Cardiovascular problems in pregnancy[1]

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The past two decades have witnessed major advances in the treatment of the pregnant woman with a cardiovascular disorder. A greater awareness of the physiologic burden that pregnancy places upon the already compromised cardiovascular system has led to more accurate preconception counseling and improved surgical and medical care of these patients. The authors present a current overall review of the subject, including acquired and congenital heart disease, coronary artery disease, management of prosthetic valves during pregnancy, common drugs encountered, and peripartum cardiomyopathy.

Index term: Pregnancy complications, cardiovascular

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The altered physiologic state of pregnancy presents a unique challenge to those involved in the medical care of these patients. This is most evident during gestation for patients with cardiovascular problems. When evaluating and treating a pregnant woman with a cardiovascular disorder, the cardiologist-internist must keep in mind that this is not one, but two patients.

Cardiovascular disease may predate pregnancy (atrial septal defect, ventricular septal defect, valvular heart disease) or be induced by it (peripartum cardiomyopathy, preeclampsia). Pregnancy may improve, worsen, or not alter the woman's clinical status.

The past two decades have brought about a decline in both maternal and fetal morbidity and mortality. Maternal mortality ranges from 0.4% in functional class I–II patients

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(NYHA) to 6.8% overall in class III–IV patients.[1,2]

The incidence of heart disease in pregnancy has remained constant at 0.4% to 4.1%,[3] despite improved outcome. This is primarily because of improved medical management and early antepartum surgical correction of congenital and acquired cardiac lesions. These various interventions have produced a new population of patients once advised against pregnancy. The offspring of a patient with congenital heart disease may have as high as a 15% likelihood of being affected by the same defect.[4]

Hemodynamic physiology in pregnancy

Soon after implantation of the fertilized ovum, a number of cardiovascular and respiratory physiologic changes affect its proper growth and development. These changes are well tolerated by women with a normal cardiovascular system and by most women with organic heart disease. However, a number of cardiovascular disorders are made worse by the increased circulatory burden of pregnancy. To participate in the diagnosis and management of these patients, one must have a working knowledge of the circulatory physiologic changes brought about by pregnancy, including changes in blood volume, cardiac output, and systemic and pulmonary vascular resistances. The subject of cardiovascular physiology as it pertains to pregnancy has been extensively reviewed by Metcalfe et al.[5] We highlight this and other work.

Blood volume

Blood volume, under the influence of the renin-angiotensin-aldosterone system, begins to increase early in the first trimester, reaching a plateau at 30–32 weeks nearly 50% above baseline levels, accounting for an average weight gain of 10–15 kg.[3,5] The mechanisms that increase plasma volume are complex and appear to be estrogen- and progesterone-mediated.[5,6] Increased plasma renin activity encourages sodium retention and an increase in total body water via aldosterone secretion. As much as 500–900 mEq of sodium and 5–6 L of total body water retention occurs in the course of an average pregnancy. A disproportionate increase in fluid accounts for an average decrease in plasma osmolality of 10 mOsm/Kg.[6] Blood volume is increased in the multiparous patient and in patients with multiple fetuses in utero.[3,5] Maximum blood volume is maintained until term, when the source of hormone elevation is gone and a spontaneous diuresis occurs. This is a very crucial period in the management of the patient with moderate to severe left ventricular dysfunction or left ventricular outflow obstruction, such as idiopathic hypertropic subaortic stenosis,[7,8] who relies on increased blood volume to maximize cardiac output. A sudden diminution in left ventricular filling volume may result in severe outflow obstruction.

RBC mass

Coincident with increased blood volume is increased RBC mass by 20–40%. The red cell and plasma volume changes account for the anemia seen in normal pregnancy, despite normal iron and folate stores.[5] Blood viscosity is decreased, which may be a hemodynamic advantage.[9] The hemoglobin concentration can be kept near normal values with administration of supplemental iron.

Cardiac output

Cardiac output begins to increase by the 10th weeks and plateaus at 40% above baseline by the 20th week. Cardiac output has been demonstrated to decrease significantly during the latter half of pregnancy.[10] However, these studies were performed with the patient supine; in this position the venous return is inhibited significantly by the weight of the enlarging uterus on inferior vena caval blood flow. Subsequent work by Ueland et al[11] demonstrated much less significant decrements in cardiac output when measurements are made in the left lateral decubitus or sitting positions. Increased stroke volume accounts for the initial rise in cardiac output in the first half of pregnancy.[5] This is later maintained by an increased heart rate. Rubler[12] demonstrated echocardiographic evidence of increased right and left ventricular dimensions early in pregnancy, with an increase in the velocity of circumferential shortening throughout pregnancy. The combination then of increased blood volume, decreased systemic vascular resistance, and increased cardiac contractility account for the elevated cardiac output. The enhanced contractility as well as decreased vascular resistance may well be steroid-mediated.[4,12]

Blood pressure

Blood pressure normally falls during pregnancy. A greater fall in diastolic pressure occurs,

resulting in an increased pulse pressure and stroke volume.[13] Despite an increase in stroke volume, blood pressure decreases as a result of decreased systemic and pulmonic vascular resistance thought to be prostacyclin-mediated from the placenta.

