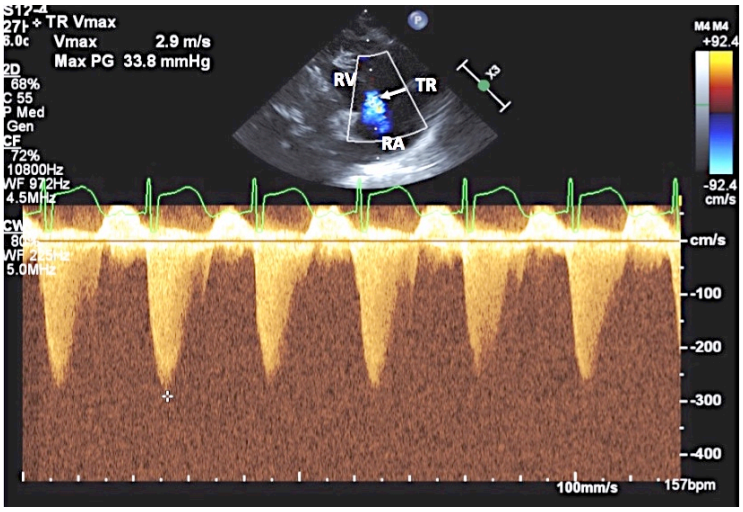

Figure 10. Two-dimensional and color Doppler recording to demonstrate tricuspid regurgitent (TR) jet (top) along with continuous wave Doppler recording of TR jet (bottom) is shown. This is used to calculate the pulmonary artery systolic pressure: peak velocity of 2.9 indicates 34 mmHg gradient (by modified Bernoulli equation) across the tricuspid valve. To this an assumed right atrial (RA) pressure of 5 mmHg is added to calculate the pulmonary artery pressure, assuming that there is no pulmonary outflow tract obstruction (see the text for details). RV, right ventricle.

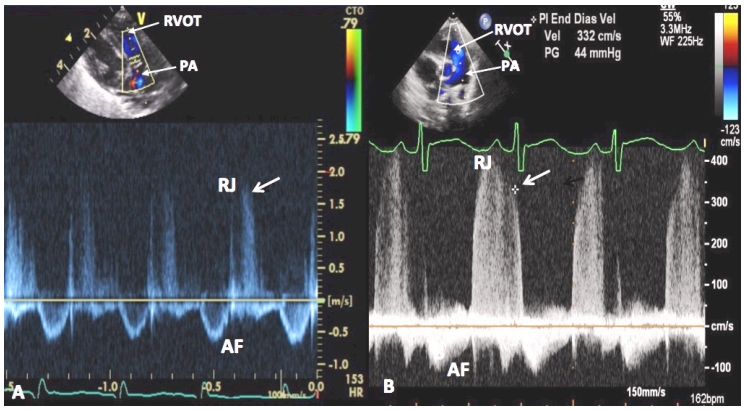

Figure 11. A. Pulse Doppler recording in the parasternal short axis view as shown in the insert at the top demonstrating pulmonary valve regurgitant jet (RJ). This is low (arrow) (1.6 m/s), suggesting low pulmonary artery pressure (See the text for further discussion). B. Continuous wave Doppler recording in the parasternal short axis view as shown in the insert at the top exemplifying high pulmonary valve RJ (arrow) (3.3 m/s). This high velocity indicates high pulmonary artery pressure (See the text for further clarification). AF, anterograde pulmonary flow. PA pulmonary artery, RVOT, right ventricular outflow tract.

normal anterograde diastolic flow - ratio of pulmonary to systemic blood flow (Qp:Qs) of 1, absent diastolic flow - Qp:Qs of 1.3, and retrograde diastolic flow - Qp:Qs of 1.7 or greater. Illustrations of normal anterograde (Figure 12) and abnormal retrograde (Figure 13) diastolic flow patterns are shown.

Summary of Echo-Doppler Findings of PDA (Table)

The LA, LA:Ao ratio (<1.4:1) and LV are likely to be normal in size in small PDAs, and the LV function is normal. The LA and LV are dilated and LA:Ao ratio is increased (>1.6:1) in large PDAs. In the beginning, the LV function is normal or hyper-dynamic, and with time, LV function may deteriorate resulting in increased LV end-diastolic and LA pressures with consequent deterioration of the respiratory status. In moderate PDAs, the values are in the middle with moderate dilatation of LA (LA:Ao ratio of 1.4 to 1.6) and LV. In most, the LV function is preserved.

The minimal ductal diameter is small with high Doppler velocity across it in small PDAs (Figure 7); whereas, the minimal ductal diameter is large with low Doppler velocity across the ductus in large PDAs (Figure 9). These values are in the middle in moderate-sized PDAs (Figure 8). In small PDAs the PA pressures are usually normal while they are likely to be high in large PDAs. While the above assertions are largely correct, the PA pressures also depend upon the degree of pulmonary parenchyma disease. In addition, in very low birth weight infants, the PA pressure may not be elevated parallel to the Pulmonary Parenchymal Disease because of under-developed pulmonary vasculature in the premature.

