HEART FAILURE IN CHILDREN

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Objectives

- Definition
- Etiology
- Symptoms and signs
- Diagnosis and Differential Diagnosis
- Management
- Prognosis
Congestive Heart Failure (CHF)

Definition:

**CHF is defined as inadequate oxygen delivery by the heart or circulatory system to meet the demands of the body.**
CHF Definition (cont.):

Oxygen delivery = oxygen content of the blood $\times$ the cardiac output.

Oxygen content = oxygen saturation $\times$ hemoglobin saturation.

Cardiac output = heart rate $\times$ stroke volume.
CHF Definition (cont.):

Stroke volume is dependent on:

1. Preload i.e. the filling volume of the heart.

2. Afterload i.e. the resistance the ventricles face on ejection of blood.

3. Inotropic state i.e. efficiency of heart muscle contractility.
CHF Definition (cont.):

Therefore, Oxygen delivery may be improved (and CHF treated) by adjustments to:

Preload,
Afterload,
Contractility,
Heart rate,
Arterial oxygen saturation, and Hemoglobin.
Heart failure in newborn occurs in 0.1-0.2 % of live birth.

( Kay, Am. Heart J., 2001 )
Causes of CHF

A. Congenital heart defects (CHD) and other malformations:

1. Left to right shunts:
VSD, AVSD, and large PDA are common causes of increased pulmonary blood flow resulting in CHF.
Patent Ductus Arteriosus

Normal

Patent Ductus Arteriosus
Causes of CHF (cont.):

2. Cyanotic heart disease with increased pulmonary flow:

Transposition of great arteries (TGA), truncus arteriosus (TA), totally anomalous pulmonary venous return (TAPVR) are all having increased pulmonary blood flow in addition to the mixing abnormalities.
Transposition of the Great Vessels

Normal

Transposition of the Great Vessels
Total Anomalous Pulmonary Venous Return
Supradiaphragmatic

Normal

TAPVR

AO: Aorta
PA: Pulmonary Artery
LA: Left Atrium
LV: Left Ventricle
RA: Right Atrium
RV: Right Ventricle
SVC: Superior Vena Cava
PV: Pulmonary Vein
IVC: Inferior Vena Cava

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Causes of CHF (cont.):

3. Obstructive lesions:
   They include critical or severe aortic, or mitral valve stenosis, coarctation of aorta, interrupted aortic arch, hypoplastic left heart syndrome, TAPVR with obstruction, and pathologic elevation in systemic vascular resistance.
Hypoplastic Left Heart Syndrome

Normal

Hypoplastic Left Heart

AO: Aorta
PA: Pulmonary Artery
LA: Left Atrium
LV: Left Ventricle
RA: Right Atrium
RV: Right Ventricle
PDA: Patent Ductus Arteriosus

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Causes of CHF (cont.):

4. **Coronary anomalies:**

Anomalous origin of left coronary artery from the pulmonary artery (ALCAPA) and coronary fistula are possible causes of CHF.
Causes of CHF (cont.):

**B: Acquired Heart Diseases:**

1- Rheumatic carditis and residual rheumatic valvular diseases (significant mitral or aortic valve lesions).
Acute Rheumatic Fever Vegetations
Causes of CHF (cont.):

2. Dilated (Congestive) Cardiomyopathy:
Incidence in USA: 36.5/100,000 children. Genetic causes account for more than 30%. The commonest cause in children is viral myocarditis. Other causes are too many including infections, metabolic, storage, neuromuscular, ischemic, and toxic diseases.
CXR in DCM
Causes of CHF (cont.):

3. Coronary disease:

The commonest cause of acquired coronary disease in pediatrics is Kawasaki disease. Unusually the coronary lesions are severe enough to cause CHF.
Kawasaki disease
Causes of CHF (cont.):

4. Arrhythmias:

Both severe tachycardia and bradycardia are capable of producing CHF.

5. Hypertension.
Causes of CHF (cont.):

6. Anthracycline Toxicity:

   e.g. Adriamycin.

   Dose related toxicity.

   240 mg/ M2.

   Epirubicin ? Less toxic.
S&S of CHF:

The presenting S & S depend on the cause of CHF and can be summarized as follows:

1. Pulmonary venous congestion:
   Tachypnea, wheezing, rales, feeding difficulties, and irritability.
S&S of CHF (cont.):

2. Systemic venous congestion:

Hepatomegaly, and peripheral edema.

3. Impaired cardiac output:

Decreased precordial activity, diminished arterial pulses, and delayed capillary refill.
S&S of CHF (cont.):

4. Volume loading:

Increased precordial activity and gallop sounds.