Effects of labor and delivery

The period surrounding labor, delivery, and early postpartum is particularly dangerous for the patient with cardiac disease. Both pain from labor and increased venous return from the contracting uterus combine to increase cardiac output by 20%.[11] Heart rate declines by 8% and stroke volume increases by 22% with the patient supine, and these changes are less pronounced with the patient in the lateral decubitus position.[5]

The mode of anesthesia influences hemodynamic changes that occur during labor and delivery. When pain is not well controlled as labor progresses, cardiac output (CO) increases to as high as 45–50% above baseline values.[5] However, regional anesthesia results in a less profound increase in cardiac output, especially between contractions, and provides a more stable hemodynamic environment in these patients.[3]

Respiratory changes during normal pregnancy

Minute ventilation and oxygen consumption increase during pregnancy. There is a state of mild hyperventilation thought to be caused by the central action of progesterone.[14] Increased minute ventilation results in a mild, compensated respiratory alkalosis.

Cardiopulmonary symptoms and signs in normal pregnancy

A number of cardiopulmonary symptoms and signs that occur in normal pregnancy may simulate heart disease.[3] Recognizing these normal changes is essential to avoid over-diagnosing cardiac disease. Fatigability, dyspnea, and decreased exercise tolerance are commonly recognized. A supine hypotensive syndrome, the result of an enlarging uterus impeding inferior vena caval blood flow, may result in light-headedness or even syncope.[15] A physical examination may reveal peripheral edema and basilar rales. A small "water hammer pulse" because of the increase in pulse pressure may simulate the bounding pulse of aortic insufficiency. The increase in vascular volume may result in permanent, irregular venous pulsations and increased right ventricular impulse. S1 and P2 are increased in most patients, and there may be a loud third or fourth heart sound noted as the result of a volume-overloaded, hypercontractile myocardium.[3] Various murmurs are appreciated during pregnancy. The most frequently noted is a soft midsystolic murmur heard with greatest intensity at the left upper sternal edge.[16] This has been attributed to increased pulmonic blood flow. Supraclavicular systolic murmurs are heard because of increased flow through the innominate and left subclavian arteries. Continuous murmurs are produced by venous hums and the mammary and uterine souffles.[3]

Diagnostic evaluation

The diagnostic workup of the patient with heart disease and pregnancy should include routine blood work, electrocardiography to evaluate left or right ventricular hypertrophy, and, if necessary, Holter monitoring for arrhythmia evaluation. Chest x-ray should not be performed routinely, but may, if necessary, be safely done with shielding after the first trimester.[3] With the advent of two-dimensional (2-D) echocardiography to evaluate congenital and rheumatic cardiac disorders, the need for invasive procedures, such as left heart catheterization, in pregnant patients has diminished. Although Majdan described successful heart catheterization using the Sones' technique,[17] this procedure should be avoided when possible.

Noninvasive means of evaluating the function and structure of the heart during pregnancy include real-time two-dimensional[18] and pulsed Doppler echocardiography.[19] These methods can now accurately assess the presence and severity of rheumatic and congenital heart lesions and may be used throughout gestation to follow the hemodynamic status of the patient. The most recent advancement in Doppler systems includes real-time color flow mapping, offering for the first time spatial relationship of cardiac blood flow.[20,21] Its use in congenital heart disease has recently been reviewed by Swenson,[22] who describes the color flow findings in three simple congenital lesions, including atrial septal defect (ASD), ventricular septal defect (VSD), and patent ductus arteriosus (PDA).

Because of the increased incidence (up to 15%) of congenital heart defects in the fetus of a parent with congenital heart disease, noninvasive assessment of this possibility is available and should be

used to aid prenatal counseling, perinatal management, and postnatal care. The use of 2-D echocardiography to evaluate spatial anatomy and rhythm disturbances of the infant in utero has rapidly evolved since 1980[23,24] and may be performed as early as the 16th week of gestation.[24] The addition of pulsed Doppler[25] and more recently Doppler color flow mapping[26] of the fetal heart have been reviewed and proven to be of additional benefit in selected cases.

Acquired and congenital heart disease

Cardiac lesions well tolerated

Mitral and aortic insufficiency: Chronic mitral or aortic insufficiency is usually well tolerated during pregnancy if the patient is asymptomatic or only mildly symptomatic before gestation. However, NYHA functional class III–IV patients with surgically correctable cardiac disease should undergo surgery before pregnancy. If the patient is pregnant when seen for the first time, conservative treatment including bedrest, digitalis, prudent use of diuretics, and close follow-up is usually all that is necessary.[3,27] Infective endocarditis is a real risk, which should be minimized with antibiotic prophylaxis when appropriate.

ASD, VSD, PDA: Congenital arterial-venous shunts, such as ASD, VSD, and PDA, are uniformly well tolerated. Their tolerance depends on the degree of left-to-right shunt and the presence or absence of significant pulmonary hypertension. Fortunately, most patients with significant ASD, VSD, or PDA have had these shunts surgically repaired in childhood.