Finally, normal anterograde descending aortic diastolic flow is seen in small PDAs (Figure 12); whereas, the descending aortic diastolic flow

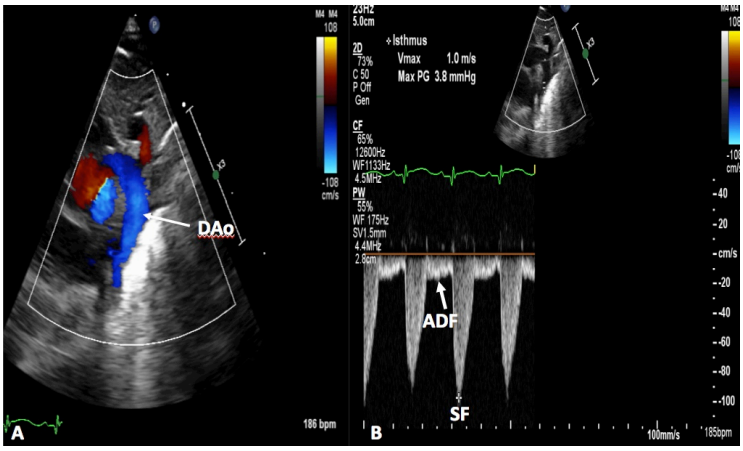

Figure 12. A. Echocardiographic frame from a suprasternal notch view illustrating laminar flow in the descending aorta (DAo) in a premature infant with a small ductus (not shown). B. Continuous wave Doppler recording in the same infant shows normal systolic flow (SF) (*) and normal anterograde diastolic flow (ADF) in the DAo; the diastolic flow is seen below the baseline.

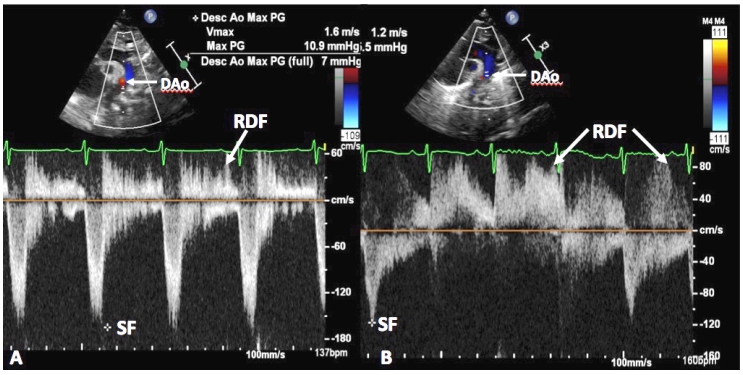

Figure 13. Doppler recordings from a suprasternal notch view demonstrating retrograde diastolic flow (RDF) in the descending aorta (DAo) in two different premature babies (A & B respectively) with large PDA indicating that there is likely to be hemodynamically significant PDA. Systolic flow (SF) (*) suggests no evidence for obstruction.

is either retrograde (Figure 13) or no normal anterograde descending aortic diastolic flow is seen in large PDAs.

It should be known that no single parameter reviewed in the preceding paragraphs is correct by itself. A mixture of the above discussed parameters is likely to be useful in quantifying the significance of the ductus. The PDA may be labeled as small when the minimal PDA diameter is ≤1.4 mm, LA:Ao ratio ≤1.4:1 and the descending aortic diastolic flow is anterograde, whereas a PDA diameter ≥2.0 mm and LA:Ao ratio ≥1.6 along with retrograde descending aortic diastolic flow may signify a large or hsPDA. Values in-between indicate moderate PDA (Table).

