Cardiac disease in pregnancy

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Abstract

Cardiac disease is a significant cause of maternal mortality. In the UK in the last maternal mortality report, it was the leading cause of indirect maternal deaths (2.39 deaths per 100,000 maternities). The overall rate of maternal mortality from cardiac disease has significantly increased over the last three decades, with this increase being mostly attributable to deaths from ischaemic heart disease, myocardial infarction and peripartum cardiomyopathy. Conditions such as pulmonary hypertension, rheumatic heart disease and congenital cardiac lesions also significantly contribute to the mortality figures. With the current increase in age of mothers, increasing rate of maternal obesity and improved survival of children with congenital heart disease, more mothers will require careful cardiovascular assessment and monitoring of their pregnancies. Many women with cardiac conditions will aim to manage their peripartum care in a specialist centre; however, in an emergency they may present to any delivery suite in any hospital. This means it is essential for all obstetric anaesthetists to have a good understanding of different cardiac conditions and how the physiological changes of pregnancy may affect cardiac function.

Keywords Cardiac disease; cardiomyopathy; maternal mortality; pulmonary hypertension

Royal College of Anaesthetists CPD Matrix: 1A01, 2B06, 2C04, 3B00.

Learning objectives

After reading this article, you should be able to:

- describe general considerations for the management of pregnancy in those with cardiovascular disease
- explain the physiological cardiovascular changes in pregnancy
- describe the WHO classification of maternal cardiovascular risk

Physiology

The physiological changes to the cardiovascular system during pregnancy take place to facilitate the increased demand for oxygen and nutrients by the utero-placental unit, and that of the growing fetus. Blood flow to the uterus increases from 50 ml/minute at 10 weeks' gestation to 850 ml/minute at term. This is accomplished by a 50% rise in cardiac output (CO) and blood volume.

There is a drop in systemic and pulmonary vascular resistance due to vasoactive prostaglandins and nitric oxide production, thus preventing a rise in pulmonary artery pressure from the increased circulating volume.[1] The systolic and diastolic pressures fall, reaching their lowest values during the second trimester, before increasing as term approaches, although never reaching pre-pregnancy values.

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During labour CO increases by a further 25–50% with up to 500 ml of blood returned from the intervillous spaces during contractions. Pain and anxiety can supplement this rise in CO by increasing heart rate, blood pressure (BP) and systemic vascular resistance (SVR). The CO further increases after delivery due to a relative hypervolaemic state. This can result in a clinical deterioration in patients with cardiac disease due to the associated rise in ventricular filling pressure and end-diastolic volume. There is a 15% reduction in colloid osmotic pressure during pregnancy, further increasing the risk of pulmonary oedema in these patients.

Pharmacokinetics in pregnancy

Physiological changes during pregnancy result in altered drug handling by the body. There is an increase in liver enzyme activity, glomerular filtration rate and plasma volume. This combined with altered protein binding and a reduction in serum albumin levels leads to changes in drug pharmacokinetics. This needs to be considered when managing pregnant individuals with cardiovascular disease.

General approach to cardiac disease in pregnancy

Preconception counselling

Women should have access to comprehensive individualized pre-pregnancy counselling if they are considered to be at risk of significant physiological deterioration during pregnancy from either a congenital or acquired cardiac condition. These complex patients require a holistic approach. Consideration should be given not only to their medical condition, but also the psychological, emotional, cultural and ethical context. Risk of maternal and fetal mortality or morbidity (such as risk of congenital disease, miscarriage rate and long term prognosis) should be thoroughly assessed and discussed openly. Doing so enables women to make informed decisions regarding contraception, becoming pregnant, peripartum care and termination of pregnancy.

Risk assessment

The assessment and risk stratification may take into account the type of cardiac disease and previous cardiac events, current functional capacity, and modifiable risk factors such as obesity, smoking, alcohol consumption and optimization of pharmacological management.

Evaluation of cardiovascular status should include:

- *Medical history* – to elicit symptoms relating to heart failure, arrhythmias and ischaemic events. Functional status should also be determined.