5. Pressure loading:

Gallop rhythm, precordial heave, and murmurs.
S&S of CHF (cont.):

6. Adaptive changes:

Tachycardia, pallor, sweating, low urine output, and growth failure.
Treatment of CHF:

A. Medical treatment:

1. Extreme or emergent cases of CHF must be treated in an ICU. If respiratory distress is severe, support of airway and breathing is critical.
Treatment of CHF (cont.):

After resuscitation:
treatment with IV inotropic drugs:
dopamine and dobutamine,
Or phosphodiesterase III inhibitors;
amrinone or milrinone; may be needed.
Treatment of CHF (cont.):

2. If circulatory congestion, evidenced by pulmonary or peripheral edema, is present, then the initial treatment is with a diuretic.
Furosemide, a loop diuretic, is usually recommended with a dose of 1 mg/kg IV and the dose may be repeated 2 to 6 times per day.
Addition of spironolactone is recommended if a high dose of furosemide is needed to avoid potassium wasting that may otherwise occur.
Treatment of CHF (cont.):

3. **Digoxin**, a cardiac glycoside, is another mainstay of medical treatment of patients with CHF. It improves myocardial contractility, relieves tachycardia, and is a good initial treatment of certain arrhythmias.
Treatment of CHF (cont.):

The usual dose of digoxin is 8 – 10 micrograms/kg/day orally in 2 divided doses.
4. Angiotensin converting enzyme inhibitors, such as captopril and enalapril have been found to be effective in cases of CHF secondary to hypertension, myocardial dysfunction, and intracardiac shunts such as VSD.
5. Iron supplementation or blood transfusion may be required to increase the hemoglobin level.

6. Corticosteroids may be very important in the treatment of CHF due to rheumatic carditis or pericardial effusion.
Treatment of CHF (cont.):

B. Surgical treatment:

In cases of CHF secondary to congenital heart defects, surgery is often the treatment of choice.

Types of operations can be divided into three groups:
1. Palliative surgeries:

Example is pulmonary artery banding in case of massive left to right shunts while definitive reparative surgery is impossible.
Treatment of CHF (cont.):

2. **Definitive reparative surgeries:**

Examples are corrective surgical treatment of TGA, TAPVR, VSD, AVSD, PDA, interrupted aortic arch, and anomalous origin of left coronary artery from the pulmonary artery.
Treatment of CHF (cont.):

3. **Heart or heart-lungs transplantation:**

This may be the only effective treatment for patients with end-stage cardiomyopathy or complex lesions such as left hypoplastic heart syndrome.

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Mr. Washansky

1st human heart transplantation

South Africa

December, 1967.
INFECTIVE ENDOCARDITIS IN CHILDREN

Dr. Maged M. El Samady
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Objectives

• Etiology
• Symptoms and Signs
• Laboratory and Echo Findings
• Criteria for Diagnosis
• Management and Prognosis
• Prophylaxis
INFECTIVE ENDOCARDITIS IN CHILDREN

INTRODUCTION:

Infective endocarditis is a rare but fatal infection. It involves cardiac endothelium of patients usually - but not always - having pre-existing congenital or acquired cardiac lesion causing alteration in blood flow dynamics and damage to the endothelium.
INFECTIVE ENDOCARDITIS IN CHILDREN

EPIDEMIOLOGY:

- The incidence in childhood is difficult to estimate but an annual incidence in the order of 3 to 4 per million compares to incidence in adults of 12 to 62 per million.

- There are evidences suggesting an increasing incidence and change in patient population.

(cont.)
The affected population is increasingly a post surgical one, whereas rheumatic fever and unoperated congenital heart disease are declining as causes.

The following factors may account for these changes:
EPIDEMIOLOGY (cont.):

1- Children with complex CHD are often palliated with prosthetic aortopulmonary shunts; with increased risk for endocarditis.

2- Children with simpler lesions are repaired earlier, reducing their risk.

3- The incidence of rheumatic fever is decreasing.