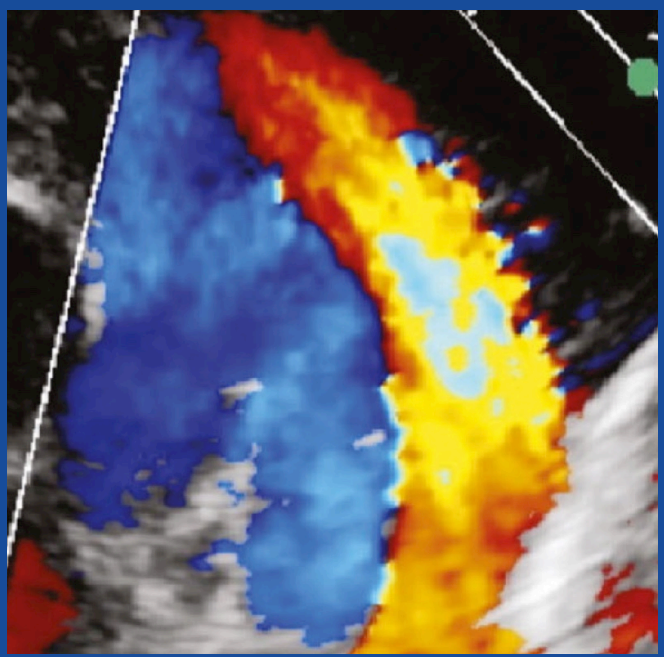

Table. Echo-Doppler Characteristics of Patent Ductus Arteriosus in the Preterm Infant			
Parameter	**Small PDA**	**Moderate PDA***	**Large PDA***
Size of the Left Atrium	Normal	Mildly dilated	Moderate to severely dilated
LA:Ao Ratio	≤1.4:1	1.4 to 1.6	≥1.6
Size of the Left Ventricle	Normal	Mildly dilated	Moderate to severely dilated
Systolic Function of the Left Ventricle	Normal	Normal	Normal, hyper-contractile or diminished function
Estimated Pulmonary Artery Pressure	Normal	Mildly elevated	Moderate to severely elevated
Minimal Diameter of the PDA	≤1.4 mm	1.4 to 2.0 mm	≥2.0 mm
Doppler Velocity across the PDA	High (3.0 to 4.0 m/s)	~ 2.0 m/s	Low (~1.0 m/s)
Descending Aortic Doppler Flow Velocity Pattern	Normal anterograde flow (Figure 12)	Normal anterograde flow (Figure 12)	Normal or absent anterograde flow or presence of retrograde flow (Figure 13)

** Likely to be a hemodynamically significant Patent Ductus Arteriosus (hsPDA) if associated with deterioration of respiratory function or fail to wean from respiratory support at a normal rate.*

Ao, aorta; LA, left atrium; mm, millimeter; m/s, meters per second; PDA, Patent Ductus Arteriosus; PA, pulmonary artery.

Severity of PDA- Hemodynamically Significant (hsPDA) vs. Non-Significant PDA (PDA)

Hemodynamically significant PDA (hsPDA) has variously been defined.[4,10,32] The available studies utilized diverse criteria to define hsPDA which makes it hard to compare the outcomes of one study with those of others. Clinical implication of PDA and stratification as hsPDA vs. not significant PDA is usually based on: clinical (presence of bradycardia or apnea, feeding intolerance, oxygenation difficulty, need for respiratory support, systemic hypotension, oliguria with increased plasma creatinine, need for inotropic agent(s) and others), roentgenographic (cardiomegaly and increased pulmonary vascular markings) and echocardiographic (LA size, LA:Ao ratio, left ventricular size and function, minimal ductal diameter, Doppler flow characteristics across the ductus, and flow pattern in the descending aorta) features.[12,32]

A medium to large-sized ductus, as defined in the Table. in preterm babies who deteriorate in their clinical status, needing more intense ventilatory management, and requiring more frequent diuretic administration, or babies who fail to progress in efforts to wean off respiratory support may be considered to have hsPDA.[8]

Investigations attempting to characterize hsPDA will be reviewed. Babies weighing less than 1,500g needing mechanical ventilation in the first 30 hours of life and a PDA diameter of 1.5 mm or more have a high probability of requiring future management for PDA; the sensitivity was 83% with a specificity of 90%.[22] In a more recent, but retrospective study of 29 infants less than 29 weeks gestation, indicated that infants with a minimal ductal diameter more than 1.5 mm between 6-48 hours of life are likely to become hsPDA; this was with a sensitivity of 91% and a specificity of 100%.[23] Babies with LA:Ao ratio greater than 1.5 on echocardiography after first Day of Life are likely to exhibit hsPDA later, with 88% sensitivity and 95% specificity.[10,11] Retrograde diastolic descending aortic flow or absence of anterograde diastolic flow may suggest hsPDA when associated minimal ductal diameter is ≥ 1.5 mm.[28] The serum brain natriuretic peptide (BNP) levels also seem to be helpful in predicting hsPDA; BNP above 70 pg/mL imply hsPDA with a high sensitivity (92.9%) and a modest specificity (73.3%).[33] The BNP levels return to normal after successful treatment.[33] Finally, low perfusion index (PI) with reduced perfusion to lower extremities secondary to large left-to-right shunt across the PDA may identify hsPDA.[34]

Summary and Conclusions

The ductus arteriosus is a muscular structure that connects the main pulmonary artery with the descending thoracic aorta. In the fetal circulation, the ductus diverts less oxygenated blood from the pulmonary artery into the descending aorta, umbilical arteries and placenta for oxygenation. The ductus closes spontaneously shortly after birth, but persistence patency beyond 72 hours after birth is defined as a PDA. The ductal patency is more frequent in the preterm than in the term babies; the lower the gestational age, the higher the incidence. The PDA causes left-to-right shunt, mainly proportional to the minimal ductal diameter. Such a shunt may cause pulmonary and cardiac compromise. While clinical features, chest roentgenogram and serum BNP levels may help identify a PDA, hemodynamically significant PDAs may be best detected and quantitated by echo-Doppler studies. The size of the LA, LA:Ao ratio, the diameter of the LV, estimated pulmonary artery pressures, minimal ductal diameter, Doppler flow velocity across the PDA and descending aortic Doppler flow pattern help us to identify the size of the PDA (Table). When a medium to large PDA is present along with respiratory compromise, a hemodynamically significant PDAs may be diagnosed.