- *Examination* – to include auscultation for new or changing murmurs, blood pressure monitoring with investigation for proteinuria if hypertension is found and monitoring of oxygen saturations in patients with congenital heart disease.
- *Investigations* – as a minimum electrocardiogram (ECG), echocardiography and exercise test should be conducted as part of the initial risk assessment for preconception counselling. Consideration should also be given to computed tomography (CT) and magnetic resonance imaging as well as natriuretic peptide levels.[2]

Disease-specific risk assessment should be made using the modified World Health Organization (mWHO) classification (Table 1). The strongest predictors for peripartum cardiac events include:[2,3]

- prior cardiac event or stroke
- prior arrhythmia
- New York Heart Association (NYHA) functional class greater than 2 or cyanosis
- left-sided heart obstruction – including valve disease or hypertrophic cardiomyopathy (aortic valve area <1.5 cm^2, mitral valve area <2 cm^2 or outflow tract gradient >30 mmHg)
- left ventricular ejection fraction $<40\%$.

Risk assessment needs to be re-evaluated at every pre-pregnancy visit, with women at moderate or high risk of complications during pregnancy being managed by an expert, multidisciplinary 'Pregnancy Heart Team'.[2] This specialized multidisciplinary team should be made up of consultant cardiologists, obstetricians and anaesthetists as a minimum, with other expert input sort as necessary.

Peripartum care planning

Women should be seen early in joint cardiology and obstetric clinics. Consideration of available facilities, specialists and mWHO classification will inform the decision about where a woman books for her pregnancy and delivery care.

Cardiac function should be optimized, which may include surgical interventions such as valve replacement. Known teratogenic medications should be discontinued.

Further investigations should be conducted as indicated as the pregnancy progresses. They may include:[1,2]

- *12 lead ECG* – common changes of pregnancy relating to a gradual change in position of the heart include a 15–20 degree left axis deviation, the presence of a Q wave with inverted T waves in lead III and inverted T waves in leads V1 and V2. There may also be transient ST/T wave changes. Holter moinitoring should be used in patients with suspected arrhythmias.
- *Echocardiography* – transthoracic echocardiography this is the preferred method of assessment of cardiac function in pregnancy as it does not involve exposure to radiation and can be easily repeated to monitor changes in cardiac function throughout pregnancy. It is recommended in any pregnant patient with new or unexplained cardiovascular signs or symptoms. As with ECG, pregnancy can cause

Modified WHO classification of maternal cardiovascular risk[1]

Risk class	Risk of pregnancy	Examples of conditions
I	No detectable increased risk of maternal mortality and no/mild increase in morbidity	Uncomplicated pulmonary stenosis, patent ductus arteriosus Successfully repaired simple lesions, e.g. atrial or ventricular septal defects
II	Small increase risk of maternal mortality or moderate increase in morbidity	Unoperated atrial or ventricular septal defects Repaired tetralogy of Fallot Most arrhythmias
III	Significantly increased risk of maternal mortality or serious morbidity. Requires expert counselling and intensive specialist input throughout	Mechanical valve Systemic right ventricle Fontan circulation Cyanotic heart disease Aortic dilatation 45–50 mm (40–45 mm in Marfan syndrome)
IV	Extremely high risk of maternal mortality or severe morbidity, pregnancy contraindicated. If becomes pregnant termination should be discussed, if pregnancy continues care as class III	Pulmonary arterial hypertension Left ventricle ejection fraction $<30\%$ or NYHA III-IV Previous peripartum cardiomyopathy with residual LV impairment Severe mitral or aortic stenosis Aortic dilatation >50 mm (>45 mm in Marfan syndrome Severe coarctation

Table 1

changes in normal parameters; there may be slight dilatation of the chambers, increased valve gradient and changes in LV wall thickness. Transoesophageal echocardiography may be required in patients with complex congenital cardiac disease.
- *Exercise testing* – this can be used prior to pregnancy in women with grown up congenital heart disease and in patients with acquired valve disease to aid preconception planning. If already pregnant submaximal exercise testing may be considered in asymptomatic individuals.
- *Chest X-ray* – although the amount of radiation exposure to the fetus is low, the risks should be communicated and the investigation only used if other methods have failed to clarify the cause of symptoms. Lung ultrasound may be a viable alternative.
- *Cardiac catheterization* – may be useful for coronary angiography or electrophysiological studies and ablation. Studies should be restricted to cases in which medical treatment has failed to reverse haemodynamic compromise as the radiation exposure is considerable.

An individual care plan should be formulated by the multidisciplinary team to include plans for timing and mode of delivery. In the majority of cases vaginal delivery is recommended as first choice.[2] There are however some notable exceptions, including:
- severe aortic stenosis
- dilatation of the ascending aorta >45 mm
- pre-term labour on oral anti-coagulants
- Eisenmenger's syndrome
- severe heart failure
- obstetric indications.

