Peripartum cardiomyopathy, a type of dilated cardiomyopathy of unknown origin, occurs in previously healthy women in the final month of pregnancy and up to 5 months after delivery. Although the incidence is low—less than 0.1% of pregnancies—morbidity and mortality rates are high at 5% to 32%. The outcome of peripartum cardiomyopathy is also highly variable. For some women, the clinical and echocardiographic status improves and sometimes returns to normal, whereas for others, the disease progresses to severe cardiac failure and even sudden cardiac death. In acute care, treatment may involve the use of intravenous vasodilators, inotropic medications, an intra-aortic balloon pump, ventricular-assist devices, and/or extracorporeal membrane oxygenation. Survivors of peripartum cardiomyopathy often recover from left ventricular dysfunction; however, they may be at risk for recurrence of heart failure and death in subsequent pregnancies. Women with chronic left ventricular dysfunction should be managed according to guidelines of the American College of Cardiology Foundation and the American Heart Association. (American Journal of Critical Care. 2012;21(2):89-98)
Peripartum cardiomyopathy (PPCM) is a type of dilated cardiomyopathy of unknown origin. It occurs in previously healthy women in the final month of pregnancy and up to 5 months after delivery.\(^1\) Although the incidence is low—less than 0.1% of pregnancies—morbidity and mortality rates are high, ranging from 5% to 32%.\(^2,3\)

For some women, the clinical and echocardiographic status improve and may return to normal, whereas for others, PPCM progresses to cardiac failure and even sudden cardiac death.\(^4\) In severe cases, women experience a rapid deterioration in health, show no improvement with medical therapy, and may require cardiac transplantation or die of heart failure, thromboembolic events, and/or cardiac arrhythmias.\(^5\) Thus, initial severity of left ventricular dysfunction or dilatation is not necessarily predictive of long-term functional outcome.\(^5\)

In this article, we review PPCM and present guidelines for practice.

### Epidemiology

The reported incidence of PPCM varies because the diagnosis is not always consistent and a comparison with age-matched nonpregnant women does not exist.\(^4,6,7\) Reported incidences range from 1 in 299 live births in Haiti\(^8\) to 1 in 2229 live births in Southern California\(^9\) to 1 in 4000 live births in the United States.\(^4\) The wide variation most likely is the result of geographic differences and reporting patterns.\(^10\) Also, limited access to echocardiography in some areas may lead to overestimation of PPCM.\(^11\)

Several risk factors predispose a woman to PPCM, including increased maternal age, multiparity, multiple pregnancies, and pregnancies complicated by preeclampsia and gestational hypertension.\(^4,6,12\) Although PPCM occurs more frequently in women at the upper and lower extremes of child-bearing ages and in older women of higher parity,\(^4,11\) the disease has also been reported in 24% to 37% of young primigravid women.\(^3,14\) In contrast, the results of a large population-based study from Haiti suggested that multiparity and increasing maternal age are not risk factors.\(^4\) Demakis et al\(^11\) and Brar et al\(^15\) found that African American women were 2.9 times more likely to have PPCM than were white women and 7 times more likely than were Hispanic women. The greater incidence of hypertension in African Americans may influence this finding.\(^3,7\)

### Etiology

PPCM is distinguished from other forms of cardiomyopathies by its occurrence during pregnancy.\(^16\) Precise mechanisms that lead to PPCM remain poorly defined. Many etiological processes have been suggested: viral myocarditis, abnormal immune response to pregnancy, maladaptive response to hemodynamic stresses of pregnancy, stress-activated cytokines, excessive prolactin excretion, and prolonged tocolysis.\(^4,10,17,18\) Also, a familial predisposition to PPCM has been reported.\(^19,21\) Although underlying genetic variants common to dilated cardiomyopathies are being proposed,\(^21\) a genetic basis specific to PPCM has not been systematically studied.\(^22\) The European Society of Cardiology currently classifies PPCM as a nonfamilial, nongenetic form of dilated cardiomyopathy.\(^24\)