4- The increased use of central venous catheters in immunocompromised patients has created a new population at risk.
INFECTIVE ENDOCARDITIS IN CHILDREN

DESCRIPTIVE TERMS:

♥ Acute vs. sub acute
♥ Right vs. left sided
♥ Native vs. prosthetic valve
♥ Culture negative vs. culture positive
INFECTIVE ENDOCARDITIS IN CHILDREN

PATHOGENESIS:

- Endothelium is altered by blood turbulence.
- Fibrin & platelets are deposited at the damaged site forming vegetative lesions.
- Transient bacteremia seeds vegetative lesions.
- Bacterial growth is protected from WBC.
- Bacteria can damage the valve and seed blood stream with bacteria.
PATHOGENESIS: Endothelium is altered by blood turbulence.
Lt upper: Aortic vegetation
Rt upper: Destroyed Ao valve
Rt lower: Vegetation on a valve
(microscopy)
Certain cardiac conditions are associated with endocarditis more often than others. The severity of endocarditis and the resulting morbidity can be variable according to cardiac condition.
INFECTIVE ENDOCARDITIS IN CHILDREN

HIGH RISK CARDIAC CONDITIONS:

* Prosthetic heart valves.

* Previous history of endocarditis
  
  (even in absence of other cardiac disease).

* Complex congenital cyanotic heart disease.

* Surgically constructed systemic pulmonary shunts or conduits.
INFECTIVE ENDOCARDITIS IN CHILDREN
MATERIAL RISK CARDIAC CONDITIONS:

- Most other congenital cardiac malformations (other than above and below).
- Acquired valvar dysfunction (e.g. rheumatic heart disease).
- Hypertrophic cardiomyopathy.
- Mitral valve prolapse with valvar regurgitation and/or thickened leaflets.
INFECTIVE ENDOCARDITIS IN CHILDREN
NEGLIGENCE RISK CARDIAC CONDITIONS:

- Isolated secundum atrial septal defect.
- Mitral valve prolapse without valvar regurgitation.
- Surgical repair of ASD, VSD, or PDA (without residua beyond 6 months).
- Previous rheumatic fever without valvar dysfunction.
- Previous Kawasaki disease without valvar dysfunction.
- Innocent heart murmurs.
- Cardiac pacemakers and defibrillators.
- Previous coronary artery bypass graft surgery.
## Infective Endocarditis in Children

### Bacteremia Producing Procedures:

<table>
<thead>
<tr>
<th>Procedure and Site</th>
<th>Incidence (Range) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous bacteremia</td>
<td>&lt; 1 (0-3)</td>
</tr>
<tr>
<td><strong>Oral cavity</strong></td>
<td></td>
</tr>
<tr>
<td>Tooth extraction</td>
<td>60 (18-85)</td>
</tr>
<tr>
<td>Periodontal surgery</td>
<td>88 (60-90)</td>
</tr>
<tr>
<td>Brushing teeth or chewing</td>
<td>40 (7-50)</td>
</tr>
<tr>
<td>Tonsillectomy</td>
<td>35 (33-38)</td>
</tr>
</tbody>
</table>

(cont.)
<table>
<thead>
<tr>
<th>Procedure and Site</th>
<th>Incidence (Range) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory tract</strong></td>
<td></td>
</tr>
<tr>
<td>Tracheal intubation</td>
<td>&lt; 10 (0-16)</td>
</tr>
<tr>
<td>Nasotracheal suctioning</td>
<td>16</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td></td>
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<tr>
<td>Rigid</td>
<td>15</td>
</tr>
<tr>
<td>Flexible</td>
<td>0</td>
</tr>
</tbody>
</table>

(cont.)
<table>
<thead>
<tr>
<th>Procedure and Site</th>
<th>Incidence (Range) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genitourinary tract</td>
<td></td>
</tr>
<tr>
<td>Catheter insertion or removal</td>
<td>13 (0-26)</td>
</tr>
<tr>
<td>Cystoscopy</td>
<td>17</td>
</tr>
<tr>
<td>Urethral dilatation</td>
<td>24</td>
</tr>
<tr>
<td>Circumcision</td>
<td>0</td>
</tr>
</tbody>
</table>

(cont.)
## BACTEREMIA PRODUCING PROCEDURES (cont.):

<table>
<thead>
<tr>
<th>Procedure and Site</th>
<th>Incidence (Range) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gastrointestinal tract</strong></td>
<td></td>
</tr>
<tr>
<td>Upper G I endoscopy</td>
<td>4 (0-8)</td>
</tr>
<tr>
<td>Barium enema</td>
<td>10 (5-11)</td>
</tr>
<tr>
<td>Colonoscopy</td>
<td>5 (0-5)</td>
</tr>
<tr>
<td>Sigmoidoscopy</td>
<td></td>
</tr>
<tr>
<td>Rigid</td>
<td>5</td>
</tr>
<tr>
<td>Flexible</td>
<td>0 (cont.)</td>
</tr>
<tr>
<td>Procedure and Site</td>
<td>Incidence (Range) (%)</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>Gastrointestinal tract (cont.)</strong></td>
<td></td>
</tr>
<tr>
<td>Esophageal dilatation</td>
<td>45</td>
</tr>
<tr>
<td>Transesophageal echocardiography</td>
<td>1</td>
</tr>
<tr>
<td><strong>Vascular system</strong></td>
<td></td>
</tr>
<tr>
<td>Cardiac catheterization</td>
<td>2 (0-5)</td>
</tr>
</tbody>
</table>

