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The pregnant cardiac patient and anaesthesia

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Cardiac disease is the leading cause of morbidity and mortality in pregnant women. There is a wide range of diagnoses ranging from congenital heart disease (CHD) to valvular heart disease. Obstetricians and anaesthesiologists need great understanding of physiology and pharmacological therapy of these parturients.

Physiological changes in pregnancy occur in the first trimester and peak at term. Parturients respond differently to physiological changes. Cardiovascular system changes include a fall in systemic vascular resistance (SVR), increased cardiac output (CO) and plasma volume. Oxygen consumption, metabolic rate, oxygen demand, minute ventilation and tidal volume are increased in pregnancy. Anaemia of pregnancy, fall in platelet count and hypercoagulability also occur. Serum creatinine and urea are decreased.

General principles and management of pregnant cardiac patients include optimising the mother, managing complications, analgesia and haemodynamic monitoring. Vaginal delivery and regional analgesia is generally recommended. Caesarean section (CS) can be safely done with segmental epidural anaesthesia.

Rheumatic heart disease (RHD) is the most common cause of valvular disease in pregnancy and mitral stenosis is the dominant (90%) lesion. Symptoms include orthopnoea, exertional dyspnoea or pulmonary oedema. The anaesthetic goals for mitral and aortic stenosis are to avoid tachycardia and decrease in SVR, maintain sinus rhythm and optimise preload. Labour, vaginal and CS delivery anaesthesia may be accomplished with segmental epidural. Regurgitant lesions are well-tolerated in pregnancy, and anaesthetic goals are to avoid increase in SVR and bradycardia, and prevention of myocardial depression.

CHD is becoming a common disease in pregnancy, with acyanotic lesions well-tolerated in pregnancy compared to cyanotic lesions. Acyanotic lesions' anaesthetic goals for labour, delivery and CS are to avoid intravenous injection of air, hypoxia, hypercarbia and decrease in SVR. Regional anaesthesia must be used with caution in Tetralogy of Fallot (TOF) patients, however it is deemed safe in Eisenmenger syndrome.

Pulmonary hypertension (PHT) in pregnancy carries a very high risk of mortality (5–25%) and pregnancy should be discouraged, however epidural anaesthesia is recommended in these patients. Segmental epidural is also recommended for patients with postpartum cardiomyopathy. Pregnant women presenting for emergency cardiac surgery should not be postponed due to pregnancy.

Keywords: pregnant, cardiac disease, valvular heart disease, anaesthesia

Introduction

Cardiac disease is the leading cause of morbidity and mortality in pregnant women, and successful management of the patient depends on a multidisciplinary team approach.[1] Cardiac disease in pregnancy includes a wide range of diagnoses: congenital heart disease (CHD), aortic disease, valvular heart disease, cardiomyopathies, heart failure, pulmonary hypertension, and arrhythmias.[2]

Obstetricians and anaesthesiologists are presented with a unique problem when dealing with these patients; hence good understanding of parturient physiology, pathophysiology and pharmacological therapy is crucial.[3]

Physiological changes in pregnancy

Physiological changes in pregnancy occur due to increased metabolic needs, fetal development and prepares the body for childbirth; changes occur in the first trimester and peak at term; usually they are tolerated by healthy parturients but may worsen or reveal pre-existing diseases.[4] Understanding the physiological changes in a pregnant patient is very important to appreciate the additional impact of cardiac disease.[5]

Pregnant women with cardiac disease respond differently to physiological changes depending on the type and severity of the disease.[5] Different body systems are affected by physiological changes in pregnancy.

Cardiovascular system

The cardiovascular system changes in pregnancy are significant and occur as early as eight weeks gestation; there is a fall in systemic vascular resistance (SVR) by 25–30% and increased cardiac output (CO) by 40% as compensation.[6] These changes may affect, amongst others things, patients with a risk for right to left shunting and aortic stenosis.[7] Mean arterial pressure (MAP) and arterial pressure (AP) are transiently decreased irrespective of CO increase, and the renin-angiotensin system is activated

with plasma volume increase secondary to water and sodium retention.[8]

Intravascular volume increases to 50% by the third trimester, and patients with fixed CO states like myocardial dysfunction or valvular lesions tolerate it poorly.[7]

Respiratory system

Oxygen consumption is increased by 20% and metabolic rate by 15% in pregnancy; and this causes increased oxygen demand during normal pregnancy. Minute ventilation is increased by 40–50% due to increased tidal volume, and this leads to hyperventilation and respiratory alkalosis with increased arterial partial pressure of oxygen (pO_2) and decreased partial pressure of carbon dioxide (pCO_2).[6]