The care plan may include advice on anticoagulation during labour, haemodynamic monitoring and the type of analgesia recommended. Lumbar epidural analgesia can reduce pain-related sympathetic surges and harmful tachycardias but should be used with caution in patients with obstructive lesions due to the possibility of systemic hypotension. As a general rule induction of labour should be considered at 40 weeks for all women with cardiac disease.[2]

Congenital heart disease

In most cases of congenital heart disease the diagnosis, functional status and any therapeutic strategies will be well established pre-pregnancy. Depending on the condition, pregnancy could be well tolerated or be classified as risk class IV in the modified WHO classification of maternal cardiovascular risk (Table 1).

Acquired heart disease

Acute coronary syndromes

Pregnancy increases the risk of acute myocardial infarction by threefold to fourfold, with women over 40 years old being at 30 times the risk of women under 20 years old.[4] As the average maternal age continues to increase, the number of pregnant women at risk of an ischaemic event will also increase.

Acute coronary syndromes (ACS) are estimated to occur at 3–6 per 100,000 deliveries and are related to risk factors such as smoking, hypertension, hyperlipidaemia, diabetes and a positive family history. Spontaneous coronary artery dissection is more common in pregnancy, usually occurring in the peripartum period. Maternal mortality after an ACS is estimated at 5–10%, which has improved with the increased availability of primary percutaneous coronary intervention (PCI).

The diagnostic criteria of an ACS are similar to those of non-pregnant patients. There must be a low threshold for further investigation of parturients and post-partum women that present with chest pain. A history of chest pain, ECG changes and troponin rise are the hallmarks, although inverted T waves may occur in pregnancy without underlying ischaemia. PCI is the preferred reperfusion therapy and stenting (with both bare metal and drug eluting stents) has been performed successfully during pregnancy.[2] Thrombolysis should only be used in life-threatening ACS where PCI is not available as tissue plasminogen activator, although not able to cross the placenta, may cause catastrophic bleeding at the placental site.[1] Low-dose aspirin and β-blockers are safe to use in pregnancy. Angiotensin converting enzyme inhibitors, angiotensin receptor blockers and renin inhibitors are contraindicated in pregnancy. If clopidogrel is indicated it should be used for the shortest duration possible. Breastfeeding is not recommended in mothers taking antiplatelet therapy (other than low dose aspirin).[2]

Valvular heart disease

Stenotic valvular disease carries a higher risk than regurgitant lesions during pregnancy and left-sided lesions have a higher complication rate than right-sided ones.[2,5] A short, pain-free labour and delivery may help to minimize haemodynamic changes for women with valvular disease.

Pregnancy is poorly tolerated in moderate or severe mitral stenosis (MS). Heart failure occurs frequently in those with valve areas less than 1.5 cm^2 even when previously asymptomatic. Patients are at risk of pulmonary oedema and thromboembolic events, particularly if atrial fibrillation occurs. Pulmonary hypertension (pulmonary artery pressures >50 mmHg) should be investigated and quantified as treatment with β-blockers, diuretics and anticoagulants may be indicated. The third stage of labour may also precipitate pulmonary oedema, management should be in the same way as non-pregnant patients.

Those with moderate or severe MS should be advised to delay pregnancy until balloon dilatation or valve replacement is performed. In those who are symptomatic during pregnancy, percutaneous balloon dilatation can be performed. Open surgery to the valve should be avoided if at all possible. Vaginal delivery is appropriate for most patients; however, those with NYHA class 3 or 4, or where balloon dilatation has failed, should be considered for caesarean section.

Aortic stenosis (AS) is usually caused by a congenital bicuspid valve or rheumatic fever and mild AS (valve area >1.5 cm^2) is often well tolerated in an asymptomatic patient and those with normal exercise tolerance before pregnancy. Patients with symptomatic AS and left ventricular dysfunction are at the greatest risk of heart failure, arrhythmias and ischaemic events from the increase in cardiac output associated with pregnancy. This cohort should be offered surgical intervention before conception.[2]

A general anaesthetic for caesarean section is often utilized for patients with severe AS (valve area <1 cm^2) in order to avoid the drop in systemic vascular resistance associated with a regional technique as reduced preload and afterload may be poorly tolerated.