### Viral Myocarditis

Viral myocarditis has been proposed as the main mechanism for PPCM and was first reported by Goulet et al.\(^25\) This proposal was later supported by Melvin et al,\(^26\) who found myocarditis during endomyocardial biopsy in 3 women with PPCM. The biopsy specimens had dense lymphocytic infiltration with a variable amount of myocytic edema, necrosis, and fibrosis. Others\(^27\) have also reported an association between PPCM and viral myocarditis. In a study by Felker et al,\(^28\) 62% of women with PPCM had myocarditis or borderline myocarditis on biopsy; however, clinical outcomes did not differ between women with and without myocarditis.
Abnormal Immune Response

An abnormal immune response to fetal microchimerism (harboring of fetal cells in maternal circulation) has been studied as a cause for PPCM.\(^{13}\) Other researchers\(^ {14,15,16}\) support this theory that during pregnancy fetal cells released into the maternal bloodstream are not rejected by the mother because of the natural immunosuppression that occurs during pregnancy. However, after delivery, women lose the increased immunity, and if fetal cells reside on cardiac tissue when the fetus is delivered, a pathological autoimmune response can occur, leading to PPCM in the mother after birth.

Abnormal Hemodynamic Response

During pregnancy, blood volume and cardiac output increase.\(^4\) In addition, afterload decreases because of relaxation of vascular smooth muscle.\(^ {15}\) These changes cause a brief, and reversible, hypertrophy of the left ventricle to meet the needs of the mother and fetus.\(^2\) This transient left ventricular dysfunction during the third trimester and early postpartum period resolves shortly after birth in a normal pregnancy.\(^ {2,18}\) Pearson et al\(^4\) suggested that PPCM might be due, in part, to an exaggerated decrease in left ventricular function when these hemodynamic changes of pregnancy occur.

Apoptosis and Inflammation

An increased concentration of plasma inflammatory cytokines, specifically tumor necrosis factor \(\alpha\); C-reactive protein; and Fas/Apo-1, a plasma marker for apoptosis (programmed cell death), have been identified in women with PPCM.\(^3\) Levels of Fas/Apo-1, a ligand found on cell-surface proteins that plays a key role in apoptosis, were higher in women with PPCM than in healthy volunteers.\(^3\) Furthermore, these Fas/Apo-1 levels were higher among women with PPCM who died than among those with PPCM who survived. However, a correlation between increased plasma cytokine levels and left ventricular function or outcomes has not been demonstrated. Van Hoeven et al\(^3\) further concluded that ejection fraction at the time of clinical findings suggestive of PPCM was the strongest predictor of outcome.

Prolactin

Hilfiker-Kleiner et al\(^ {16,31}\) have proposed a new pathogenic mechanism for PPCM: excessive prolactin production. Levels of prolactin are associated with increased blood volume, decreased blood pressure, decreased angiotensin responsiveness, and a reduction in the levels of water, sodium, and potassium.\(^ {31}\) Prolactin also increases the level of circulating erythropoietin, and hence hematocrit levels.\(^ {15}\) Hilfiker-Kleiner et al\(^ {16}\) discovered that PPCM develops in mice bred to have a cardiomyocyte-specific deletion of STAT3, a protein that plays a key role in many cellular processes such as cell growth and apoptosis. The deletion of STAT3 led to enhanced expression of cardiac cathepsin D, promoting the formation of a 16-kD form of prolactin. In women with PPCM, STAT3 protein levels were low in the heart, and serum levels of activated cathepsin D and 16-kD prolactin were elevated.\(^ {15,31}\)

Selenium and Malnutrition

Nutritional disorders, such as deficiencies in selenium and other micronutrients, were thought to play a role in the pathogenesis of PPCM.\(^ {12,26}\) Deficiencies of selenium increase cardiovascular susceptibility to viral infections, hypertension, and hypocalcemia. However, Fett et al\(^ {32}\) concluded that neither low serum levels of selenium nor deficiencies of other micronutrients (vitamins A, \(B_12\), C, E, and \(\beta\)-carotene), played a significant role in the development of PPCM in Haitian women. In contrast, women with PPCM from the Sahelian region of Africa had low levels of selenium.\(^ {31}\)

Prolonged Tocolysis

Prolonged tocolysis refers to the use of tocolytic agents (\(\beta\)-sympathomimetic drugs) for more than 4 weeks.\(^ {10}\) The association between tocolytic therapies and heart failure appears to be unique to pregnancy. Tocolytic agents are used for the management of various other conditions without the occurrence of signs and symptoms of heart failure like those experienced by pregnant women. Such signs and symptoms may develop in pregnant women as a result of normal physiological changes that occur, including an increase in circulating blood volume.\(^ {18}\) Lampert et al\(^ {30}\) found an association between use of tocolytic therapies and development of pulmonary edema in pregnant women and proposed a link between chronic use of \(\beta\)-sympathomimetic medications and PPCM.