Late in pregnancy, the uterus is displaced upwards and the oesophageal sphincter tone is decreased; both increase intragastric pressure and risk of aspiration.[8]

Haematological system

Physiological anaemia of pregnancy occurs due to a discrepancy in elevated plasma volume (40–50%) and red cell mass (20%), and the low haematocrit facilitates uteroplacental blood flow.[4] In pregnancy, the platelet count usually falls due to increased destruction and haemodilution, however it remains normal between 100–150 x 10^9 cells/l.[6,8] Hypercoagulability is expected in pregnancy to prevent excessive bleeding during placental separation, and anticoagulation, especially in patients at higher risk of thrombosis may be indicated.[7]

Central and peripheral nervous system

The epidural plexus is usually engorged due to increased venous pressure below the gravid uterus and this causes a decrease in epidural space and compensatory cerebrospinal fluid drop that results in a 25% reduction in local anaesthetic requirement and longer duration of action.[8]

Renal and hepatic system

Pregnancy increases the renal blood flow by 50% and glomerular filtration rate (GFR) from 100–150 ml/min, and this results in decreased serum creatinine and blood urea nitrogen.[4,8] Liver function changes in pregnancy are transient and never permanent, however liver disorders caused by pregnancy can be life-threatening, e.g. eclampsia, haemolysis, elevated liver enzyme and low platelets (HELLP).[9]

General principles for cardiac disease in pregnancy and anaesthesia

The approach to management of a pregnant woman with cardiac disease warrants a multidisciplinary team to clinically assess the patient, and to construct clear plans for management of labour, vaginal or caesarean delivery and puerperium.[2] The objectives for management of these patients include:[5]

- Optimise mother during pregnancy, e.g. beta-blocker treatment.
- Recognise and manage complications.
- Minimise cardiovascular load during delivery and postpartum period.

Pregnant patients with New York Heart Association (NYHA) I and II cardiac disease tolerate pregnancy and delivery well, whereas those with NYHA III and IV usually tolerate pregnancy poorly. Therefore careful management and individualised anaesthetic goals in these patients is crucial, and this includes:[10]

- Analgesia.
- Haemodynamic monitoring (e.g. ASA monitors, arterial blood pressure, central venous pressure).
- Optimise cardiorespiratory function (preload, SVR, heart rate, myocardial contractility, and pulmonary vascular resistance).
- Tailor anaesthetic according to cardiac lesion and fetal well-being.

Vaginal delivery and segmental regional analgesia is generally recommended for most pregnant women with cardiac disease due to low risk of blood loss, infection and venous thromboembolism.[5] Caesarean section (CS), if indicated, can be safely done with neuraxial anaesthesia; segmental epidural is advised for parturients with high-risk cardiac lesions compared to intrathecal anaesthesia.[2] General anaesthesia (GA) indications for CS include: current thromboembolism therapy, cardiopulmonary decompensation, thrombocytopenia and maternal neuraxial anaesthesia refusal.[11]

Specific cardiac diseases in pregnancy and anaesthetic implications

Valvular heart disease

Cardiac disease in pregnancy is the most common medical disorder in South Africa, 26% of the mortality is secondary to complications arising from valvular heart disease; and in developing countries, rheumatic heart disease (RHD) is the most common cause of these cardiac lesions in pregnancy.[12] A decrease in SVR and increase in plasma volume makes regurgitant lesions generally better tolerated in pregnancy compared to stenotic lesions.[3]

Mitral stenosis

Following acute rheumatic fever, the mitral valve is the most commonly affected valve.[12] Mitral stenosis may occur with right-sided valves, aortic valve disease or in isolation.[7] RHD in pregnancy results in development of predominantly mitral stenosis (90%), with 25% of patients experiencing symptoms only late in pregnancy.[10] Drop in SVR and MAP during pregnancy predisposes parturients with afterload-dependent lesions to cardiac complications during pregnancy and delivery.[2] They can present with orthopnoea, exertional dyspnoea or pulmonary oedema; and clinical findings may reveal a mid-diastolic murmur,

enlarged left atrium and atrial fibrillation (AF) in the parturient with significant mitral stenosis.[12]

Treatment for mitral stenosis depends on the severity of valvular disease.[5] The main goal of medical treatment is to control the heart rate, avoid fluid overload, prevention of low haemoglobin and sepsis.[12] Parturients with severe mitral stenosis complicated with atrial enlargement might be started on beta-blocker and heparin to avoid development of AF.[5] Severe mitral stenosis (< 1.0 cm^2) in pregnancy presents higher rates of complication and possible decompensation; therefore percutaneous balloon dilatation may be indicated.[5,12]

The main anaesthetic goals in the parturient with mitral stenosis are:[13]

- Avoid tachycardia.
- Maintain sinus rhythm.
- Avoid decrease in SVR.
- Optimise preload.

