ECHOCARDIOGRAPHY GUIDES FOR CONGENITAL HEART DISEASE INTERVENTION

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INTRODUCTION

- Interventional therapeutic catheterization procedures for CHD have replaced cardiac surgery in many types of defects
- Echocardiography is being used to diagnose CHD, guide, evaluate immediate and late results of these interventional procedures

- In this presentation, we will detail the role of echocardiography in closure of ASD, VSD, PDA, congenital coronary artery fistulas; balloon dilation of PVS
ATRIAL SEPTAL DEFECT
DEFINITION

- An ASD is a hole in atrial septum that separates the right and left atria.

- ASDs account for between 5 and 10% of all cases of CHD and are twice as prevalent among girls and boys.
1. **Ostium Secundum Defect:** 70%
2. **Ostium Primum Defect:** 15-20%
3. **Sinus Venosus Defect:** 5-10%
4. **Coronary sinus Defect:** rare

Schematic drawing showing the different types of ASD
The typical findings in a secundum ASD. The present of the defect is confirmed by color flow mapping.

Pulse-wave Doppler recording of the velocity across a ASD with left-to-right shunting during both systole and diastole.
Defect was seen in the upper atrial wall.
CORONARY SINUS DEFECT

Image showing ultrasound scan with labels:
- Ao: Aorta
- LA: Left Atrium
- CS: Coronary Sinus
- ASD: Atrial Septal Defect
- PV: Pulmonary Vein

Scan details:
- Philips TRAN HOANG LINH 15T
- Date: 02/10/2008
- Time: 11:21:38
- MI: 1.2
- 2D: 64%
- C: 41
- P: Low
- HGen: 66%
- CF: 2.5MHz
- WF: High Med

Heart rate: 80 bpm
Subcostal view illustrating color Doppler flow images of a fenestrated atrial septum with left-to-right shunting through two defects.
AMPLATZER SEPTAL OCCLUDER INDICATION

- Secundum type ASDs, diameter ≤ 34 mm
- SVC, IVC, AV valve and RUPV rims are at least 5 mm.
- Significant left-to-right shunt: Qp/Qs > 1.5 and right heart chamber enlargement.
- Small ASD or PFO with atrial arrhythmia or paradoxal embolism
ECHOCARDIOGRAPHIC CONSIDERATIONS

1. Determination of
   - Location, size of defect(s)
   - Shunt direction
   - Relationship to AV valves, drainages sites of the pulmonary and systemic veins (length of rims)

2. Hemodynamic consequences: dimensions of cardiac chambers and cardiac function

3. Pulmonary artery pressure

4. Qp/Qs

5. Associated anomalies
Apical 4-chamber view of atrial septum. Measure of the defect (dotted line) size is demonstrated.
Apical 4-chamber view of the atrial septum. Total length (dotted line) of atrial septum is visualized and measured.
PULMONARY VENOUS RIM AND ATRIOVENTRICULAR RIM SIZING

Apical 4-chamber view of the PV and AV rim. Measurement of these rims is demonstrated.
Aortic rim sizing

Parasternal short axis view of aortic rim (arrow). Measure of aortic rim is demonstrated.
Subcostal view illustrating color flow images of IVC and SVC with their junction to RA

Subcostal view of IVC and SVC rims
Atrial septal aneurysm

2D transthoracic image from the subcostal longitudinal view demonstrating a large aneurysm of the atrial septum (arrows)
TRANSESOPHAGEAL ECHOCARDIOGRAPHY
ECHOCARDIOGRAPHIC INTRA-PROCEDURE

- ASD sizing, septal rims
- Leaks around the balloon when ASD sized by the balloon stretch technique
- Device location relative to the left/right atrium and atrial appendages
- Device proximity to mitral and tricuspid valves
- Identification of fenestrated ASDs
- Guidance of device release
- Leaks across device immediately after implantation
- Residual shunt.
- Left and right ventricular dimensions
- Septal movement.
- Systolic pulmonary artery pressure
- Cardiac perforation and tamponade
View of the device positioned on both sides of the atrial defect after deployment without residual shunt
Amplatzer dislodgment

Two-dimensional transthoracic image from the apical 4-chamber view demonstrating the Amplatzer dislodgment in the RV.
Leaking Amplatzer
VENTRICULAR SEPTAL DEFECT
VSD is a hole in the ventricular septum – the wall that separates the right and the left ventricles. ASD may be single or multiple and may occur in different parts of the ventricular septum.