ASD remains the second most common congenital heart defect after bicuspid aortic valve. As with VSD and PDA, ASD is well tolerated when the shunt is less than 2:1. Rarely, congestive heart failure occurs and is most commonly noted in the older multiparous patient, probably reflecting the natural course of the disease.[28]

VSD is more common than ASD as an isolated lesion in childhood, but the determinants of tolerance are similar. Mendelson[29] reported an 8% heart failure rate and 5.5% mortality rate in 110 cases of unoperated VSD patients who became pregnant. Three patients died of circulatory collapse and three died of heart failure, paradoxical embolus, and infective endocarditis, respectively.

Pulmonary stenosis: Pregnancy, as a rule, is well tolerated in the asymptomatic woman with mild to moderate and occasionally severe pulmonic valvular stenosis.[3] Most patients with transvalvular gradients above 50 mm, however, have undergone valve repair or replacement before pregnancy. Heart failure rarely occurs, despite the increased right ventricular workload. In the rare case requiring surgical intervention during pregnancy, pulmonary valvotomy can be safely and easily accomplished, preferably during the second trimester.[28]

Idiopathic hypertrophic subaortic stenosis (IHSS): Patients with IHSS generally tolerate pregnancy well. Oakley[8] demonstrated a favorable outcome in 54 pregnancies of 23 patients, with no fetal or maternal deaths.

The increase in left ventricular end diastolic volume reduces the obstruction. However, the increased heart rate and fall in systemic vascular resistance counteract this effect. The outflow obstruction may be adversely affected during the third trimester when the patient is supine and again during labor, delivery, and early puerperium. Compression of the inferior vena cava by the enlarging uterus diminishes venous return, augmenting left ventricular outflow obstruction by decreasing left ventricular volume. Adverse effects during labor and delivery include an increase in heart rate because of pain and a decrease in venous return as a consequence of the Valsalva maneuver. However, with each uterine contraction blood is "squeezed out" of the uterine bed and augments venous return, balancing the adverse effects of the Valsalva maneuver.[5] These patients should also be closely observed for worsening outflow obstruction resulting from the diuresis of the first 48 hours of the puerperium. The frequency of coexisting mitral insufficiency exposes these patients to infective endocarditis, which should be avoided with prophylactic antibiotic use.[4] The indication for use of beta-blockers during gestation is not clear. The beneficial hemodynamic and antiarrhythmic effect is questionable, and the use of these drugs is usually not recommended.[8]

Mitral valve prolapse: Mitral valve prolapse is the most commonly diagnosed cardiac abnormality in the United States, with an incidence varying from 1.4% to 6.3% by auscultation[30,31] to 21% by echocardiography.[32] It is necessarily then frequently encountered in pregnant women, but does not appear to alter the course of pregnancy.[4] Complications in a small number of patients have included mitral insufficiency, endocarditis, arrhythmias, thromboembolism, and, very rarely, sudden death.[33] The issue of endocarditis pro-

phylaxis is not entirely clear. The general recommendation has been to administer prophylactic antibiotics at the time of bacteremia-associated procedures, including gynecologic procedures.[34,35] This is particularly important in patients with associated mitral insufficiency.

Cardiac lesions poorly tolerated

In contrast to the cardiac lesions discussed above, there are those that are less well tolerated. These lesions have in common outflow-inflow obstruction and/or right-to-left shunting.

Mitral stenosis: Mitral stenosis still accounts for nearly 90% of rheumatic heart disease during pregnancy, with 25% of patients first developing symptoms during pregnancy.[1] The relative obstruction to flow across the stenosed mitral valve increases throughout pregnancy as blood volume, heart rate, and cardiac output increase. The increased obstruction results in increased pulmonary venous congestion and may lead to frank pulmonary edema. The intrapartum period is a critical time for these patients, with a mean increase in pulmonary capillary wedge pressure of 10 mm Hg.[36] Pulmonary edema increases with maternal age and multiparity, presumably on the basis of the natural history of the disease. Pulmonary venous congestion may occur at any time, but the incidence rises as pregnancy continues.[28] Thrombi within the enlarged left atria remain a major therapeutic challenge in these patients because of the risks and side effects of anticoagulation.[37]

Medical management should include close observation throughout gestation and aggressive treatment of incipient or frank pulmonary edema. This includes bedrest, careful diuresis, and emergent correction of any arrhythmia, such as atrial fibrillation or supraventricular tachycardia. New-onset atrial fibrillation should be treated with digoxin, possibly combined with a beta-blocker to slow the ventricular response. The safety of emergent cardioversion has been demonstrated by a number of authors and should be used when appropriate.[38-40] Heparin should be administered during the first and third trimester in patients with chronic or paroxysmal atrial fibrillation, left atrial clot, or prior embolic history. Oral anticoagulation may be safely used during the second trimester. (See the section on anticoagulation below.)