Management of pain during labour and vaginal delivery in pregnant women is accomplished with segmental lumbar epidural analgesia; it allows slow titration of local anaesthetic with or without opioids to the desired pain relief with minimal haemodynamic changes compared to other modalities.[7]

Caesarean delivery may be indicated in parturients with mitral stenosis; anaesthetic options must take into consideration the fluid shift from anaesthetic technique and blood loss.[7] Both general and regional anaesthesia have been considered for caesarean delivery, however epidural anaesthesia is recommended over spinal due to its slow onset of blockade and better parturient haemodynamic control with low-dose phenylephrine (20–40 mcg).[7,10] GA anaesthesia may be used successfully where indicated, the main goal is to provide stress-free induction and emergence by avoiding sympathetic stimulation.[13] Kuczkowski[7] found that high-dose opioid-based induction may be necessary to blunt intubation without dropping SVR from short-acting intravenous induction agents depending on mitral stenosis severity.

Aortic stenosis

Aortic stenosis is a rare complication in pregnancy.[12] Three to four decades are required for this lesion to be severe and yield symptoms as a complication from RHD; however, infective endocarditis and bicuspid aortic valve commonly cause severe aortic stenosis in pregnancy.[7] Transvalvular gradient in pregnancy increases above 50 mmHg with time due to a progressive rise in blood volume and drop in SVR. This may lead to symptoms and signs of syncope, angina and heart failure; however, pregnancy should not be prevented in women with preserved left ventricular function even with severe aortic stenosis (area of < 1cm^2).[1,7,12] Symptomatic aortic stenosis and women with left ventricular dysfunction but asymptomatic, must be discouraged from falling pregnant.[12]

The mainstay treatment of symptomatic parturient will be with beta-blockers and diuretics.[12] Percutaneous valvuloplasty is recommended in symptomatic patients with severe non-calcified valves; and valve replacements should be done in patients with life-threatening symptoms.[12,14]

The anaesthetic goals for aortic stenosis:[7]

- Optimise preload and CO.
- Avoid tachycardia and bradycardia.
- Prevent sudden drop in SVR.
- Maintain sinus rhythm.

Neuraxial labour analgesia in the parturient with aortic stenosis is controversial due to the risk of decrease in preload and afterload, however it has been found that when used in low concentration it reduces haemodynamic stress and catecholamine release.[15]

As with mitral stenosis, CS may be indicated in the pregnant patient with aortic stenosis. Either general or segmental epidural anaesthesia may be applied; the same principles and cautions must be followed as with the parturient with mitral stenosis.[7]

Regurgitant lesions

Mitral valve regurgitation is the second largest valve pathology in pregnancy, and changes in pregnancy with decreased SVR and increased blood volume are well-tolerated.[7] In pregnancy, congenital mitral prolapse is more common compared to mitral regurgitation, contributing 10–15% of mitral insufficiency.[3] Later in pregnancy, the SVR and plasma volume peaks which leads to fluid overload and worsening of regurgitation – all these result in pulmonary oedema.[12] AF and systemic embolisation may complicate mitral regurgitation in pregnancy.[7] Labour and delivery analgesia may be safely provided with segmental epidural and other available techniques.[7] If CS is indicated, general or segmental epidural anaesthesia may be used with the goal of avoiding peripheral vasoconstriction and augmenting forward flow of blood; regional anaesthesia is useful in this regard, however caution must be exercised to augment ventricular preload if excessive drop in SVR occurs.[7]

Aortic regurgitation is not common in pregnancy; if it occurs, it is either congenital or rheumatic in origin.[12] The common symptoms are due to left ventricular volume overload and increased myocardial oxygen consumption than normal; therefore the anaesthetic goals centre on:[7]

- Avoiding an increase in SVR.
- Avoiding bradycardia.
- Prevention of myocardial depression.

The anaesthetic considerations for labour, vaginal and caesarean delivery are similar to those of mitral regurgitation; therefore neuraxial analgesia and anaesthesia is desirable without major complications.[7]

Mixed lesions

The left-sided valve pathology is associated with higher risk; and incompetent valves pose fewer complications compared to stenotic lesions.[12] The anaesthetic considerations will depend on the dominant valve abnormality.