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P. Syamasundar Rao, MD
Professor & Emeritus Chief of Pediatric Cardiology
University of Texas-Houston McGovern Medical School
Children's Memorial Hermann Hospital
6410 Fannin, UTPB Suite #425
Houston, TX 77030 USA
Tel: 713.500.5738; Fax: 713.500.5751
P.Syamasundar.Rao@uth.tmc.edu

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CHILDREN'S HOSPITAL OF PITTSBURGH OF UPMC
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With a strategic plan for growth and expansion, the Division of Cardiology within the Heart Institute of the Children's Hospital of Pittsburgh of UPMC / University of Pittsburgh School of Medicine is recruiting additional faculty positions.

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The Heart Institute provides comprehensive pediatric and adult congenital cardiovascular services to the tri-state region and consists of 25 pediatric cardiologists, 4 pediatric cardiothoracic surgeons, 5 pediatric cardiac intensivists and 9 cardiology fellows along with 12 physician extenders and a staff of over 100. The Heart institute is currently ranked 12th in the US News and World report ranking for pediatric cardiac programs. The Cardiac surgical program is one of the top in the country, with a 3-star rating from Society of Thoracic Surgery (STS) in the most recent survey.

Children's Hospital of Pittsburgh of UPMC has been named to U.S. News & World Report's 2015-16 Honor Roll of Best Children's Hospitals, one of only 10 hospitals in the nation to earn this distinction. Consistently voted one of America's most livable cities, Pittsburgh is a great place for young adults and families alike.

The positions come with a competitive salary and faculty appointment commensurate with experience and qualifications at the University of Pittsburgh School of Medicine. The University of Pittsburgh is an Equal Opportunity/Affirmative Action Employer. Interested individuals should forward letter of intent, curriculum vitae and three (3) letters of references. Informal inquiries are also encouraged.

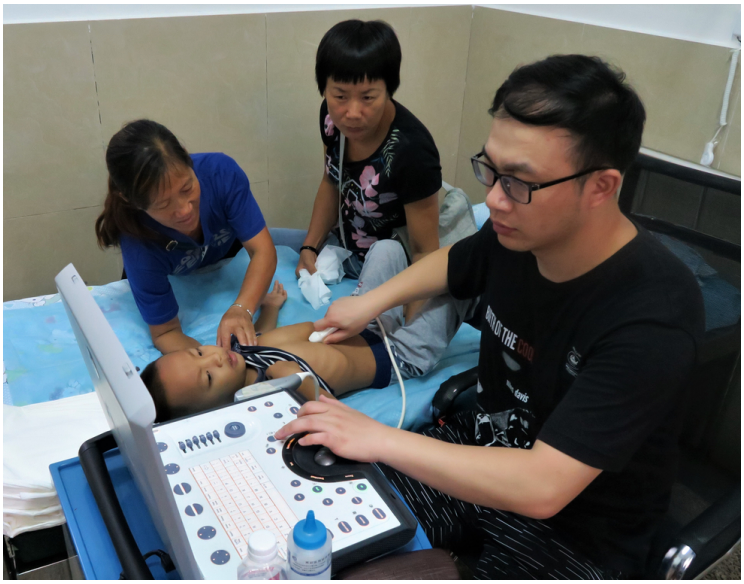
Contact information:

Jacqueline Kreutzer, MD, FSCAI, FACC.
Chief, Division of Pediatric Cardiology
Children's Hospital of Pittsburgh of UPMC
4401 Penn Avenue
Pittsburgh, PA 15224
Telephone: 412-692-6903
E-mail: Jacqueline.kreutzer@chp.edu

Three Weeks in Beautiful Yunnan Province, China
California Heart Watch Requests Volunteer Pediatric Cardiologists

By Daniel Zhang

I first heard about China California Heart Watch and the work Dr. Detrano was doing in Yunnan, China, through a quick web search. I had just finished a year-long contract teaching English to university students at the Northwest Polytechnic University in Xi'an, and was looking for something to do that would allow me to remain in China for a little bit longer. During my time in college I had always wanted to become a doctor, and often toyed with the idea of doing global health work in China after medical school. When I learned that there was a cardiologist from the University of California Irvine doing just that, I was very intrigued, and quickly sent Dr. Detrano an email asking if he would be willing to take me on as a long-term volunteer.



Dr. Liang performing an ultrasound.