Clinical Manifestations and Diagnosis

Features of a normal pregnancy include increased blood volume, increased metabolic demands, mild anemia, changes in vascular resistance associated with mild ventricular dilatation, and increased cardiac output.\(^ {13}\) Thus, the onset of PPCM can easily be masked—and missed—because the manifestations...
can mimic those of mild heart failure. Women with PPCM most commonly have dyspnea, dizziness, chest pain, cough, neck vein distention, fatigue, and peripheral edema. They can also have arrhythmias, embolic events due to the dilated, dysfunctional left ventricle, and acute myocardial infarction due to decreased perfusion to the coronary arteries. They can also have other indications typical of heart failure: hypoxia, jugular venous distention, S3 and S4 gallop, rales, and hepatomegaly. Blood pressure is often normal or decreased, and tachycardia is common.

PPCM was first defined in 1971 as the development of myocardial disease that occurs for the first time toward the end or in the early stage of the pregnancy. A modification of this classic definition added a strict echocardiographic criterion: The National Heart, Lung, and Blood Institute and the Office of Rare Diseases workshop adopted the modified definition in 2000. In 2010, the European Society of Cardiology Working Group on Peripartum Cardiomyopathy proposed a modification to the existing definition of PPCM. PPCM is defined as an idiopathic cardiomyopathy manifested as heart failure due to left ventricular systolic dysfunction toward the end of pregnancy or in the months after delivery when no other cause of heart failure is found. Thus, PPCM is a diagnosis of exclusion, suggesting that a broader definition would eliminate PPCM as a missed diagnosis.

The definitive diagnosis of PPCM depends on echocardiographic identification of new-onset heart failure during a limited period around parturition. A diagnosis of PPCM requires the exclusion of other causes of heart failure: myocardial infarction, sepsis, severe preeclampsia, pulmonary embolism, valvular diseases, and other forms of cardiomyopathy.

Chest radiographs should be obtained in suspected cases of PPCM. Chest radiographs may be helpful in acute pulmonary edema, but much less so if no clinical evidence of pulmonary congestion is revealed. Radiological indications of heart failure such as cardiomegaly, pulmonary congestion, and pleural effusions may be evident. However, diagnosing cardiomegaly on the basis of a chest radiograph in a pregnant patient is difficult because the heart is pushed upward and laterally, giving the false impression of cardiomegaly. Electrocardiograms should also be obtained. In PPCM, the tracings may be normal or may show left ventricular hypertrophy, ST-T wave abnormalities, dysrhythmias, Q-waves in the anteroseptal precordial leads, and prolonged PR and QRS intervals. Several laboratory tests should be performed: complete blood cell counts and serum levels of troponin, urea, creatinine, and electrolytes. Liver function tests should be done, and levels of thyroid-stimulating hormone should be measured. In the initial evaluation, the serum level of troponin may be helpful in ruling out myocardial infarction; however, an increase in troponin in the acute phase of PPCM, without myocardial infarction, can occur. Levels of B-type natriuretic peptide and N-terminal pro-B-type natriuretic peptide can help in confirming the diagnosis.

Unlike pulmonary artery catheterization, echocardiography is noninvasive and allows serial evaluations in pregnant women. Serial echocardiography with Doppler imaging is used to evaluate and monitor regional and global left and right ventricular function, valvular structure and function, possible pericardial pathological changes, and mechanical complications. Findings in women with PPCM are consistent with the findings in heart failure: decreased ejection fraction, global dilatation, and thinned-out cardiac walls. Cardiac magnetic resonance imaging has been suggested as a complementary tool in the diagnosis and evaluation of women with PPCM. Such imaging can be used to measure global and segmental myocardial contraction, can help in characterizing the pathogenesis of the disease, and can reveal inflammatory processes. Banuteau et al maintain that because cardiac magnetic resonance imaging can be used to distinguish inflammatory from noninflammatory pathogenesis, it can be helpful at the initial evaluation of a woman with PPCM to determine the pathophysiology and to guide further therapeutic options. Ntusi and Chin disagree, however, and do not see a benefit for obtaining cardiac magnetic resonance images in all women who have PPCM. Guidelines for diagnosis of PPCM according to the American College of Cardiology Foundation (ACCF) and the American Heart Association (AHA) are provided in Figures 1 and 2.

