PHYSIOLOGIC CONSIDERATIONS DURING PREGNANCY

A. CARDIOVASCULAR PHYSIOLOGY

► Higher rates of obesity, hypertension, and diabetes

o Half of adults aged 20 and older have at least one risk factor for cardiovascular disease

► Another related reason is delayed childbearing

► Cardiac output increases by 30-50, average of 40%

o 20% of this total takes place by 8 weeks gestation and is maximal by mid-pregnancy (25-32 weeks)

o Increase heart rate (approx. 10bpm)

-12-16 weeks AOG

- 32-36 weeks AOG

► Resting pulse and stroke volume are even higher later in pregnancy

► Increase venous pressure within lower extremities comparing upper extremities

► Multifetal pregnancies

► After 28 weeks' gestation

► Heart failure develops peripartum {nl}} nbsp; - Preeclampsia, hemorrhage and anemia, and sepsis

B. VENTRICULAR FUNCTION IN PREGNANCY

►Hemodilution --> increased renin production

-increased end-systolic and end-diastolic dimensions

► For given filling pressures, there is appropriate cardiac output so that cardiac function during pregnancy is eudynamic

- Spherical remodelling –> depressed longitudinal deformation

Diagnostic Studies

- Electrocardiogram (ECG)
- Radiography
- Echocardiography
- Cardiovascular MR Imaging
- Cardiac catheterization

Classification of Functional Heart Disease

- Class I. Uncompromised
- Class II. Slight limitation of physical activity
- Class III. Marked limitation of physical activity
- Class IV. Severely compromised

Risk Classification of CVD and Pregnancy

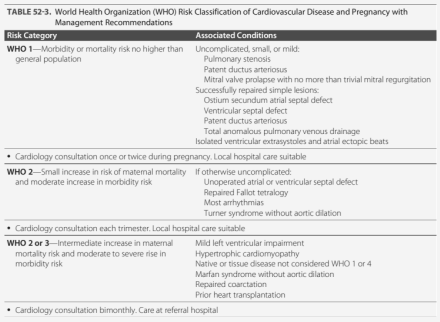
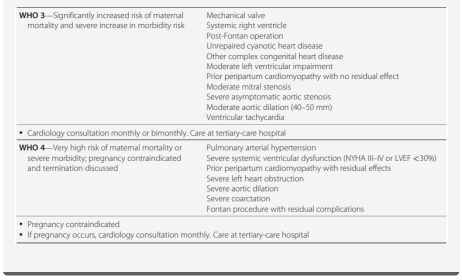


TABLE 52-3. World Health Organization (WHO) Risk Classification of Cardiovascular Disease and Pregnancy with Management Recommendations

Risk Category	Associated Conditions
WHO 1—Morbidity or mortality risk no higher than general population	Uncomplicated, small, or mild: Pulmonary stenosis Patent ductus arteriosus Mitral valve prolapse with no more than trivial mitral regurgitation Successfully repaired simple lesions: Ostium secundum atrial septal defect Ventricular septal defect Patent ductus arteriosus Total anomalous pulmonary venous drainage Isolated ventricular extrasystoles and atrial ectopic beats
• Cardiology consultation once or twice during pregnancy. Local hospital care suitable	
WHO 2—Small increase in risk of maternal mortality and moderate increase in morbidity risk	If otherwise uncomplicated: Unoperated atrial or ventricular septal defect Repaired Fallot tetralogy Most arrhythmias Turner syndrome without aortic dilation
• Cardiology consultation each trimester. Local hospital care suitable	
WHO 2 or 3—Intermediate increase in maternal mortality risk and moderate to severe rise in morbidity risk	Mild left ventricular impairment Hypertrophic cardiomyopathy Native or tissue disease not considered WHO 1 or 4 Marfan syndrome without aortic dilation Repaired coarctation Prior heart transplantation
• Cardiology consultation bimonthly. Care at referral hospital	

Risk Classification of CVD and Pregnancy (cont.)