Surgical management is reserved for those patients with intractable heart failure or hemoptysis. Closed mitral commissurotomy is safe in experienced hands, with a reported maternal and fetal mortality of 3% and 6%, respectively.[41] More recently a study of 23 cases of open valvotomy using cardiopulmonary bypass during pregnancy was reported with no maternal deaths and one fetal death.[42] When mitral valve replacement is necessary, a bioprosthetic valve is recommended to avoid the various complications of anticoagulation during pregnancy.[43] Bacterial endocarditis is a rare but severe complication during pregnancy with almost 100% fetal mortality. Although the routine use of peripartum antibacterial coverage in patients at risk has been questioned from time to time, it is generally recommended from the onset of labor to the sixth or seventh postpartum day.[28]

Aortic stenosis: Valvular aortic stenosis, be it rheumatic or congenital, has often been referred to as a young man's disease and is rarely found in women of childbearing age. High fetal (32%) and maternal (17%) mortality have been reported, with associated moderate to severe aortic stenosis during pregnancy.[44] Maternal mortality may reach 40% when elective abortion has been performed.[44] The transvalvular gradient progressively increases throughout pregnancy as a consequence of the increased blood volume and diminished systemic vascular resistance. This may result in syncope (especially with the patient supine), angina, and decreased perfusion to the fetus and placenta. Patients with moderate to severe aortic stenosis should be advised against pregnancy before surgical correction. If pregnancy does occur, bedrest in the left lateral decubitus position and the avoidance of negative inotropes is recommended. Augmenting preload with fluids and avoiding diuretics may also be beneficial in maintaining the already fixed stroke volume.[27] Again, the use of prophylactic antibiotics is recommended.

Coarctation of the aorta: Coarctation in a woman of childbearing age is increasingly uncommon because of early repair. Maternal morbidity may be as high as 90%.[29] However, the more recent experience of Deal and Wooley[45] suggests improved morbidity and recommends individual management according to functional status, associated defects, and severity. Major risks include congestive heart failure, aortic rupture or dissection, aortic valve endocarditis, and cerebral hemorrhage from associated Berry aneurysms.[3]

Marfan's syndrome: Marfan's syndrome, with its inherent abnormality of the aortic media, predisposes to aortic dissection or rupture. The increased blood volume, pulse pressure, and steroid hormonal influence during pregnancy increase the propensity for this complication to occur. It is generally recommended that those patients with marked aortic root dilatation, defined by one author as greater than 40 mm in diameter,[46] be advised against pregnancy because of the associated 50% maternal mortality.[47]

Tetralogy of Fallot: In patients with Fallot's tetralogy untreated surgically, pregnancy is associated with a fetal and maternal mortality of 30% and 4%, respectively.[28] The fixed, right ventricular outflow obstruction of pulmonary stenosis combined with decreased systemic vascular resistance in pregnancy tends to increase the right-to-left shunt with resultant cyanosis. Unfavorable signs suggested by Jacoby[48] include recurrent syncope, hematocrit above 60 vol%, oxygen saturation less than 80%, and right ventricular systolic pressure above 120 mm Hg.

Primary pulmonary hypertension and Eisenmenger's syndrome: Eisenmenger's syndrome (pulmonary hypertension with an associated reversed or bidirectional shunt at the aortopulmonary, ventricular, or atrial level) presents a major risk to the pregnant woman. As with tetralogy, the decrease in SVR increases right-to-left shunting and worsening of cyanosis. Major risks include sudden death (30–70% maternal mortality), fetal loss, intrauterine growth retardation, right ventricular failure, and hypotension.[28] This remains one of the few cardiovascular indications for therapeutic abortion.

Coronary artery disease

Coronary artery disease (CAD) is uncommon during pregnancy. Ginz[49] has reported an incidence of one in 10,000 deliveries. CAD is usually heralded by a myocardial infarction rather than angina pectoris,[17] and overall maternal mortality ranges from 28% to 52%.[1] The etiology of myocardial infarction related to pregnancy is, in some cases, not associated with true atherosclerosis but rather is secondary to intimal tearing as described by Shaver,[50] who reported on two such patients and reviewed the cases of 12 others. When unstable angina is suspected clinically, cardiac catheterization may be safely performed via the Sones technique with abdominal shielding, as suggested by Majdan.[17] Majdan has reported successful coronary artery bypass surgery on a 36-year-old gravida 5 para 4 woman.

Anticoagulation during pregnancy

A hypercoagulable state exists during pregnancy, characterized by increased levels of certain coagulation factors,[51] by decreased fibrinolysis,[52] and by augmented platelet adhesiveness.[43] Those patients with mechanical prosthetic valves constitute the largest population of patients requiring anticoagulation during pregnancy. Limet[53] has demonstrated that omitting anticoagulant treatment in these women considerably increases the danger of systemic embolization. Indications for anticoagulation in pregnancy are similar to those in a patient who is not pregnant; however, the choice of agent and timing of its use is critical. Neither warfarin nor heparin is ideal in the pregnant woman because of the associated maternal and fetal morbidity and mortality.[43,54] Oral anticoagulants result in an increased incidence of fetal death and birth defects, whereas heparin results in an increased incidence of maternal hemorrhage. Of 418 reported pregnancies during which coumadin derivatives were used, at most two thirds resulted in apparently normal infants.[54] Of 128 pregnancies during which coumadin derivatives were used reported by Salazar,[43] 28% resulted in spontaneous abortion and 7.9% revealed coumadin embryopathy. Spontaneous abortion rates in general ranged between 29% and 44%.[43] The first trimester, especially weeks six through nine, appears to be the most critical time of exposure of the developing infant to coumadin, but the second trimester is not without coumadin-related problems.[54] Maternal and fetal hemorrhage and possibly fetal visual disturbances may still develop as a result of coumadin use during the second trimester.[4]

To avoid the dangers of coumadin exposure, the use of antiplatelet agents has been proposed.[55] Although the rate of spontaneous abortions is reportedly low, thromboembolic episodes have been considerable.[43] In general, this approach is not widely accepted.