**Management**

**Compensated Heart Failure**

Management of PPCM is similar to standard treatment for other forms of heart failure. However, no randomized clinical trials have been done to evaluate these therapies specifically in PPCM. Furthermore, careful attention should be paid to fetal safety and to excretion of drug or drug metabolites.
during breastfeeding after delivery. The goals in treating heart failure are to improve hemodynamic status, minimize signs and symptoms, and optimize the long-term outcomes. Treatment focuses on reducing preload and afterload and increasing cardiac inotropy. Pearson et al reinforce that collaboration among medical specialists, including obstetricians, cardiologists, perinatologists, and neonatologists, is essential in care of women with PPCM. Of note, polypharmacy may be required for optimal management, to slow progression of heart failure and to improve outcomes in women with left ventricular systolic dysfunction. Medications should be continued until evidence indicates improved and/or resolved left ventricular dysfunction. Women with PPCM should be treated in the hospital when they have evidence of hypotension, worsening heart failure, altered mental status, and increased work of breathing.

Preload reduction is accomplished by administration of vasodilators, such as nitrates, most of which are safe during pregnancy and breastfeeding. Loop diuretics are important for management of signs and symptoms and for preload reduction, although caution is warranted in antepartum women because rapid changes in intravascular volume can lead to a decrease in blood supply to the uterus and therefore the fetus. Restriction of dietary sodium is also helpful in preload reduction. Bed rest was once standard care but is no longer recommended because of the increased risk of thromboembolism. The current recommendation is light exercise such as walking.

Ideal medications intrapartum include hydralazine, nitrates, digoxin, and diuretics. Angiotensin-converting enzyme inhibitors are contraindicated during pregnancy because of their teratogenicity, but these medications are the mainstay of treatment of PPCM after delivery for afterload reduction. Safe alternatives during pregnancy include hydralazine and nitrates. Aldosterone antagonists have been effective when angiotensin-converting enzyme inhibitors were not tolerated, but the antagonists should not be used during pregnancy.

β-Adrenergic antagonists, such as extended-release metoprolol and carvedilol, have been approved for use in PCCM and can improve survival. However, β-blockers should not be given in the early stages of PPCM because they can decrease perfusion in the acute decompened phase of the disease. Pearson et al have proposed that carvedilol be used in postpartum women who continue to have signs and symptoms of heart failure and have echocardiographic evidence of left ventricular compromise after more than 2 weeks of therapy. Digoxin, an inotropic agent, is also safe during pregnancy and should be considered for women with left ventricular systolic dysfunction and an ejection fraction of less than 40% who have signs and symptoms of heart failure while receiving standard therapy.
often required; however, attempts involving noninvasive ventilation may obviate intubation. Noninvasive ventilation must be used with caution because of the high risk for aspiration. Breathing is supported with supplemental oxygen to relieve signs and symptoms related to hypoxemia and is assessed via continuous pulse oxymetry. Women should have cardiac monitoring, including ST-segment monitoring when available. Blood pressure should be monitored with noninvasive blood pressure cuffs until arterial catheters are placed. Venous and arterial access should be obtained early so that medications can be administered promptly and monitoring can be streamlined. Some clinicians advocate for the use of pulmonary artery catheters in women whose heart failure is refractory; however, this logic has been questioned because many of the drugs used to treat PPCM produce benefits by mechanisms that cannot be assessed by measurement of short-term changes in hemodynamic status. Pulmonary artery catheters may be beneficial in patients with heart failure, but little information is available on their use in women with PPCM.

In antepartum women, fetal heart rate monitoring should be started early because abnormalities in fetal heart rate tracings are common when maternal oxygenation and circulation are compromised. Medical stabilization of the mother’s condition is critical and may result in resolution of fetal distress and prevent the need for emergency cesarean delivery that most likely would be poorly tolerated by the mother.