WHO 3—Significantly increased risk of maternal mortality and severe increase in morbidity risk	Mechanical valve Systemic right ventricle Post-Fontan operation Unrepaired cyanotic heart disease Other complex congenital heart disease Moderate left ventricular impairment Prior peripartum cardiomyopathy with no residual effect Moderate mitral stenosis Severe asymptomatic aortic stenosis Moderate aortic dilation (40–50 mm) Ventricular tachycardia
• Cardiology consultation monthly or bimonthly. Care at tertiary-care hospital	
WHO 4—Very high risk of maternal mortality or severe morbidity; pregnancy contraindicated and termination discussed	Pulmonary arterial hypertension Severe systemic ventricular dysfunction (NYHA III–IV or LVEF <30%) Prior peripartum cardiomyopathy with residual effects Severe left heart obstruction Severe aortic dilation Severe coarctation Fontan procedure with residual complications
• Pregnancy contraindicated • If pregnancy occurs, cardiology consultation monthly. Care at tertiary-care hospital	

PERIPARTUM MANAGEMENT CONSIDERATIONS

►Women in NYHA class I and most in class II- No morbidity

- Avoid contact with persons who have respiratory infections

-Cigarette smoking and illicit drug use are prohibited

► Women in NYHA class III and IV

Prolonged hospitalization and bedrest

LABOR AND DELIVERY

► Vaginal delivery under epidural anesthesia

► Indication for Cesarean delivery

- dilated aortic root >4 cm or aortic aneurysm;

- acute severe congestive heart failure;

- recent myocardial infarction;

- severe symptomatic aortic stenosis;

- warfarin administration within 2 weeks of delivery;

- need for emergency valve replacement immediately after delivery

ANALGESIA AND ANESTHESIA

► IV analgesia - Continuous epidural analgesia

► Women with pulmonary arterial hypertension or aortic stenosis - narcotic regional or general anesthesia

► Significant heart disease - Subarachnoid block not generally recommended

► Cesarean delivery - epidural analgesia

INTRAPARTUM HEART FAILURE

‣ Cardiovascular decompensation during labor may manifest as pulmonary edema with **hypoxia or as hypotension**, or both.

-K-sparing diuretics B-blocking agents

PUERPERIUM

‣ Decompression —> Intravascular compartment —> peripheral vascular resistance —> increased myocardial performance

‣ For puerperal tubal sterilization after vaginal delivery, the procedure can be delayed up to several days to ensure that the mother has normalized hemodynamically

SURGICALLY CORRECTED HEART DISEASE

Valve replacement before pregnancy

Porcine tissue valves

LIFETIME ANTICOAGULATION (MECHANICAL VALVE)

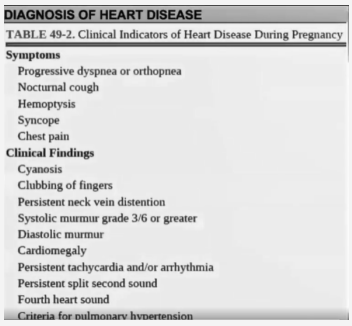
‣ Warfarin - dose given at <5mg/d

‣ Heparin

- high maternal mortality

- Overdose: Protamine Sulfate

DIAGNOSIS OF HEART DISEASE



DIAGNOSIS OF HEART DISEASE

TABLE 49-2. Clinical Indicators of Heart Disease During Pregnancy

Symptoms
Progressive dyspnea or orthopnea
Nocturnal cough
Hemoptysis
Syncope
Chest pain
Clinical Findings
Cyanosis
Clubbing of fingers
Persistent neck vein distention
Systolic murmur grade 3/6 or greater
Diastolic murmur
Cardiomegaly
Persistent tachycardia and/or arrhythmia
Persistent split second sound
Fourth heart sound
Criteria for pulmonary hypertension

RECOMMENDATIONS FOR ANTICOAGULATION

1. Adjusted-dose LMWH (SC below umbilicus) is given twice daily, given until 13 weeks, and then warfarin is substituted until near delivery and is replaced by Heparin again.

2. In women judged to carry a high risk of thrombosis, warfarin is suggested throughout pregnancy, then Heparin is substituted close to delivery. In addition, aspirin, 75 to 100 mg, is given daily. Heparin is discontinued 24 hrs before delivery. If delivery happens while the anticoagulant is still effective, and extensive bleeding is encountered, then protamine sulfate is given intravenously.