Heparin has been found by many to be an effective alternative method of anticoagulation.[43,56] It is not teratogenic because it cannot cross the placenta. However, heparin is cumbersome to administer and impractical during all three trimesters. When heparin is used, the prothrombin time must be monitored closely, be-

cause heparin requirements increase as pregnancy progresses.

Recently, Rayborn and Levin[57] have recommended administering heparin subcutaneously during the entire gestation and following maternal heparin levels, not the prothrombin time.

A seemingly practical method suggested by Spearing[58] would include subcutaneous heparin (10,000 units q 12 hours) during the first trimester and oral anticoagulation during the second and most of the third trimester until approximately two to three weeks before delivery. Heparin therapy should then be resumed until approximately one week postpartum. This regimen is designed to minimize both the maternal and fetal side effects of these drugs (warfarin embryopathy, spontaneous abortion, peripartum bleeding, etc.) while providing maximum protection against thromboembolic episodes.

It is important that the indications for anticoagulant use be clear and prenatal counseling include the risks involved. Although not a popular alternative, therapeutic abortion may be advised in some cases.

To avoid the risks of anticoagulation, it is suggested that tissue valves be used in women of childbearing age despite the likely need for subsequent valve replacement.[3,43,27]

Drugs

Most drugs commonly used in cardiovascular practice can safely be administered. Below is a brief review of the major pharmacologic agents that may be administered during pregnancy.

Digoxin

Although digoxin crosses the placenta, it has no known teratogenic or arrhythmogenic effects on the fetus.[11] Pregnancy decreases the serum digoxin level usually attributed to the increased glomerular filtration rate and hypervolemia of pregnancy.[3] Dose requirements may reach two to three times normal. Patients taking digitalis have shorter labors, which may be because of a "toning up" effect of digitalis on the myometrium.

Diuretics

Thiazide diuretics freely cross the placenta, but are not teratogenic. However, these agents have been reported to cause fetal arrhythmias, neonatal jaundice, thrombocytopenia, and meconium staining.[55] They may cause uterine inertia, prolonged labor, and hypovolemia in the mother. Diuretics should be used in pregnancy only for congestive heart failure and not for the common fluid retention of pregnancy.

Beta-blockers

Both cardioselective and noncardioselective beta-blockers cross the placenta; however, there have been no reports implicating any beta-blocker in fetal malformations.[59] Although there has been some evidence associating propranolol with fetal intrauterine growth retardation, prematurity, and bradycardia, no long-term, adverse effects have been reported. Neonatal hypoglycemia, polycythemia, hyperbilirubinemia, and respiratory depression have also been associated with propranolol use. Again, however, no long-term effect was noted.[59]

Antiarrhythmics

Quinidine, procainamide, and lidocaine have demonstrated safety.[3] Dilantin has been associated with congenital heart defects, mental and growth retardation, and craniofacial malformations in 6% of exposed live births.[59] Little is known regarding amiodarone in pregnancy. Penn described its use from the 16th week of pregnancy with successful outcome.[60] Experience with verapamil in the treatment of maternal arrhythmias is limited; however, its use has revealed no adverse effects on the fetus or the course of pregnancy.[59] It may safely be used during pregnancy to treat maternal supraventricular tachycardia and has been used with digoxin to treat fetal supraventricular tachycardia in utero.[59]

Peripartum cardiomyopathy

Among the least common causes of heart failure is peripartum cardiomyopathy (PPCM). It presents as a dilated cardiomyopathy first noted in the last gestational month or within the first six months postpartum. It remains a diagnosis of exclusion after all other causes of heart failure have been ruled out. The incidence in the United States varies from 1 per 1300 to 1 per 4000.[61] Associated risk factors appear to include black multiparous females, twinning, toxemia of pregnancy, and the presence of postpartum hypertension.[62] The etiology of PPCM is unknown but may be multifactorial, including poor nutrition, small vessel coronary disease, hormonal changes, or maternal immunologic responses to fetal antigens.[61]

Sanderson et al recently described 11 African women who had signs and symptoms of peripartum cardiomyopathy. All 11 patients underwent myocardial biopsy, five revealing evidence of "healing myocarditis." No viral infections were detected and no viral particles were seen with electron microscopy. They concluded that myocardial damage may be caused by an abnormal immunologic response.[63] A viral etiology has been suggested, but would by definition be a viral cardiomyopathy, not peripartum cardiomyopathy.

The presenting signs and symptoms of PPCM parallel those of other dilated cardiomyopathies. These usually include fatigability, dyspnea on exertion, edema, and, less commonly, hemoptysis, cough, embolic phenomenon, or arrhythmias.