Women with acute heart failure benefit from intravenous administration of positive inotropic agents such as dobutamine and milrinone, none of which are contraindicated in pregnancy. Positive inotropic agents improve cardiac performance, facilitate diuresis, preserve end-organ function, and promote clinical stability. Dobutamine requires β-receptors for its inotropic effects, whereas milrinone does not, an important distinction in planning care for a patient who is being treated with β-blocking drugs. Furthermore, milrinone has vasodilator properties for both the systemic and the pulmonary circulation, a mechanism that may be a marked benefit over other inotropic agents. In women with systolic blood pressure less than 90 mm Hg, dobutamine may be preferred over milrinone. Vasodilatory drugs such as nitroglycerin and nitroprusside also may be of benefit. Nitroprusside should be used with caution in pregnant women because the toxic effects of thiocyanate can be harmful to the fetus.

Clinicians should not focus therapy on a specific blood pressure value that might or might not indicate hypotension; rather, they should focus on signs and symptoms associated with poor cardiac output and hypoperfusion, such as cold clammy skin, cool upper and lower extremities, decreased urine output, and altered mental status. Inotropic agents are of greatest value in women who have relative hypotension and an intolerance or no response to vasodilators and diuretics. Regardless, if invasive monitoring of hemodynamic status is used, once the clinical status of the woman has stabilized, every effort should be made to devise an oral regimen that can maintain symptomatic improvement and reduce the subsequent risk of any deterioration in her condition.

Left ventricular thrombus is common in women with PPCM whose ejection fraction is less than 35%. Warfarin should be given to postpartum women whose ejection fraction is 35% or less, and heparin or a low-molecular-weight heparin should be given to women who are pregnant and have a similar ejection fraction. Anticoagulation therapy should be continued until left ventricular function is normal according to echocardiographic findings. Arrhythmias should be aggressively treated.

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Diagnostic criteria for peripartum cardiomyopathy

All 4 of the following:

Classic
1. Development of cardiac failure in the last month of pregnancy or within 5 months postpartum
2. No identifiable cause for the cardiac failure
3. No recognizable heart disease before the last month of pregnancy

Additional
1. Strict echocardiographic indication of left ventricular dysfunction:
   a. Ejection fraction <45%
   b. Fractional shortening <30%
   c. End-diastolic dimension >2.7 cm/m²

Consultation with cardiologist, obstetrician, perinatologist
If diagnosis is made before the woman gives birth: involve anesthesiology and neonatology also, and consider transfer to a high-risk perinatal center

No: Consider other cause
Yes: Meets criteria for diagnosis for peripartum cardiomyopathy

Figure 2 Diagnosis of peripartum cardiomyopathy.
Based on Pearson et al and Sliwa et al.
to minimize thrombus formation and to optimize cardiac function.6-10

Immunosuppressive and anti-inflammatory therapies have not improved the outcome in PPCM and, in general, are not recommended.45 Because of the various mechanisms of PPCM, immunosuppression most likely would not help all women.13,15,45

In a case report, Jahns et al46 stated that bromocriptine, a dopamine antagonist that inhibits prolactin secretion, prevented the expected deterioration in the size of the left ventricle and systolic function when given in addition to standard heart failure therapy in a woman with PPCM. The treatment of STAT3-deficient mice with bromocriptine also prevented the development of PPCM in a study by Hilfiker-Kleiner et al.16 The results of assessments of the therapeutic effects of prolactin blockade with bromocriptine are promising, and trials are being done in women with PPCM.16-22 In a case study, de Jong et al23 argue that the benefit of using cabergoline, another potent dopamine receptor antagonist like bromocriptine, is the long half-life, 14 to 21 days, of cabergoline, so a single dose is often enough.