3. Anticoagulant therapy with warfarin or heparin may be restarted 6 hours following vaginal delivery. If CS delivery, full anticoagulation is withheld, resuming heparin 6 to 12 hours or after 24 hours

CARDIAC SURGERY DURING PREGNANCY

‣ Valve replacement - lifesaving

‣ Elective surgery

- Pump flow rate should remain >2.5 L/min/m2

- Normothermic perfusion pressure should exceed 70 mm Hg

- Hematocrit should be kept >28 volumes percent

PREGNANCY AFTER HEART TRANSPLANTATION

‣ Major complications

- Rejections during the early puerperium

- Renal failure

- Spontaneous abortions

CONGENITAL HEART DISEASE

Atrial Septal Defects

‣ Atrial septal defects (ASDS) - asymptomatic until the third or fourth decade

‣ Secundum-type (70%)

‣ Pregnant woman with ADS - managed with compression stockings and prophylactic heparin

Ventricular Septal Defects

‣ Paramembranous

‣ Pregnancy is well tolerated with small-to-moderate sized shunts

‣ Eisenmenger syndrome - pregnancy not advisable

‣ 10-16% - can be inherited

Atrioventricular Septal Defects

‣ 3% of all congenital cardiac malformations Complications include

‣ Complications include

- 23% persistent deterioration of NYHA class

- 9% significant arrhythmias

- 2% heart failure

‣ Seen in 15% of the offspring

Persistent (Patent) Ductus Arteriosus

‣ The ductus connects the proximal left pulmonary artery to the descending aorta just distal to the left subclavian artery

‣ Prophylaxis for bacterial endocarditis is indicated at deliver

‣ For unrepaired defects the incidence of inheritance is 4%

Cyanotic Heart Disease

‣ Producing right-to-left shunting of blood past the pulmonary capillary bed and developing cyanosis

CONGENITAL HEART DISEASE (cont)

- Most common is Tetralogy of Fallot - maternal mortality rate approaches 10%
- Ebstein anomaly

Pregnancy after Surgical Repair

- Transposition of the Great Vessels
  - Prior Mustard and Senning procedure
- Single Functional Ventricle
  - Fontan repair - high risk for complications.
- Eisenmenger Syndrome
  - Considered to be an absolute contraindication to pregnancy

VALVULAR HEART DISEASE

Mitral Stenosis secondary to Rheumatic Endocarditis

- Normal mitral valve - 4.0 cm2; stenosis <2.5 cm2
- Consequences:
  - passive pulmonary HTN
  - 25% of women with mitral stenosis have heart failure for the first time during pregnancy
  - pulmonary edema
- Management
  - Limited physical activity
  - B-blocker drug therapy
  - If new-onset atrial fibrillation develops
    - Intravenous verapamil, 5 to 10 mg
    - Electrocardioversion is performed.
  - If Chronic fibrillation
    - Digoxin, a B-blocker, or a calcium-channel blocker can slow ventricular response
- Surgical intervention is considered for women with symptomatic severe mitral stenosis: Balloon valvuloplasty

VALVULAR HEART DISEASE (cont)

Mitral Insufficiency

- Acute mitral insufficiency
- Chronic mitral regurgitation

Mitral valve prolapse

- Myxomatous degeneration
- B-blockers

Aortic Stenosis

- Congenital lesion: bicuspid valve
- During pregnancy, several common events acutely lower preload further
- Complication rates were higher if the aortic valve area measured

Management

- Asymptomatic - observation
- Symptomatic:
  - Strict limitation of activity and treatment of infections
  - Critical aortic stenosis - intensive monitoring during labor is essential
- During labor and delivery, narcotic epidural analgesia seems ideal and avoids potentially hazardous hypotension

Aortic Insufficiency

- Aortic valve regurgitation or insufficiency allows diastolic flow of blood from the aorta back into the left ventricle.
- If symptoms of heart failure develop, diuretics are given and bed rest is encouraged

Pulmonic Stenosis

- Usually congenital
- May be associated with Fallot tetralogy or Noonan syndrome

VALVULAR HEART DISEASE (cont)

- Surgical correction done before pregnancy; if symptoms progress - balloon valvuloplasty

PULMONARY HYPERTENSION

TABLE 52-8. Comprehensive Clinical Classification of Pulmonary Hypertension of the European Society of Cardiology and the European Respiratory Society

1. Pulmonary arterial hypertension
- Idiopathic
- Heritable
- Drug and toxin induced
- Associated with connective tissue disease; HIV infections, portal hypertension, congenital heart diseases, schistosomiasis

1′ Pulmonary venoocclusive disease and/or pulmonary capillary hemangiomatosis
- Idiopathic
- Heritable
- Drugs, toxins and radiation induced
- Associated with connective tissue disease; HIV infection

1″ Persistent pulmonary hypertension of the newborn

2. Pulmonary hypertension due to left heart disease
- Left ventricular systolic dysfunction
- Left ventricular diastolic dysfunction
- Valvular disease
- Congenital/acquired left heart inflow/outflow tract obstruction and congenital cardiomyopathies
- Congenital/acquired pulmonary vein stenosis