Women with aortic valve regurgitation (AVR) can benefit from the reduced systemic resistance of pregnancy, which reduces the volume of regurgitant blood. AVR may be managed with systemic vasodilators such as hydralazine or nifedipine and diuretics, however those with severe disease should be offered intervention before pregnancy. Vaginal delivery with epidural analgesia and shortened second stage is recommended.[2] Patients with AVR associated with Marfan syndrome should be carefully monitored to detect early aortic dissection.

Mechanical heart valves and anticoagulation

In women contemplating pregnancy the choice of prosthetic heart valve should be made in consultation with the pregnancy heart team as there are implications for both mechanical and bioprosthetic valves, both carry high risk of complications during pregnancy. Those with mechanical heart valves require lifelong anticoagulation and have pregnancy-associated risks including thrombosis, haemorrhage, infection and valve failure. The safest strategy for the mother is to continue warfarin as this is associated with the lowest rate of valve thrombosis. However, warfarin is associated with a risk of embryopathy, stillbirth, and fetal intracerebral haemorrhage. Unfractionated heparin (UFH) and low-molecular-weight heparin (LMWH) are alternative methods of anticoagulation but carry a higher risk of valve thrombosis. LMWH may be used throughout pregnancy or can be restricted to use in the 6–12/40 week period to avoid the teratogenic effects of warfarin. When LMWH is used, close monitoring of the anti-Xa levels is essential as increased volume of distribution and renal clearance often lead to an increase in the dose requirement as pregnancy progresses. A delivery care plan formulated with input from a haematology specialist may help to manage a conversion from LMWH to unfractionated heparin during labour to allow closer control of anticoagulation and management of haemorrhage.

Infective endocarditis (IE) prophylaxis

In general, the same precautions and management apply as in non-pregnant individuals. The 2008 National Institute for Health and Care Excellence guidelines (reviewed in 2015)[6] on antibiotic prophylaxis for IE advise against offering routine antibiotic prophylaxis to women at higher risk for IE during childbirth. The guideline also advises that if a woman at risk of IE is undergoing a gastrointestinal or genitourinary procedure at a site with a suspected infection, she should receive an appropriate antibiotic.

Aortic disease

Various conditions may predispose to aortic disease (Box 1). Risk factors for aortic pathology in the general obstetric population include hypertension and advanced age. As pregnancy can be a high risk period for women with aortic disease, recommendations include antenatal counselling regarding the risk to the mother, imaging of the entire aorta and regular echocardiography to monitor aortic size during pregnancy. If the ascending aorta diameter is less than 4 cm a vaginal delivery is recommended.

Conditions that may predispose to aortic disease

- Marfan syndrome
- Ehlers-Danlos syndrome
- Turner's syndrome
- Bicuspid aortic valve
- Familial aortopathy
- Congenital heart disease

Box 1

Aortic dissection is a potential risk due to haemodynamic stress on the aorta and hormonal changes of pregnancy which can affect the aorta at the cellular level, therefore strict blood pressure control is advised. Patients with aortic pathology should deliver at centres with a cardiothoracic surgery service. Steps should be taken at the time of delivery to minimize cardiovascular stress for these patients, including β-blockade and/or regional anaesthesia.

Pulmonary hypertension

There is a high maternal mortality rate associated with pulmonary hypertension, previously up to 50% in historical series, and more recently published data suggests mortality figures of 15–30%.[1] Death due to worsening pulmonary hypertension, pulmonary thrombosis or right heart failure tends to occur in the third trimester or first months after delivery and can effect women who were asymptomatic before pregnancy. Ideally patients with significant pulmonary hypertension should be managed in centres that have the expertise and all therapeutic options available with the aim of avoiding precipitating factors such as hypotension, hypoxia and acidosis.

Acute pulmonary oedema

Acute pulmonary oedema typically presents with sudden onset breathlessness with or without agitation, and has several associated conditions and risk factors (Table 2) with an incidence of up to 1 in 200 pregnancies.[7]

Acute pulmonary oedema during pregnancy can be divided into that occurring with hypertension and that without hypertension.[7] This allows appropriate management and pharmacological therapy.