Medical therapy can be unsuccessful in women with PPCM, and mechanical cardiovascular support with an intra-aortic balloon pump or ventricular assist devices may be required.46,47 Left ventricular assist devices can be a bridge to recovery or to transplantation.13,49-51 Use of short-term extracorporeal membrane oxygenation has also been of benefit in women with PPCM whose heart failure was refractory to medical therapy and who had persistent pulmonary edema with hypoxemia.45,50 Extracorporeal membrane oxygenation can also serve as a bridge to left ventricular assist devices in patients with refractory cardiogenic shock despite use of an intra-aortic balloon pump and full inotropic support.51

Women in whom maximal medical management is unsuccessful may be candidates for cardiac transplantation.48 According to one study,14 cardiac transplantation was necessary in 4% of women with PPCM. In another study12 in which 69 women underwent cardiac transplantation for PPCM, the investigators concluded that heart transplantation is a practical therapeutic option for women with PPCM who have advanced heart failure and signs and symptoms unresponsive to medical therapies. The risk of organ rejection in women with PPCM does not appear to be higher than the risk in women of similar age who have a history of pregnancy and undergo transplantation for other causes. However, in an earlier study, Koegh et al49 found that the incidence of biopsy-proven early rejection, necessitating increased cytolytic therapy, was marginally higher in

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### Table 1 Management of compensated heart failure in peripartum cardiomyopathy

<table>
<thead>
<tr>
<th>Nonpharmaceutical therapies</th>
<th>Oral pharmaceutical therapies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-sodium diet: limit of 2 g sodium per day</td>
<td>Lisinopril (starting dose 2.5-5 mg daily, target dose 5 mg daily)</td>
</tr>
<tr>
<td>Fluid restriction: 2 L/day</td>
<td>Ramipril (starting dose 1.25-2.5 mg 2 times a day, target dose 2.5-5 mg 2 times a day)</td>
</tr>
<tr>
<td>Light daily activity: if tolerated (eg, walking)</td>
<td>Captopril (starting dose 6.25-12.5 mg 3 times a day, target dose 25-50 mg 3 times a day)</td>
</tr>
</tbody>
</table>

### Antepartum management of peripartum cardiomyopathy

<table>
<thead>
<tr>
<th>β-blocker</th>
<th>Vasodilator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carvedilol (starting dose 3.125 mg twice a day, target dose 25 mg twice a day)</td>
<td>Hydralazine (starting dose 10 mg 3 times a day, target dose 40 mg 3 times a day)</td>
</tr>
<tr>
<td>Extended-release metoprol (starting dose 0.125 mg daily, target dose 0.25 mg daily)</td>
<td>Dibutamide (starting dose 0.125 mg daily, target dose 0.25 mg daily)</td>
</tr>
</tbody>
</table>

### Postpartum management of peripartum cardiomyopathy

<table>
<thead>
<tr>
<th>Angiotensin-converting enzyme (ACE) inhibitor</th>
<th>Angiotensin-receptor blocker (if ACE inhibitor not tolerated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captopril (starting dose 6.25-12.5 mg 3 times a day, target dose 25-50 mg 3 times a day)</td>
<td>Candesartan (starting dose 2 mg daily, target dose 32 mg daily)</td>
</tr>
<tr>
<td>Enalapril (starting dose 1.25-2.5 mg 2 times a day, target dose 10 mg 2 times a day)</td>
<td>Valsartan (starting dose 40 mg twice a day, target dose 160 mg twice a day)</td>
</tr>
</tbody>
</table>

### Consider nitrates or hydralazine if woman is intolerant to ACE inhibitor and angiotensin-receptor blocker

<table>
<thead>
<tr>
<th>Loop diuretic</th>
<th>Aldosterone antagonist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furosemide intravenously or by mouth—dosing considerations should be made on the basis of creatinine clearance</td>
<td>Spironolactone (starting dose 12.5 mg daily, target dose 25-50 mg daily)</td>
</tr>
<tr>
<td>Glomerular filtration rate &gt;60 mL/min per 1.73 m²: furosemide 20-40 mg every 12-24 h</td>
<td>Eplerenone (starting dose 12.5 mg daily, target dose 25-50 mg daily)</td>
</tr>
<tr>
<td>Glomerular filtration rate &lt;60 mL/min per 1.73 m²: furosemide 20-40 mg every 12-24 h</td>
<td>β-blocker as above</td>
</tr>
<tr>
<td>Vasodilator</td>
<td>Warfarin if ejection fraction &lt;35%</td>
</tr>
<tr>
<td>Hydralazine (starting dose 3.75 mg 3 or 4 times a day, target dose 40 mg 3 times a day)</td>
<td></td>
</tr>
<tr>
<td>Isosorbide dinitrate (starting dose 20 mg 3 times a day, target dose 40 mg 3 times a day)</td>
<td></td>
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</tbody>
</table>

*Based in part on Jessup et al48 and Heart Failure Society of America.42*
Based in part on Jessup et al and Heart Failure Society of America.