3. Pulmonary hypertension due to lung diseases and/or hypoxia
- Chronic obstructive pulmonary disease
- Interstitial lung disease
- Other pulmonary diseases with mixed restrictive and obstructive pattern
- Sleep-disordered breathing
- Alveolar hypoventilation disorder
- Chronic exposure to high altitude
- Developmental lung diseases

4. Chronic thromboembolic pulmonary hypertension/other pulmonary artery obstructions
- Chronic thromboembolic pulmonary hypertension
- Other pulmonary artery obstructions, ie, tumors, arteritis, pulmonary stenosis, parasites

5. Pulmonary hypertension with unclear and/or multifactorial mechanisms
- Hematological disorders: chronic hemolysis, myeloproliferative disorders, splenectomy
- Systemic disorders: sarcoidosis, pulmonary histiocytosis, neurofibromatosis
- Metabolic disorders: glycogen storage disease, Gaucher disease, thyroid disorders
- Others: fibrosing mediastinitis, chronic renal failure

PULMONARY HYPERTENSION (cont)

Diagnosis

- Symptoms may be vague
- Chest radiography often shows enlarged pulmonary hilar arteries and attenuated peripheral markings
- Final common pathway of pulmonary hypertension - right heart failure and death
- The maternal mortality rate increased - idiopathic pulmonary hypertension

Management

- Activity limitation
- Diuretics, supplemental oxygen, and pulmonary vasodilator drugs are standard therapy
- Prostacyclin analogues
- Inhaled nitric oxide
- Phosphodiesterase-5 inhibitors
- Bosentan - contraindicated in pregnancy

INFECTIVE ENDOCARDITIS

- Risk Factors:
  - Congenital heart lesions Intracardiac devices
  - Intravenous drug users
  - Degenerative valve disease
  - Intracardiac devices
- Diagnosis and Management:
  - Fever - 80%
  - Murmur
  - Constitutional symptoms
- Duke's criteria:
  - Positive blood cultures for typical organisms and evidence of endocardial involvement
- Pregnancy
- The American Heart Association recommends prophylaxis for dental procedures in those with:
  - A prosthetic valve used in a valve repair
  - Prior endocarditis
  - Unrepaired cyanotic hear defect or repaired lesion with residual defect at prosthetic sites
  - Valvulopathy after heart transplantation

INFECTIVE ENDOCARDITIS (cont)

TABLE 52-9. Single-Dose Antibiotic Prophylaxis for Infective Endocarditis in High-Risk Patients

American College of Obstetricians and Gynecologists (2018b)
Standard (IV): ampicillin 2 g ***or*** cefazolin or ceftriaxone 1 g
Penicillin-allergic (IV): cefazolin or ceftriaxone 1 g ***or*** clindamycin 600 mg
Oral: amoxicillin 2 g

American Heart Association/European Society of Cardiology (Karchmer, 2018)
Standard: amoxicillin 2 g PO ***or*** ampicillin 2 g IV or IM
Penicillin-allergic: clarithromycin or azithromycin 500 mg PO; cephalexin 2 g PO; clindamycin 600 mg PO, IV, or IM; ***or*** cefazolin or ceftriaxone 1 g IV or IM

IM = intramuscularly; IV = intravenously; PO = per os (orally).
Cefazolin or ceftriaxone given 30 minutes, and all others given 1 hour prior to procedure

HEART FAILURE

- Risk factors include
  - Preeclampsia
  - Hemorrhage
  - Infection
- Symptoms
  - Dyspnea

HEART FAILURE (cont)

  - Orthopnea, palpitations,
  - substernal chest pain
- Clinical findings include:
  - Persistent basilar rales, hemoptysis
  - Cardiomegaly and pulmonary edema
- Diagnosis
  - Acute flash edema
  - Onset: at the end of the second/beginning of the third trimester and peripartum
- Management:
  -Diuretic administration
  - Hypertension - hydralazine
  - Chronic heart failure - Heparin

CARDIOMYOPATHY

- Primary Cardiomyopathy
- Secondary Cardiomyopathy

Hypertrophic Cardiomyopathy

- Hypertrophied and nondilated left ventricle (echocardiography)
- Most women are asymptomatic
- Sudden death - most frequent cause of death
- Management:
  - Strenuous exercise is prohibited during pregnancy.
  - Drugs that evoke diuresis or diminish vascular resistance are generally not used

Dilated Cardiomyopathy

- Characterized by left and/or right ventricular enlargement and reduced systolic function