VSDs are the most common forms of CHD, accounting for 25% of all cases or 1.5 – 2/1000 alive childbirth. They affect boys and girls with equal frequency.
1. **Perimembranous VSD**: 60-70%
2. **Muscular VSD**: 15-25%
3. **Doubly committed VSD**: 3-6%
PERIMEMBRANOUS VSD
MUSCULAR DEFECT OF THE OUTLET SEPTUM
MUSCULAR DEFECT OF THE TRABECULAR SEPTUM
MULTIPLE MUSCULAR DEFECTS OF THE TRABECULAR SEPTUM
MUSCULAR DEFECT OF THE INLET SEPTUM
DOUBLY COMMITTED VSD
AMPLATZER SEPTAL OCCLUDER INDICATION

- Perimembranous VSD: diameter < 14mm, aortic rim > 2 mm
- Muscular VSD: diameter < 10mm, distance of more than 4 mm between the VSD and the aortic, pulmonic, mitral, tricuspid valves
- Significant left-to-right shunt, without irreversible hypertensive PVR
ECHOCARDIOGRAPHIC CONSIDERATIONS

1. Anatomic location of the defect with extension, borders and relationship to the AV and semilunar valves; defect size; shunt direction; maximal left-to-right gradient.
2. Signs of spontaneous closure
3. Hemodynamic consequences
4. Pulmonary artery pressure
5. Qp/Qs
6. Associated anomalies
VSD SIZING

FR 47Hz
17cm

2D
64%
C 50
P Low
HGen

LV
RV
VSD
Ao
RA
LA

Dist 0.381 cm
Dist 0.840 cm

78bpm
AORTIC RIM

FR 47Hz
17cm

2D 57%
C 50
P Low
HGen

LV
RV
VSD
Ao rim
Ao

80bpm
PERIMEMBRANOUS ANEURYSM
ECHOCARDIOGRAPHY INTRA-PROCEDURE

- Localization, size VSD
- Guiding catheter and wire through VSD
- Device location within the left/right ventricle for guidance of device release
- Proximity of device to AV valves
- Residual leaks
ECHOCARDIOGRAPHIC POST-PROCEDURE

❖ Location of device
❖ Residual shunt, aortic regurgitation
❖ Dimensions of heart chambers
❖ Pulmonary artery pressure
Aortic regurgitation after procedure
AORTIC REGURGITATION AFTER PROCEDURE
RESIDUAL SHUNT POST-PROCEDURE

Spectral continuous Doppler showing residual shunt VSD

Parasternal short axis view of a color Doppler echocardiogram 24 hours after deployment of the device with residual shunt (arrow)
PATENT DUCTUS ARTERIOSUS
A blood vessel connecting the proximal left pulmonary artery to the descending aorta, distal to the left subclavian artery.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Silent:</strong></td>
<td>Need not be closed? No heart murmur audible, minimal ductal diameter &lt; 1mm</td>
</tr>
<tr>
<td><strong>Small:</strong></td>
<td>Audible long-ejection or continuous m., radiating to the back. Negligible hemodynamic change. Normal peripheral pulse. D: 1-3 mm</td>
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<tr>
<td></td>
<td>Normal LA and LV size with no pulmonary hypertension</td>
</tr>
<tr>
<td><strong>Moderate:</strong></td>
<td>Wide, bouncy peripheral pulses. Audible continuous murmur. LA, LV enlargement; D: 3-5mm</td>
</tr>
<tr>
<td></td>
<td>Some degree of reversible pulmonary hypertension</td>
</tr>
<tr>
<td><strong>Large:</strong></td>
<td>Signs of pulmonary hypertension; D &gt; 5mm. Eisenmenger physiology. Continuous murmur is absent. Differential cyanosis and toe clubbing</td>
</tr>
</tbody>
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ECHOCARDIOGRAPHIC CONSIDERATIONS

- Position, course, diameter and morphology
- LA, LV dilation: significant left-to-right shunt of a hemodynamically important PDA.
- Systolic pressure gradient across the PDA.
- Pulmonary artery pressure
- Associated lesions
CLASSIFICATION

Type A: the narrowest segment was at the pulmonary insertion.

Type B: the ductus was short and narrowed at the aortic insertion.

Type C: tubular ductus without constriction.

Type D: multiple constrictions.

Type E: long, tortuous duct
Parasternal short axis view of a color Doppler echocardiogram of a 22-year-old girl showing ductus arteriosus (arrow)
Left-to-right shunt PDA

Vel 469 cm/s
PG 88 mmHg
Left ventricular dilation
PDA CLOSURE IS RECOMMENDED

(1) For hemodynamic reasons, in patients with substantial left-to-right shunt and left heart dilatation.

(2) To eliminate the risk of endocarditis

(3) To reduce the risk of pulmonary hypertension

(4) For Silent Ductus after device/coil occlusion if residual shunt persist 6 to 12 months after device/coil closure of PDA
Identify residual shunt immediately post-implantation.