Mortality rates range from 25–50%, with the predominant number of deaths occurring within the first three months postpartum. The risk associated with future pregnancies depends on the degree of residual left ventricular dysfunction. Should serious left ventricular dysfunction persist, future pregnancy is not advised.

Medical management of PPCM parallels the conventional treatment of heart failure, including digoxin, diuretics, and salt restriction. The use of systemic anticoagulants has been recommended for patients with severe left ventricular dysfunction, a left ventricular thrombus, or history of embolization.[61] The role of endomyocardial biopsy is not clearly defined, but should be considered early in the course of the illness, particularly if the patient does not respond to medical therapy.

General management guidelines

Because maternal mortality varies directly with functional class, the patient's functional status should be accurately determined before surgery.[3] Those cardiovascular disorders that absolutely contraindicate pregnancy include Eisenmenger's complex, primary pulmonary hypertension, and Marfan's syndrome with aortic root involvement or functional class III–IV patients from any cardiac cause.

The physician must maintain a high index of suspicion for worsening signs and symptoms in any pregnant woman with cardiovascular problems. These may include a diminished exercise tolerance, increase in dyspnea, development of cyanosis, or sudden weight gain. Signs of venous congestion (rales, jugular venous distention) must be recognized and treated promptly due to the high (50%) maternal mortality with frank pulmonary edema.[3]

By limiting unnecessary demands upon the already stressed circulation (anemia, fever, infection, arrhythmias, etc.) and by careful medical management throughout pregnancy, most patients can expect an uneventful pregnancy and delivery. Activity should be restricted with frequent rest, and the diet should be well balanced with moderate sodium restriction. The use of drugs during pregnancy has been reviewed. Alcohol should be avoided because of its negative effect on cardiac output[3] and cigarette smoking because of its propensity to transiently increase blood pressure in the mother.[64] Smoking also results in the delivery of infants who are small for their gestational age, an increased incidence of stillbirths, and increased neonatal risks.[65,66]

Management at Delivery

Delivery and the first 48 hours postpartum are critical times for women with cardiovascular problems. The cardiologist, anesthesiologist, and obstetrician must work closely together. The early induction of labor is usually not necessary, and most patients should be allowed to proceed to spontaneous labor.[67] Hemodynamic monitoring with a flow-directed catheter may be beneficial during labor and delivery in patients at risk for the development of peripartum pulmonary edema. In general, epidural anesthesia with low-outlet forceps is recommended for most patients, but should be avoided when a decrease in systemic vascular resistance is contraindicated (aortic stenosis, IHSS, pulmonary hypertension). Control of pain is essential, which epidural anesthesia affords. Spinal anesthesia is contraindicated because of its hemodynamic instability.

Arrhythmias

Cardiac arrhythmias associated with pregnancy are largely benign and include atrial and ventricular extra systoles, wandering atrial pacemaker, junctional rhythm, and supraventricular tachyarrhythmias including atrial fibrillation. The underlying cardiac disease may preclude certain types of rhythm disturbances such as mitral stenosis and atrial fibrillation or dilated cardiomyopathy and ventricular tachyarrhythmias.

The onset of supraventricular arrhythmias with a resultant rapid ventricular response should

be regarded as a medical emergency because of the high rate of associated heart failure.[28] Szekely and Snaith[68] demonstrated a significantly greater risk of heart failure and thromboembolism in patients with atrial fibrillation associated with rheumatic heart disease compared with patients in normal sinus rhythm. New-onset atrial fibrillation during gestation is particularly ominous.

Supraventricular tachyarrhythmias usually respond to digoxin, beta-blockers, or verapamil.[27] When necessary, synchronized cardioversion has proven efficacy and safety.[38-40]

Ventricular arrhythmias are fortunately rare and respond to the usual medications, including intravenous lidocaine or type 1 antiarrhythmic therapy. Amiodarone, as mentioned in the section on drug therapy, appears safe and effective, although its use has been limited in patients with ventricular arrhythmias.