Peripartum Cardiomyopathy

- Diagnostic criteria:

CARDIOMYOPATHY (cont)

1. Development of cardiac failure in the last month of pregnancy or within 5 months after delivery
2. Absence of a cause for the cardiac failure
3. Absence of recognizable heart disease prior to the last month of pregnancy
4. Left ventricular systolic dysfunction demonstrated by classic echocardiographic criteria

- Preeclampsia with cardiomyopathy
  - Began postpartum
  - 50% recover within 6 months of delivery
- Preeclampsia with hypertensive heart failure
  - Symptoms start antepartum
  - Mortality rate approaches 85%

Other Cardiomyopathy Types

- Arrhythmogenic right ventricular dysplasia
  - Progressive replacement of right ventricular myocardium with adipose and fibrous tissue.
- Restrictive cardiomyopathy is probably the least common type
  -Inherited cardiomyopathy
  - Pregnancy is not advised
- Takotsubo cardiomyopathy
  - Rare form of acute reversible left ventricular apical wall ballooning

ARRHYTHMIAS

Bradyarrhythmias

- Compatible with a successful pregnancy
- Some women with complete heart block have syncope during labor and delivery, and occasionally temporary cardiac pacing is necessary
- Women with permanent artificial pacemakers usually tolerate pregnancy well

ARRHYTHMIAS (cont)

Supraventricular Tachycardias

- Paroxysmal supraventricular tachycardia
  - Twofold greater risk of septal defects
  - Embolic stroke
- For acute treatment, raising vagal tone and blocking the atrioventricular node is done by:
  -Vagal maneuvers, which include Valsalva maneuver
  - Carotid sinus massage, bearing down
  - Immersion of the face in ice water
  - Intravenous adenosine is a short-acting endogenous nucleotide that also blocks atrioventricular nodal conduction.
- Synchronize cardioversion - recommended
- Long term anticoagulation
  - Intravenous metoprolol or propranolol
  - Intravenous verapamil
  - Intravenous procainamide
  - Intravenous amiodarone
- Pregnancy may predispose otherwise asymptomatic women with Wolff-Parkinson-White (WPW) syndrome to exhibit arrhythmias

Ventricular Tachycardia

- Uncommon in healthy young women without underlying heart disease pregnancy
- Emergency cardioversion

Prolonged QT-Interval

- Torsades de pointes
- B-blocking agents-propranolol
- Many medications may predispose to QT prolongation

DISEASES OF THE AORTA

Aortic Dissection

- Marfan syndrome and coarctation
- Bicuspid aortic valve, Turner or Noonan syndrome and Ehlers- Danlos syndrome
- Initial medical treatment - lower blood pressure
- Proximal dissections - resected and the aortic valve replaced if necessary
- Distal dissections - may be treated medically

Marfan Syndrome

- Autosomal dominant connective tissue disorder
- 2 to 3 cases per 10,000 individuals
- Characterized by generalized tissue weakness that can result in dangerous cardiovascular complications
- Prophylactic aortic repair Prophylactic ß-blocking agents
- Vaginal delivery with regional analgesia - <4cm
- Elective CS - 4-5cm

Aortic Coarctation

- Relatively rare lesion
- The aorta is abnormally narrowed and is often accompanied by abnormalities of other large arteries
- Typical findings include hypertension in the upper extremities but normal or reduced pressures in the lower extremities.
- Major complications with aortic coarctation include:
  - Congestive heart failure , and aortic rupture
  - Bacterial endocarditis of the bicuspid aortic valve

DISEASES OF THE AORTA (cont)

- B-blocking drugs

ISCHEMIC HEART DISEASE

Myocardial Infarction During Pregnancy

- Mortality rate in pregnancy is higher compared with age- matched nonpregnant women
- Coronary angiography - diagnostic gold standard
- Myocardial ischemia is also associated with prostaglandin E1 vaginal suppositories given for labor induction
- Treatment
  - Percutaneous transluminal coronary angioplasty and stent placement during pregnancy is successful
  - If the infarct has healed sufficiently, cesarean delivery is reserved for obstetrical indications, and epidural analgesia is ideal for labor

Pregnancy with Prior Ischemic Heart Disease

- Pregnancy in most of these women seems inadvisable
  - Ventricular performance should be assessed
  - For those who become pregnant before these studies are performed, echocardiography is done.
  - Exercise tolerance testing may be indicated, and radionuclide ventriculography exposes the fetus to minimal radiation