A little bit about China California Heart Watch, or China Cal, for short. Dr. Detrano started China Cal in response to the need he saw for high quality cardiac care and education in the rural areas of China while on a bike trip through southeastern Yunnan in 2008. In the beginning, China Cal offered free blood pressure readings and hypertension counseling to the farmers of Yunnan. Within time though, many farmers would bring their children to also be examined, and Dr. Detrano discovered that there were many children suffering from untreated Congenital Heart Disease (CHD). Nowadays, Dr. Detrano and his wife Shan Shan help to organize traveling clinic trips to remote parts of Yunnan, offering free heart exams to children suspected of having CHD. Any child in need of treatment is referred to China Cal's partner hospitals. Treatment costs are covered in part by insurance, and in part by private donations made by charitable foundations and individuals through China Cal.

Dr. Detrano with patient.

Group photo: China Cal team along with the Chinese medical team.

Patient intake.

China Cal invites US and Chinese students interested in global health and medicine to come on clinic trips as part of the China Cal Externship Activity. The first externship I went on was to the prefecture of Xishuangbanna in July, 2017. Xishuangbanna is a prefecture located in the southern hills of Yunnan, just north of the Chinese-Laotian border. Most of the people there are part of the Dai ethnic group, a group of people closely related to the people of Thailand. As a result, much of the architecture is reminiscent of the temples of northern Thailand.

The climate in Banna is very tropical, and in the afternoon the locals would shut down three hours for an afternoon siesta. On my trip there were four students from the US and three from China. We would beat the heat by buying dragonfruit, which was sold by the kilo, and snack on it in the shade during the hottest hours of the day.

Our first day of clinic was at Chengnan Hospital in the town of Mengla. The hospital director had taken all of us out to dinner the night before, and now he stood at the hospital entrance, cigarette in hand, overseeing the nurses directing families toward us. The hallway outside our clinic room was soon filled with mothers carrying their children on their back, and fathers clutching past hospital records in their darkly tanned hands. Talking to one of the nurses, I found out that some of these families had travelled almost 6 hours on rough country roads to reach our little clinic.

The patients would enter our intake room to have their vital signs taken, and be asked a series of questions relating to the most common symptoms of Congenital Heart Defects. Any past hospital records were photographed and later transferred onto a hard drive for record keeping. After this, they would go outside and wait until one of our physicians was available to see them. For the majority of the clinic trip, I worked with Dr. Liang, an echocardiology specialist from China; I entered patient information and notes for him.

The first few hours of the clinic went by in a blur; we were able able to reassure many families that their child was perfectly healthy. A few children Dr. Liang diagnosed with small Patent Ductus Arteriosis (PDAs) or Atrial Septal Defects (ASDs), were referred for surgery if the child was large enough. It was rewarding to see the change in the parents demeanor when they were told that their child was healthy, or would be able to be helped through surgery. It seemed as though a visible weight was lifted from their shoulders, and their faces would light-up with smiles as they thanked Dr. Liang and me, while wiping off the ultrasound gel from their child after the exam.

In the afternoon after our lunch break, we went back to the exam room to find a young man and his younger brother waiting to be seen. What struck me was how small and skinny this young boy was, as well how deeply colored his lips were. Later, I would learn that this was called cyanosis and is a symptom of advanced CHD. Unlike most of the children his age, he was very calm as Dr. Liang placed the ultrasound probe on his chest. The older brother told us that his younger brother was frequently out of breath and unable to run for more than a few steps before becoming exhausted. The exam revealed that this young boy had a large 7 mm Ventricular Septal Defect (VSD). In addtiion, Dr. Liang found that the boy already had high pulmonary hypertension and was not a candidate for surgery. The flow of blood in between his ventricles had already reversed from right-to-left, meaning that this boy had already progressed to Eisenmanger's Syndrome (ES).

By the end of the externship activity, our traveling clinic had visited all three counties of Xishuangbanna prefecture. In the process, we were able to see more than 500 patients, 43 of which needed surgical treatment. Reflecting upon my experiences, I was glad we were able to help refer many children for the treatment they needed that they may not have otherwise received. I learned a lot about common what CHD is, and about the importance of early treatment. However, I don't think I will ever forget how I felt when we had to give the older brother the news that we wouldn't be able to help his brother. ES is relatively rare in the U.S. due to the fact that CHDs in patients is identified early on in a child's life, and it is easy to access treatment to correct them. Dr. Detrano told me that in all his time as a practicing cardiologist in the US, he saw a total of three ES cases; in comparison, we saw three cases in a single week during our trip in China. There is a need for improvement regarding the ability of rural hospitals in China to screen for CHD in young children, as well as accessibility to surgical treatment needed to repair CHD's. In the meantime, the best hope for the children of Yunnan to receive the care they need rests on the dedicated staff and physicians of organizations such as China California Heart Watch.