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References

1. Szekely P, Snaith L. Heart Disease and Pregnancy. London, Churchill-Livingstone, 1974.
2. Selzer A. Risks of pregnancy in women with cardiac disease. JAMA 1977; **238**:892–893.
3. Perloff JK. Pregnancy and cardiovascular disease. [In] Braunwald E, ed. Heart Disease. A Textbook of Cardiovascular Medicine. 2nd ed. Philadelphia, WB Saunders, 1984, pp 1763–1781.
4. McAnulty JH, Metcalfe J, Ueland K. Heart disease and pregnancy. [In] Hurst JW, ed. The Heart, 6th edition. New York, McGraw-Hill, 1985, pp 1383–1397.
5. Metcalfe J, McAnulty JH, Ueland K. Cardiovascular physiology. Clin Obstet Gynecol 1981; **24**:693–710.
6. Gallery EDM. Volume homeostasis in normal and hypertensive human pregnancy. Semin Nephrol 1984; **4**:221–231.
7. Shah DM, Sunderji SG. Hypertrophic cardiomyopathy and pregnancy: report of a maternal mortality and review of literature. Obstet Gynecol Surv 1985; **40**:444–448.
8. Oakley GDG, McGarry K, Limb DG, Oakley CM. Management of pregnancy in patients with hypertrophic cardiomyopathy. Br Med J 1979; **1**:1749–1750.
9. Burch GE. Heart disease and pregnancy. Am Heart J 1977; **93**:104–116.
10. Lees MM, Taylor SH, Scott DB, Kerr MG. A study of cardiac output at rest throughout pregnancy. J Obstet Gynaec Br Comm 1967; **74**:319–328.
11. Ueland K, Novy MJ, Peterson EN, Metcalfe J. Maternal cardiovascular dynamics. IV. The influence of gestational age on the maternal cardiovascular response to posture and exercise. Am J Obstet Gynecol 1969; **104**:856–864.
12. Rubler S, Damani PM, Pinto ER. Cardiac size and performance during pregnancy estimated with echocardiography. Am J Cardiol 1977; **40**:534–540.
13. Katz R, Karliner JS, Resnik R. Effects of a natural volume overload state (pregnancy) on left ventricular performance in normal human subjects. Circulation 1978; **58**:434–441.
14. Lyons HA, Antonio R. The sensitivity of the respiratory center in pregnancy and after the administration of progesterone. Trans Assoc Am Physicians 1959; **72**:173–180.
15. Kerr MG. The mechanical effects of the gravid uterus in late pregnancy. J Obstet Gynaecol Br Comm 1965; **72**:513–529.
16. Northcote RJ, Knight PV, Ballantyne D. Systolic murmurs in pregnancy: value of echocardiographic assessment. Clin Cardiol 1985; **8**:327–328.
17. Majdan JF, Walinsky P, Cowchock SF, Wapner RJ, Plzak L. Coronary artery bypass surgery during pregnancy. Am J Cardiol 1983; **52**:1145–1146.
18. Salcedo EE. Atlas of Echocardiography. Philadelphia, WB Saunders, 1985.
19. Hatle L, Angelsen B. Doppler Ultrasound in Cardiology. Physical Principles and Clinical Application. Philadelphia, Lea and Febiger, 1982.
20. Durell M and Nanda NC. Appendix III. Doppler Color Flow Mapping in Doppler Echocardiography. New York, Igaku Shain, 1985, pp 515–516.
21. Sahn DJ. Real-time two-dimensional Doppler echocardiographic flow mapping. Circulation 1985; **71**:849–853.
22. Swennson RE, Sahn DJ, Valdes-Cruz LM. Color flow Doppler mapping in congenital heart disease. Echocardiography 1985; **2**:545–549.
23. Kleinmann CS, Hobbins JC, Jaffe CC, Lynch DC, Talner NS. Echocardiographic studies of the human fetus: prenatal diagnosis of congenital heart disease and cardiac dysrhythmias. Pediatrics 1980; **65**:1059–1067.
24. Allan LD, Crawford DC, Anderson RH, Tynan MJ. Echocardiographic and anatomical correlations in fetal congenital heart disease. Br Heart J 1984; **52**:542–548.
25. Maulik D, Nanda NC, Moodley S, Saini VD, Thiede HA. Application of Doppler echocardiography in the assessment of fetal cardiac disease. Am J Obstet Gynecol 1985; **151**:951–957.
26. DeVore GR, Hornstein J, Siassi B, Platt LD. Doppler color flow mapping. Its use in the prenatal diagnosis of congenital heart disease in the human fetus. Echocardiography 1985; **2**:551–557.
27. Sullivan JM, Ramanathan KB. Management of medical problems in pregnancy—severe cardiac disease. N Engl J Med 1985; **313**:304–309.
28. Szekely P, Julian DG. Heart disease and pregnancy. Curr Probl Cardiol 1979; **4(6)**:1–74.
29. Mendelson CL. Cardiac Disease in Pregnancy. Philadelphia, Davis, 1960.
30. Barlow JB, Pocock WA. The problem of nonejection clicks and associated mitral systolic murmurs: emphasis on the billowing mitral leaflet syndrome. Am Heart J 1975; **90**:636–655.
31. Procacci PM, Savran SV, Schreiter SL, Bryson AL. Prevalence of clinical mitral valve prolapse in 1169 young women. N Engl J Med 1976; **294**:1086–1088.
32. Markiewicz W, Stoner J, London E, Hunt SA, Popp RL. Mitral valve prolapse in one hundred presumably healthy young females. Circulation 1974; **53**:464–473.
33. Cheitlin MD, Byrd RC. The click-murmur syndrome: a clinical problem in diagnosis and treatment. JAMA 1981; **245**:1357–1361.