Table 2  Management of decompensated heart failure in peripartum cardiomyopathy

<table>
<thead>
<tr>
<th>Airway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubate promptly upon distress for increased work of breathing to prevent complications with difficult airway later in treatment</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Breathing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide supplemental oxygen</td>
</tr>
<tr>
<td>Maintain continuous pulse oximetry to monitor SaO2</td>
</tr>
<tr>
<td>Measure arterial blood gases (if available) every 4-6 h until breathing is stable</td>
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<table>
<thead>
<tr>
<th>Circulation</th>
</tr>
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<tbody>
<tr>
<td>Start cardiac and blood pressure monitoring</td>
</tr>
<tr>
<td>Insert arterial catheter for accurate blood pressure monitoring and blood sampling</td>
</tr>
<tr>
<td>Obtain central venous access with central venous pressure monitoring</td>
</tr>
<tr>
<td>In antepartum women, obtain fetal monitoring</td>
</tr>
</tbody>
</table>

Pharmacological management of acute heart failure in peripartum cardiomyopathy

<table>
<thead>
<tr>
<th>Intravenous loop diuretic (caution is advised in antepartum women)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furosemide: dosing considerations should be made on the basis of creatinine clearance</td>
</tr>
<tr>
<td>Glomerular filtration rate &gt;60 mL/min per 1.73 m2:</td>
</tr>
<tr>
<td>furosemide 20-40 mg intravenously every 12-24 h</td>
</tr>
<tr>
<td>Glomerular filtration rate &lt;60 mL/min per 1.73 m2:</td>
</tr>
<tr>
<td>furosemide 20-80 mg intravenous every12-24 h</td>
</tr>
<tr>
<td>In severe fluid overload, consider furosemide infusion or ultrafiltration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vasodilator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitroglycerin infusion 5-10 µg/min, titrate to clinical status and blood pressure</td>
</tr>
<tr>
<td>Nitroprusside 0.1-5 µg/kg per minute, use with caution in antepartum women</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Positive inotropic agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milrinone 0.125-0.5 µg/kg per minute</td>
</tr>
<tr>
<td>Dobutamine 2.5-10 µg/kg per minute</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Avoid β-blockers in the acute phase, as they can decrease perfusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heparin sodium, alone or with oral warfarin (Coumadin) therapy</td>
</tr>
</tbody>
</table>

| Consider endomyocardial biopsy; if proven viral myocarditis, consider immunosuppressive medications (eg, azathioprine, corticosteroids) |
| Every effort should be made to devise an oral regimen that can maintain symptomatic improvement and reduce the subsequent risk of worsening clinical status |

If no improvement clinically:

- Consider cardiac magnetic resonance imaging |
- Perform endomyocardial biopsy to detect viral myocarditis (if not previously completed)

<table>
<thead>
<tr>
<th>Assist devices:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-aortic balloon pump</td>
</tr>
<tr>
<td>Left ventricular assist devices</td>
</tr>
<tr>
<td>Extracorporeal membrane oxygenation</td>
</tr>
<tr>
<td>Transplantation</td>
</tr>
</tbody>
</table>

If a woman remains refractory to therapy, consult your institution’s guidelines for bromocriptine or cabergoline administration for suppression of prolactin production

*Based in part on Jessup et al and Heart Failure Society of America.

Outcomes of PPCM

Prognosis of PPCM is positively related to the recovery of ventricular function. Failure of heart size to return to normal is associated with increased mortality and morbidity. Women with persistent left ventricular dysfunction are less likely to survive and recover normal cardiac function than are women with improved left ventricular function. A fractional shortening less than 20% and a left ventricular diastolic dimension of 6 cm or greater at the time of diagnosis are associated with a more than 3-fold higher risk for persistent cardiac dysfunction.