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China California Heart Watch
28251 Silverado Canyon Rd. # 517
Silverado, CA, 92676-0517
www.chinacal.org

China California Heart Watch (China Cal) brings together experts from the United States, China, and around the world. Together, they use innovative and sustainable methods to combat the growing epidemic of heart disease in Yunnan Province, China. Their overarching mission is to serve the people of Yunnan through teaching, improving access to care, research, and advocacy. China California Heart Watch is a 501(c)3 organization. China Cal is in need of donations, GE Health Care VSCAN ultrasound recorders and volunteers. Please contact Daniel Zhang, daniel@chinacal.org, for an application or any questions.

Daniel Zhang
Student and China Cal Externship
Tel: 630.730.8705
daniel@chinacal.org

Compiled and Reviewed by Kate Baldwin, Special Projects Editor

FDA Approves the World's Smallest Mechanical Heart Valve for Pediatric Patients with Heart Defects

On March 6, 2018 Abbott announced the U.S. Food and Drug Administration (FDA) approved the Masters HP™ 15mm rotatable mechanical heart valve, the world's smallest mechanical heart valve, that will allow doctors to treat babies and toddlers in need of a mitral or aortic valve replacement. Until today, surgeons could only use a range of larger-sized valves to replace a pediatric heart valve that could not be repaired, and larger valves are often not suitable given the smaller size of children's hearts. This dime-sized new valve is the first and only pediatric mechanical heart valve developed for newborns and infants, and offers hope for pediatric patients in urgent need of treatment who have no other approved options.

In the U.S. alone, Congenital Heart Defects (CHDs) affect nearly 1% – about 40,000 – births each year.[1] For children who have a poorly functioning valve that cannot be repaired, a valve replacement procedure using Abbott's 15mm mechanical heart valve is now an option.

"In my practice, I want to be able to provide a treatment option that works for a critically ill child when a larger-sized valve may not be suitable," said Kirk R. Kanter, MD, Professor of Surgery and Director of the Heart Transplant Program at Children's Healthcare in Atlanta at Emory University School of Medicine, which was the top enrollment site for the trial that led to approval of this new treatment option. "The approval of this smaller pediatric mechanical heart valve provides surgeons with a much-needed option for treating these vulnerable, high-risk children."

The heart's mitral and aortic valves move blood through the heart, providing the body with oxygen-rich blood. Both valves, when functioning properly, open and close sequentially as blood enters and leaves the heart with each contraction. This forward transfer of blood is a critical process for the heart to function as intended,[2] and when either valve doesn't work properly,[3] the condition can lead to life-threatening heart failure.[4]

Sadie Rutenberg, now a 3-year-old, was only a few months old when her parents noticed she was breathing fast, stopped gaining weight and was not eating well due to a congenital heart problem.

"When we were told that Sadie would need surgery right away, and was a candidate for a new clinical trial of a heart valve sized for her small body, we were willing to try it to hopefully save her life," said Lee'or Rutenberg, Sadie's father. "When the doctor came out of surgery and told us the surgery was a success – as a parent, it's a moment I'll never forget. The valve saved Sadie's life."

When the tissues of the heart valve have a significant malformation or are too damaged and cannot be repaired to function properly, it may be necessary to replace the valve with a mechanical valve. A mechanical heart valve mimics the valve of a healthy heart, opening and closing with each heartbeat, permitting proper blood flow through the heart.

"There's an urgent need for the smallest babies and children who need a suitable replacement valve in order to survive," said Michael Dale, Vice President of Abbott's Structural Heart Business. "Abbott's new mechanical pediatric heart valve is a life-changing technology for the smallest pediatric patients, giving them a better chance at a long, healthy life with a fully functioning heart."

The approval of Abbott's new Masters HP™ 15mm rotatable mechanical heart valve was primarily based on the results of a clinical trial, which enrolled pediatric patients five years of age or younger who had a diseased, damaged or malfunctioning heart valve. Jonathan M. Chen MD, Co-Director of the Seattle Children's Hospital Heart Center and Division Chief for Pediatric Cardiothoracic Surgery, was the first physician in the trial to implant the Masters HP 15mm valve in a pediatric patient. Dr. Chen treated Sadie Rutenberg, who was the first infant to undergo the treatment in the clinical trial. She is now a healthy 3-year-old.

The Masters HP™ 15mm rotatable mechanical heart valve is a rotatable, bileaflet mechanical heart valve designed for implantation in the mitral or aortic position and is part of the Masters Series line, which now includes seven valves with diameter sizes ranging from 15 to 27mm.

Initially approved in 1995, the valves have pyrolytic carbon leaflets and orifice rings, an 85-degree leaflet opening angle to improve flow and reduce turbulence, and a controlled torque rotation mechanism for rotation and intraoperative adjustment. A sewing cuff contains additional suture markers for more accurate placement.

For U.S. Important Safety Information on the Masters HP Series, visit http://abbo.tt/2taeyVL.

For more information: www.abbott.com.