Pulmonary oedema associated with hypertension may be due to pregnancy-induced hypertension, essential hypertension or a combination. Development of pulmonary oedema in these patients is associated with excessive fluid administration and increasing disease severity. Pre-eclampsia predisposes to pulmonary oedema due to several factors including elevated systemic vascular resistance, increased left ventricular end diastolic pressure, a reduction in colloid osmotic pressure and increased endothelial permeability. The precipitating event is due to an increased fluid load which may be due to sudden vasoconstriction through sympathetic nervous system activation or excessive fluid administration. The immediate management includes activation of an emergency medical team, respiratory support through non-invasive/invasive means, introduction of pharmacological therapy and transfer to a high-dependency area when appropriate. Medical management of pulmonary oedema should

Causes of pulmonary oedema

Pre-existing conditions	Cardiac conditions
	Obesity
	Endocrine disorders
	Increased maternal age
Diseases in pregnancy	Pre-eclampsia
	Sepsis
	AFE
	Preterm labour
	PE
Drugs	B-agonists
	Steroids
	Magnesium
	Cocaine
Iatrogenic	Excess fluid
Fetal conditions	Multiple gestation

Table 2

be led by guidelines on acute and chronic heart failure.[1] Glyceryl trinitrate (GTN) and furosemide can also be used to produce venodilation and diuresis. If hypertension persists despite this therapy, nifedipine can be added. Early echocardiography may be helpful to guide management.

Pulmonary oedema without hypertension has several causes (Table 2). Early identification of at-risk patients and careful fluid management in the perinatal period are essential to prevent development of pulmonary oedema. The acute management is similar to that of non-pregnant patients and includes furosemide, vasodilators, inotropes and ventilation when required.

Cardiomyopathy

Peripartum cardiomyopathy

Peripartum cardiomyopathy (PPCM) is a form of dilated cardiomyopathy. It is a pregnancy-specific disease condition with certain predisposing risk factors (Box 2); however, the cause is unclear with inflammation and angiogenic imbalance being suggested aetiologies. PPCM causes systolic dysfunction and a decrease in left ventricular ejection fraction, usually <45%.[2] It is a diagnosis of exclusion when no other cause if the heart failure can be found. It usually occurs late in pregnancy or in the first 6 months postpartum. Diagnosis should be suspected in a patient presenting with breathlessness, tachycardia and signs of heart failure including pulmonary oedema. A dilated ventricle and sluggish circulation predisposes to thrombus formation, which may cause systemic emboli, making thromboprophylaxis in these patients essential. Management includes treatment of heart failure, (oxygen, diuretics, vasodilators, β-blockers and inotropic support), elective delivery if antenatal and angiotensin-converting enzyme inhibitors if postnatal. Severe cases may require ventilation, cardiac assist devices (such as balloon pumps) or even transplantation. Its estimated 50% of women make a full recovery, although there is a risk of recurrence of PPCM in future pregnancies of 30–50%, and reported mortality ranges from 2 to 24%.[2]

Predisposing factors for development of peripartum cardiomyopathy

- Multiparity
- African ethnicity
- Family history
- Smoking
- Diabetes
- Malnutrition
- Hypertension
- Pre-eclampsia
- Advanced maternal age
- Teenage pregnancy

Box 2

Hypertrophic and dilated cardiomyopathy

Patients with hypertrophic cardiomyopathy (HCM) are often asymptomatic and may present during pregnancy. It is often well tolerated[8] and symptoms such as breathlessness may be treated with β-blockers. A recognized complication is diastolic dysfunction, which may predispose to pulmonary oedema, so strict fluid balance is essential. Dilated cardiomyopathy (DCM) can be due to a number of pathologies including ischaemia, drugs, viral disease or hypertensive heart disease. It usually presents in the first or second trimesters as the blood volume and haemodynamic load is increasing and may manifest with symptoms of heart failure, LV dilatation and LV systolic dysfunction.[2] Unlike HCM, pregnancy in DCM is often poorly tolerated.

Arrhythmias

Palpitations are a common complaint during pregnancy, with atrial and ventricular ectopics the most common cause. The most frequently occurring arrhythmia during pregnancy is a supraventricular tachycardia, which can be terminated in the same way as for non-pregnant patients by use of vagal manoeuvres and drugs (adenosine, verapamil, β-blockers). Drugs to be avoided if possible during pregnancy include amiodarone and atenolol in the first trimester. An underlying cause of an arrhythmia should be sought, such as sepsis, pulmonary embolism or underlying structural heart disease. Pacemakers, implantable defibrillators and direct current cardioversion have been used successfully and are thought to be relatively safe during pregnancy. ◆

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FURTHER READING

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