Sliwa et al found that ejection fraction was the strongest predictor of outcome in women with PPCM. Abboud et al reported that 50% of women with PPCM recover baseline ventricular function within 6 months of delivery. In contrast, Ntusi and Mayosi found that only 30% of women with PPCM have complete recovery of cardiac function; most have partial recovery. Medical therapy as outlined in the ACCF/AHA guidelines should be continued when a woman does not recover function. When appropriate, implantation of defibrillators to prevent sudden cardiac death and use of cardiac revascularization therapy should be considered.

Reported mortality rates for PPCM vary widely. In a study by Sliwa et al, the mortality rate in 29 women was 32%, whereas in a large population-based study in Haiti by Fett et al, the mortality rate was 15.8%. In a study of 123 women by Elkayam et al, the rate was 9% at a mean follow-up time of 24 months. Brar et al concluded that mortality rates associated with PPCM were lower than initially reported at 2.5%, and Mielenzczuk et al reported a mortality rate of 1.36% to 2.05%. Earlier diagnosis, coupled with modern management of heart failure, most likely has an important influence on the mortality associated with PPCM.

Although rates have improved, mortality remains extremely high in women with PPCM.

One of the most frequently cited issues for women who survive PPCM is whether or not they can safely become pregnant again. No clearly established recommendations for future pregnancies in these women exist. Left ventricular recovery and function are considered the most reliable prognostic factors and predictors of survival in subsequent pregnancies. Future pregnancies are not recommended in women with persistent heart failure, because the heart most likely would not be able to

Women with PPCM than in women with dilated cardiomyopathy. Table 2 presents guidelines for management of decompensated heart failure in PPCM.
tolerate the increased cardiovascular workload associated with the pregnancy. Women whose cardiomyopathy appears to have resolved are a more difficult group to counsel. Because multiparity has been associated with PPCM, subsequent pregnancies can increase the risk for recurrent episodes of PPCM, irreversible cardiac damage and decreased left ventricular function, worsening of a woman’s clinical condition, and even death.

Williams et al have suggested that dividing women into 2 categories (recovered vs nonrecovered left ventricular function) is most appropriate for counseling on future pregnancy. Even though the cardiac function has normalized in the group of women with recovered cardiac function, the left ventricular contractile reserve may remain impaired, and recurrence of PPCM is still possible. The subset of women with persistent left ventricular systolic dysfunction should be counseled against subsequent pregnancies; the risks are 19% higher for maternal death than among women with PPCM whose heart failure has resolved.

Conclusion

PPCM affects previously healthy women in the final month of pregnancy and up to 5 months after delivery. The diagnosis is based on 4 criteria. For some women, the clinical and echocardiographic status improve rapidly and sometimes return to normal. In other women, the clinical condition rapidly worsens, no improvement occurs with medical therapy, and chronic heart failure from persistent ventricular dysfunction develops. No single explanation of the pathogenesis of PPCM is relevant for all women; the disease has a multifactorial origin. In acute care, treatment may involve the use of intravenous vasodilators, inotropic medications, an intra-aortic balloon pump, ventricular assist devices, and/or extracorporeal membrane oxygenation.

Survivors of PPCM often recover from left ventricular dysfunction; however, they may be at risk for recurrence of heart failure and death in subsequent pregnancies. Women with chronic left ventricular dysfunction should be managed according to ACCF/AHA guidelines. Careful assessment of risk factors in pregnant women could help in the prevention of PPCM. Tools to stratify women by risk who have recovered from PPCM are needed to predict the risk of future pregnancies.

FINANCIAL DISCLOSURES
None reported.

REFERENCES
37. Pyatt JR, Dubey G. Peripartum cardiomyopathy: current
35. Lampert MB, Hibbard J, Weinert L, Briller J, Lindheimer M,
33. Cénac A, Simonoff M, Moretto P, Djibo A. A low plasma
29. Ansari AA, Fett JD, Carraway RE, Mayne AE, Onlamoon N,
28. Felker GM, Jaeger CJ, Klodas E, et al. Myocarditis and
27. Midei MG, DeMent SH, Feldman AM, Hutchins GM, Baugh-
Peripartum Cardiomyopathy: Review and Practice Guidelines
Leah Johnson-Coyle, Louise Jensen and Alan Sobey

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