INFECTIVE ENDOCARDITIS IN CHILDREN

MICROBIOLOGY:

Common endocarditis pathogens are:

1- Alpha hemolytic streptococci.
2- Staphylococcus aureus (MRSA or MSSA).
3- Staphylococcus epidermidis (MRSE or MSSE).

Frequency of endocarditis caused by previous pathogens reduced from 75% in 1975 to 50% in recent studies with concomitant increase in cases caused by the following pathogens: (cont.)
MICRO BIOLOGY (cont.):

4- HACEK organisms

**H:** Homophiles species

**A:** Actinobacillus

**C:** Cardiobacterium

**E:** Eikenella

**K:** Kingella

HACEK organisms are common in neonates and immunocompromised children. (cont.)
MICRO BIOLOGY (cont.):

5- Entertococci.
6- Brucella.
7- Anaerobes.
8- Fungi.
9- Rickettsiae.
10- Chlamydia.
11- Viruses.
Classic Syndrome:

Fever, Anemia, Heart Murmur, Embolic phenomena (FAME).

1. Fever: 90% of patients.
2. Heart murmur: 85% have murmur at some stage.
   90% of patients with a new regurgitant murmur develop CHF.

(cont.)
3. Cutaneous:

Petichiae are the commonest finding (20-40%).
Osler nodules (10-25%).
Splinter hemorrhages (15%).
Janeway lesions (<10%).

4. Ophthalmologic:

Conjunctival petichiae: common.
Roth spot: (<5%).

(cont.)
5. Splenomegaly: 25 – 60%.

6. Musculoskeletal:
   Back pain: the presenting complaint in 5-10% of cases.
   Arthritis: can be both immunologic and septic.
Janeway lesions
Splinter hges
Roth Spot
INFECTIVE ENDOCARDITIS IN CHILDREN
LABORATORY & IMAGING FINDINGS

1. Blood cultures:
   Positive in 99% if prior to starting antibiotics. Multiple blood cultures, long incubation, and check for HACEK organisms.

2. CBC:
   Anemia in 50-80%.
   Leukocytosis is usually present.
   Thrombocytopenia is unusual.

(cont.)
3. ESR: Almost always elevated but nonspecific.

4. CRP: Commonly elevated but nonspecific.

5. Urinalysis: Microscopic hematuria and proteinuria are the commonest findings (*immune complex injury*). Pyuria (*metastatic infection*), cellular casts (*immune complex mediated glomerulonephritis*), or gross hematuria (*infarction*) may be seen.

6. Rheumatoid Factor: Positive in 50%. Resolves after appropriate treatment. (cont.)
7. CXR:
   - Peripheral nodular densities (*metastatic lesions*).
   - Pleural effusions in 75% of cases.
   - Cavitations or atelectasis.

8. Echocardiogram:
   - Looking for vegetations, myocardial abscess, valve competence, and risk for embolism.
   - A- TTE: less sensitive for vegetations (40-70%) but noninvasive.
   - B- TEE: 90-95% sensitive for a vegetation.
INFECTIVE ENDOCARDITIS IN CHILDREN

DIAGNOSIS:

The most acceptable current diagnostic criteria are:

Duke Criteria

Duke criteria are divided into:
A- Major criteria.
B- Minor criteria.

For definite diagnosis we must have:
2 major criteria, or
1 major + 3 minor criteria, or
5 minor criteria.

(cont.)
Duke Major Criteria:

1- Positive blood culture for a typical pathogen or multiple positive cultures.