34. Cheitlin MA, Byrd RC. Prolapsed mitral valve: the commonest valve disease? Curr Probl Cardiol 1984; **8(10):**1–54.
35. Hickey AJ, MacMahon SW, Wilcken DEL. Mitral valve prolapse and bacterial endocarditis: When is antibiotic prophylaxis necessary? Am Heart J 1985; **109:**431–435.
36. Clark SL, Phelan JP, Greenspoon J, Aldahl D, Horenstein J. Labor and delivery in the presence of mitral stenosis: central hemodynamic observations. Am J Obstet Gynecol 1985; **152:**984–988.
37. Selzer A. When is cardiac surgery necessary during pregnancy? J Cardiovasc Med 1982; **7:**1332–1333.
38. Ueland K, McAnulty JH, Ueland FR, Metcalfe J. Special considerations in the use of cardiovascular drugs. Clin Obstet Gynecol 1981; **24:**809–823.
39. Schroeder JS, Harrison DC. Repeated cardioversion during pregnancy: treatment of refractory paroxysmal atrial tachycardia during 3 successive pregnancies. Am J Cardiol 1971; **27:**445–446.
40. DeSilva RA, Graboys TB, Podrid PJ, Lown B. Cardioversion and defibrillation. Am Heart J 1980; **100:**881–895.
41. Zitnik RS, Brandenberg RO, Sheldon R, Wallace RB. Pregnancy and open-heart surgery. Circulation 1969; **39(suppl I):**I-257–I-262.
42. Becker RM. Intracardiac surgery in pregnant women. Ann Thorac Surg 1983; **36:**453–458.
43. Salazar E, Zajarias A, Gutierrez N, Iturbe I. The problem of cardiac valve prostheses, anticoagulants, and pregnancy. Circulation 1984; **70(suppl I):**I-169–I-177.
44. Arias F, Pineda J. Aortic stenosis and pregnancy. J Reprod Med 1978; **20:**229–232.
45. Deal K, Wooley CF. Coarctation of the aorta and pregnancy. Ann Intern Med 1973; **78:**706–710.
46. Pyeritz RE. Maternal and fetal complications of pregnancy in the Marfan syndrome. Am J Med 1981; **71:**784–790.
47. Morrison JC, Meeks GR, Bates GW, Rahman FR, Menzel DM, Wiser WL. Management of the pregnant patient with cardiovascular disease. CVP 1981; **February/March:**17–25.
48. Jacoby WJ Jr. Pregnancy with tetralogy and pentalogy of Fallot. Am J Cardiol 1964; **14:**866–873.
49. Ginz B. Myocardial infarction in pregnancy. J Obstet Gynaec Br Comm 1970; **77:**610–615.
50. Shaver PJ, Carrig TF, Baker WP. Postpartum coronary artery dissection. Br Heart J 1978; **40:**83–86.
51. Casanegra P, Avilés G, Maturana G, Dubernet J. Cardiovascular management of pregnant women with a heart valve prosthesis. Am J Cardiol 1975; **36:**802–806.
52. Ismail MB, Abid F, Trabelsi S, Taktak M, Fekih M. Cardiac valve prostheses, anticoagulation, and pregnancy. Br Heart J 1986; **55:**101–105.
53. Limet R, Grondin CM. Cardiac valve prostheses, anticoagulation, and pregnancy. Ann Thorac Surg 1977; **23:**337–341.
54. Hall JG, Pauli RM, Wilson KM. Maternal and fetal sequelae of anticoagulation during pregnancy. Am J Med 1980; **68:**122–140.
55. Tamari I, Eldar M, Rabinowitz B, Neufeld HN. Medical treatment of cardiovascular disorders during pregnancy. Am Heart J 1982; **104:**1357–1363.
56. Hirsh J, Cade JF, Gallus AS. Anticoagulants in pregnancy: a review of indications and complications. Am Heart J 1972; **83:**301–305.
57. Rayburn WF, Lavin JP. Drug prescribing for chronic medical disorders during pregnancy: an overview. Am J Obstet Gynecol 1986; **155:**565–569.
58. Spearing G, Fraser I, Turner G, Dixon G. Long-term self administered subcutaneous heparin in pregnancy. Br Med J 1978; **1:**1457–1458.
59. Rotmensch HH, Elkayam U, Frishman W. Antiarrhythmic drug therapy during pregnancy. Ann Intern Med 1983; **98:**487–497.
60. Penn IM, Barrett PA, Pannikote V, Barnaby PF, Campbell JB, Lyons NR. Amiodarone in pregnancy. Am J Cardiol 1985; **56:**196–197.
61. Homans DC. Peripartum cardiomyopathy. N Engl J Med 1985; **312:**1432–1437.
62. Julian DG, Szekely P. Peripartum cardiomyopathy. Prog Cardiovasc Dis 1985; **27:**223–240.
63. Sanderson JE, Olsen EGJ, Gatei D. Peripartum heart disease: an endomyocardial biopsy study. Br Heart J 1986; **56:**285–291.
64. Briggs JSG. Blood pressure changes following smoking in pregnancy. Aust NZ J Obstet Gynecol 1975; **15:**204.
65. Leontic EA. Respiratory disease in pregnancy. Med Clin North Am 1977; **61:**111–128.
66. Naeye RL. Influence of maternal cigarette smoking during pregnancy on fetal and childhood growth. Obstet Gynecol 1981; **57:**18–21.
67. Ueland K. Pregnancy and cardiovascular disease. Med Clin North Am 1977; **61:**17–41.
68. Szekely P, Snaith L. Atrial fibrillation and pregnancy. Br Med J 1961; **5237:**1407–1410.

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