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Siemens Healthineers Introduced a Portable Cardiovascular-Dedicated Ultrasound System at the ACC

At the American College of Cardiology's 67th Annual Scientific Session and Expo, Siemens Healthineers launched its new portable cardiovascular ultrasound solution, the ACUSON Bonsai. According to a recent study, 34 million echo exams were performed in the U.S. in 2017.[1] The ACUSON Bonsai addresses the challenge of these increased clinician workloads by providing a portable and quick system, while maintaining high-quality imaging and diagnostic confidence through user-friendly applications. Together with Mindray Medical International Limited, Siemens Healthineers created a cardiovascular-dedicated, maneuverable system to transform the care delivery of routine echo exams.

"We are pleased to debut this new offering which will help clinicians meet the growing demands for echocardiography in their practices," says Peter Pellerito, SVP Ultrasound, Siemens Healthineers North America. "By adding the ACUSON Bonsai to our portfolio, we've responded to the needs of our customers by implementing clinical optimization, offering standard cardiology presets, and creating a design that provides the flexibility to scan virtually anywhere, making the ACUSON Bonsai ideal for transforming the care delivery of routine echo exams in fast-paced environments."

High-Quality Imaging in a Touch: In one portable system, the ACUSON Bonsai provides one-touch image optimization and advanced imaging. The system automatically optimizes the ultrasound image with the touch of a button, eliminating the need for manual optimization on the part of the sonographer for improved workflow and image quality consistency. The ACUSON Bonsai also utilizes advanced imaging to optimize specific to routine echocardiograms and cardiovascular workflows. The ACUSON Bonsai is compatible with a comprehensive set of 14 TTE and TEE transducers.

Comprehensive Clinical Applications: The ACUSON Bonsai comes fully loaded with a complete set of user-friendly cardiology applications for fast and easy handling of routine echo exams. Included applications such as "Auto EF" for semi-automatic ejection fraction measurements and "Auto IMT" for automatic intima-media thickness measurements help clinicians acquire measurements in one click, which enables quicker exams and consistent and reproducible results.

Ultra-portable with Improved Workflow: The ultra-portable and ergonomic user design of the ACUSON Bonsai's laptop and mobile cart system offers flexibility in scanning locations. The laptop is over 1.7 cm thinner than the industrial average, and its companion cart has a slim design and small footprint for maneuverability. Automated protocols reduce scan times up to 43%[2] and reduce keystrokes up to 75%,[2] improving workflows and patient throughput. Raw Data capabilities on the system can also improve scan times and allow for flexibility with image optimization and measurements after the acquisition.

1. Arlington Medical Research, Echo monitor report 2017
2. The Role of a Protocol Management Feature in Improving Ultrasound Lab Efficiency, 2016

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Publication Company Address:
11502 Elk Horn Dr. Ste. 201
Clarksburg, MD 20871 USA
Tel: +1.301.279.2005

Publishing Management:

- Tony Carlson, Founder, President & Sr. Editor - *TCarlsonmd@gmail.com*
- Richard Koulbanis, Group Publisher & Editor-in-Chief - *RichardK@CCT.bz*
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8 zig
12mm to 24mm Expansion

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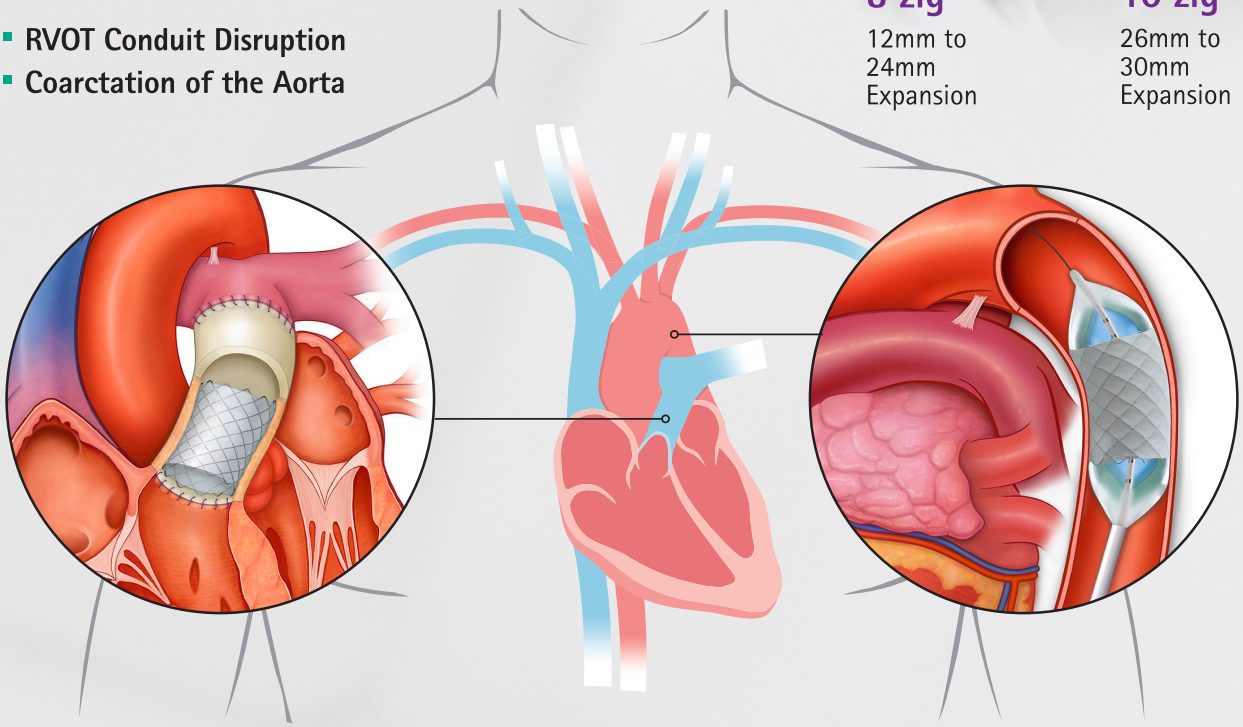
- Coarctation of the Aorta