2- Evidence of endocardial involvement:
   a- New evidence of valve regurgitation (i.e. new coming murmur).
   b- Positive echocardiogram: vegetation present or intra-cardiac abscess.
Duke Minor Criteria:

1. Fever.
2. Presence of predisposing heart disease.
3. Positive blood culture but not for a typical pathogen.
4. Echo finding but not meeting major criterion.
5. Immune phenomena: Osler node, Roth spot, or glomerulonephritis.
6. Vascular phenomena: Janeway lesion, arterial emboli, or intracranial hemorrhage.
Additional ? Minor Criteria

1. Newly diagnosed splenomegaly.
2. Newly diagnosed clubbing.
3. Splinter hemorrhages.
4. Petechiae.
5. High ESR and/ or high C-reactive protein.
6. Microscopic hematuria.
7. Central or Peripheral venous lines.
Mortality remains at 20-25%. Complications occur in 50-60% of cases. The commonest complications are:

1. Cardiac failure due to valve vegetations, myocardial abscesses, toxic myocarditis, acquired VSD, or heart block.
2. Systemic emboli: often with central nervous system or renal manifestations.
4. Ruptured mycotic aneurysms.
INFECTIVE ENDOCARDITIS IN CHILDREN

TREATMENT:

For **Complete** eradication of the causing organism we need **Prolonged, Parenteral, and Bactericidal** antibiotic regimen guided by antibiotic sensitivity studies. **Empiric treatment** should be started as soon as diagnosis is suspected.

Recommended combination of **penicillinase resistant penicillin** (or vancomycin) and **gentamicin** can be initiated. (cont.)
SURGICAL INDICATIONS IN ENDOCARDITIS

1. Hemodynamically unstable:
   a. New or worsening heart failure.
   b. Valvular dysfunction.

2. Uncontrolled infection:
   a. Remaining positive blood cultures.
   b. Fungal endocarditis.
   c. Perivalvular or myocardial abscess.

3. Embolic manifestations.
Prevention of Infective Endocarditis

Updated Guidelines From the American Heart Association (2007)
Prevention of Infective Endocarditis

IE prophylaxis used to be indicated (before 2007 updates) in:

1. Moderate and high risk cardiac conditions.
2. Prior to dental, upper respiratory tract procedures, GI, and GU procedures.
Updated Guidelines From the American Heart Association (2007)

IE prophylaxis is indicated in:

1. High risk cardiac conditions.

2. Prior to dental, upper respiratory tract procedures.
Cardiac Conditions Associated with the Highest Risk of Adverse Outcome from Endocarditis for Which Prophylaxis with Dental Procedures is Recommended

- Prosthetic cardiac valve
- Previous infective endocarditis
- Congenital heart disease (CHD)*
  - Unrepaired cyanotic CHD, including those with palliative shunts and conduits
  - Completely repaired CHD with prosthetic material or device either by surgery or catheter intervention during the first 6 months after the procedure**
  - Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)
- Cardiac transplantation recipients who develop cardiac valvulopathy

*Except for the conditions listed above, antibiotic prophylaxis is no longer recommended for any other form of congenital heart disease.

**Prophylaxis is recommended because endothelialization of prosthetic material occurs within 6 months after the procedure.
Endocarditis Prophylaxis for Dental Procedures

Highest-risk patients require endocarditis prophylaxis for all dental procedures that involve manipulation of gingival tissue or the periapical region of teeth or perforation of the oral mucosa.

Exceptions that do not require prophylaxis:

- Routine anesthetic injections through noninfected tissue
- Taking of dental radiographs
- Placement of removable prosthodontic or orthodontic appliances
- Adjustment of orthodontic appliances
- Placement of orthodontic brackets
- Shedding of deciduous teeth and bleeding from trauma to the lips or oral mucosa

Source: Cardiosource © 2007 by the American College of Cardiology Foundation
# Regimens for a Dental Procedure

<table>
<thead>
<tr>
<th>Situation</th>
<th>Agent</th>
<th>Regimen – Single Dose (30-60 Minutes Before Procedure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>amoxicillin</td>
<td>Adults: 2 gm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Children: 50 mg/kg</td>
</tr>
<tr>
<td>Unable to take oral medication</td>
<td>ampicillin or cefazolin or ceftriaxone</td>
<td>Adults: 2 g IM or IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Children: 50 mg/kg IM or IV</td>
</tr>
<tr>
<td>Allergic to penicillins or ampicillin (oral)</td>
<td>cephalaxin*† or clindamycin or azithromycin or clarithromycin</td>
<td>Adults: 2 g IM or IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Children: 50 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 mg/kg</td>
</tr>
<tr>
<td>Allergic to penicillins or ampicillin (unable to take oral meds)</td>
<td>cefazolin or ceftriaxone† or or clindamycin</td>
<td>Adults: 1 g IM or IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Children: 50 mg/kg IM or IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 mg/kg</td>
</tr>
</tbody>
</table>

*Or other first or second generation oral cephalosporin in equivalent adult or pediatric dosage.
†Cephalosporins should not be used in an individual with a history of anaphylaxis, angioedema, or urticaria with penicillins or ampicillin. IM = intramuscular; IV = intravenous.
Thank you