Two major types of leaks across the device:

- Low velocity jets across the foam or Dacron of the device (disappear 15-30 min after procedure)
- Discrete high velocity jets through the upper or lower edges of these devices (remain or disappear within 3-6 months)
Parasternal short Axis view of a Color Doppler Echocardiogram 24 hours after Deployment of the Devide (arrow) with Residual shunt.
VALVULAR PULMONARY STENOSIS
Valvular pulmonary stenosis means that the leaflets of the pulmonary valve are abnormal. They are often thickened and do not open fully, causing a narrowing where the blood crosses the valve from the RV.

VPSs account for between 80% and 90% of all cases of PS and 7–12% of all cases of CHD. VPSs occur equally among boys and girls.
Morphology of the stenotic pulmonic valve: domed thickened pulmonic valve.

Diameter of the “pulmonary annulus” is crucial for the selection of balloon size.

RV dimension

Pulmonary artery dilation

Severity of the obstruction

Associated anomalies: subvalvar or supravalvar obstruction as an additional lesion
**SEVERITY OF THE PULMONARY VALVE STENOSIS**

<table>
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<tr>
<th>n</th>
<th>Severity</th>
<th>RV/PA maximal gradient (mmHg)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Non-significant</td>
<td>&lt; 25</td>
</tr>
<tr>
<td>2</td>
<td>Mild</td>
<td>25-49</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>50-79</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>≥ 80</td>
</tr>
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(39)"Clinical course in pulmonary stenosis” Supp I Circulation. 1997; 56(2): I38-47
THE VALVE APPEARS TO DOME IN SYSTOLE
TRANSPULMONIC VALVULAR GRADIENT

1. PVpeakV = 5.00 m/s
2. PeakPG = 100.00 mmHg
3. MeanPG = 65.34 mmHg
4. PV VTI = 124.7 cm
5. PVaccT/EjccT = 0.50

DMP

2D: 14 cm
f: 1.7 MHz H
f: 1.82 MHz
VLE: 3.8 m/s
LVR: 32 cm/s
INDICATION OF BALLOON VALVULOPLASTY

- Isolated valvular pulmonary stenosis with transpulmonic valve gradient > 50 mmHg.
- Infundibular pulmonic stenosis or dysplastic pulmonary valves: valvuloplasty only for pts being operated or impossible surgically corrected CHD).
- Tetralogy Fallot, CHD with cyanose: Balloon dilation is for pts with severe cyanose or for pts being completely corrected by surgery.
Echocardiography can identify if the catheters centered across pulmonary valves before inflating the balloon.

Residual obstruction and insufficiency caused by balloon dilation procedure.

The cusp perforation or avulsion.
ECHOCARDIOGRAPHY AFTER PROCEDURE

- RV and LV dimensions, RV systolic pressure, thickness of RV wall.
- Septal movement.
- Diameter of PA
- Transpulmonic and transinfundibular gradients
- Pulmonary regurgitation
CONGENITAL CORONARY ARTERY FISTULA
DEFINITION

- Anomalous connection of a coronary artery with a cardiac chamber or major thoracic vessel.
- Rare malformation: 1/ 50,000 of all CHD.
ORIGIN OF CORONARY ARTERY FISTULAS: Dilation of the coronary artery, its diameter exceeds 3 mm

TRAJECTORY: Tortuous, dilated; +/- aneurysmal dilatation in the region of the fistula

DRAINAGE SITE: disturbed continuous flow in Color Doppler mapping

FUNCTIONAL CONSEQUENCES: The chamber or vessel into which the fistula drains is dilated. The potential ischemic effects of a coronary steal: evaluate global and regional wall motion.
The proximal right coronary artery is markedly dilated
Coronary involved is tortuous and dilated
Color flow mapping shows turbulent flow (arrow) in the RA (drainage of the right coronary fistula).
ECHOCARDIOGRAPHY POST CATHETERIZATION
OTHER MALFORMATIONS
ECHOCARDIOGRAPHY IS CRUCIAL IN

- Balloon dilation and stent management of stenotic BT bypass, restrictive PDA in tetralogy, branch pulmonary artery stenosis, coarctation of the aorta,
- Balloon dilation of aortic stenosis, LA membranous stenosis in cor triatriatum
ECHOCARDIOGRAPHY IS CRUCIAL IN

- Percutaneous transluminal septal myocardial ablation in HOCM
- Occlusion of arteriovenous pulmonary fistulas
- Balloon atrial septostomy in transposition great artery, pulmonary atresia, total anomalous pulmonary venous connection
THANK YOU FOR YOUR ATTENTION!