Indications for Use:

The CP Stent is indicated for use in the treatment of native and/or recurrent coarctation of the aorta involving a compliant aortic isthmus or first segment of the descending aorta where there is adequate size and patency of at least one femoral artery and balloon angioplasty is contraindicated or predicted to be ineffective.

The Covered CP Stent is indicated for use in the treatment of native and/or recurrent coarctation of the aorta involving the aortic isthmus or first segment of the descending aorta where there is adequate size and patency of at least one femoral artery associated with one or more of the following: acute or chronic wall injury; nearly atretic descending aorta of 3 mm or less in diameter; a non-compliant stenotic aortic segment found on pre-stent balloon dilation; a genetic or congenital syndrome associated with aortic wall weakening or ascending aortic aneurysm.

The Covered CP Stent is indicated for use in the treatment of right ventricle to pulmonary artery (right ventricular outflow tract) conduit disruptions that are identified during conduit pre-dilatation procedures performed in preparation for transcatheter pulmonary valve replacement.

Caution: Federal (USA) Law restricts this device to sale by or on the order of a physician. **Contraindications:** Clinical or biological signs of infection. Active endocarditis. Pregnancy. **Contraindications (CoA only):** Patients too small to allow safe delivery of the stent without compromise to the systemic artery used for delivery. Unfavorable aortic anatomy that does not dilate with high pressure balloon angioplasty. Curved vasculature. Occlusion or obstruction of systemic artery precluding delivery or the stent. Known allergy to aspirin, other antiplatelet agents, or heparin. **Contraindications (RVOT only):** Patients too small to allow safe delivery of the stent without injury to a systemic vein or to the right side of the heart. **Warnings / Precautions:** Radiofrequency heating during MRI scans on overlapped, 10 zig CP Stents has not been evaluated. Excessive force while crimping may weaken welds of the stent. Crimping the 8 zig stent on a balloon catheter smaller than 12mm, and the 10 zig on a balloon catheter smaller than 26mm, may cause damage to the stent. The stent is rigid and may make negotiation through vessels difficult. **Warnings / Precautions (CoA only):** Coarctation of the aorta involving the aortic isthmus or first segment of the descending aorta should be confirmed by diagnostic imaging. The NuMED CP Stent has not been evaluated in patients weighing less than 20kg. As with any type of implant, infection secondary to contamination of the stent may lead to aortitis, or abscess. Over-stretching of the artery may result in rupture or aneurysm formation. **Warnings / Precautions (Covered CP Stent only):** Excessive handling and manipulation of the covering while crimping the stent may cause the covering to tear off of the stent. Crimping the device in the opposite direction of the folds in the covering may cause the covering to catch while inserting into the hemostasis tool and introducer. This could cause the covering to tear off the stent. Pulling the Covered stent back through the introducer and/or hemostasis valve may cause the covering to catch and tear off of the stent. **Warnings / Precautions (RVOT only):** During the Premarket Approval study the Medtronic Melody valve was used for valve restoration. The safety and effectiveness of the Covered CP Stent for pre-stenting of the right ventricular outflow tract (RVOT) landing zone (i.e. prophylaxis or prevention of either RVOT conduit rupture or TPVR fracture; use as a primary RVOT conduit) in preparation of a transcatheter pulmonary valve replacement (TPVR) has not been evaluated. As with any type of implant, infection secondary to contamination of the stent might lead to endocarditis, or abscess formation. The Covered Stent can migrate from the site of implant potentially causing obstruction to pulmonary artery flow. Over-stretching of the RVOT may result in rupture or aneurysm of the RV-PA conduit or the native pulmonary artery. The inflated diameter of the stent should at least equal the diameter of the intended implant site. **Reference the IFU for a complete listing of indications, contraindications, warnings and precautions. www.bisusa.org**

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