Prosthetic valves

During pregnancy, the bioprosthetic valves are associated with minimal risk, however thrombosis and sepsis are the major risk in pregnant patients with mechanical prosthetic valves.[12] The patients with mechanical valve replacements are usually on warfarin, which is replaced by low molecular weight heparin during pregnancy to avoid fetal congenital abnormalities.[7] Regional anaesthesia is best avoided in the pregnant patient on anticoagulants.[7]

Congenital heart disease

CHD is becoming a common disease in pregnancy.[16] Palliative surgery and total correction of these defects allow the patients to increasingly reach childbearing age.[7] There are mainly two groups of CHD: acyanotic (left to right shunt) and cyanotic (right to left shunt) heart disease.

Acyanotic heart disease

The most common acyanotic heart lesion, and likely to be missed during screening, is atrial septal defect (ASD), and this is due to favourable decrease in SVR associated with pregnancy.[10] Pregnancy is well-tolerated with this lesion even when pulmonary blood flow is increased, however left ventricular failure and supraventricular dysrhythmias may occur secondary to fluid overload.[7]

Other acyanotic lesions in pregnancy include ventricular septal defect (VSD) and patent ductus arteriosus (PDA). Patients with these uncorrected lesions without pulmonary hypertension can tolerate pregnancy as well.[7,16]

The anaesthetic goals for labour, delivery and CS are:[16]

- Avoid intravenous injection of air.
- Avoid decrease in SVR especially with pulmonary hypertension.
- Hypoxia, hypercarbia and acidosis prevention.

Segmental epidural is well-tolerated for labour, vaginal and caesarean delivery in this group of patients as it prevents excessive rise in SVR due to pain; and GA may be used during CS if excessive increase in SVR can be prevented during intubation.[12]

Cyanotic heart disease

Tetralogy of Fallot (TOF) in pregnancy accounts for 5% of CHD and consists of four components: VSD, right ventricular outflow tract obstruction, overriding of aorta and right ventricular hypertrophy.[16] The common symptoms are cyanosis, hypoxaemia, polycythermia and fatigue secondary to right to left shunt; and pregnancy changes with low SVR worsen the shunt and symptoms on the already decompensated heart.[17] The main anaesthetic goal is to prevent worsening of right to left shunt by minimising haemodynamic changes like drop in SVR and venous return.[7] Labour and vaginal delivery analgesia should be achieved with systemic narcotics; moreover, general anaesthetic with ketamine should be considered with CS as the regional anaesthesia can decrease SVR and extreme caution must be exercised.[7]

Eisenmenger syndrome is a condition consisting of arterial hypoxaemia, pulmonary hypertension and a right-to-left shunt resulting from pulmonary hypertension (PHT) superimposed on previous left-to-right shunt.[7,10] Neuraxial analgesia for labour and vaginal delivery is recommended via segmental epidural provided excessive decrease in SVR is prevented.[16] Balancing the SVR and pulmonary vascular resistance (PVR) is the main anaesthetic goal for CS in the parturient with Eisenmenger syndrome, both segmental epidural and GA are deemed safe with the latter recommended during emergency.[16,18]

Pulmonary hypertension in pregnancy

PHT in pregnancy carries a very high risk of mortality (5–25%) and cardiopulmonary complications; therefore pregnancy is discouraged and possibly terminated in these patients.[5,19] Severity of the disease will determine the signs and symptoms, which usually arise from right ventricular hypertrophy, low CO and PHT.[7] Anaesthetic considerations in the parturient with PHT are:[7]

- Prevent increase in PVR from hypoxia or stress.
- Avoid decrease in right ventricular volume.
- Avoid decrease in SVR and blood pressure.

Slow-onset epidural analgesia and anaesthesia is recommended for labour, vaginal delivery and CS; this avoids the need for ventilation and increased intrathoracic pressure during general anaesthetic.[7]

Peripartum cardiomyopathy

Peripartum cardiomyopathy (PPCM) is defined as heart failure in the absence of obvious cause in pregnancy occurring anytime from one month pre-delivery up to five months postpartum.[5] Signs and symptoms of PPCM range from dyspnoea, orthopnoea and swelling.[20] For labour, vaginal and caesarean delivery, segmental epidural is recommended for patients with good physiological reserve, however there is no formal anaesthetic protocol that dictates one technique over the other.[20]

Cardiovascular surgery and cardiopulmonary bypass in pregnancy

Pregnant women presenting for emergency cardiac surgery should not be postponed due to pregnancy, risk of prematurity, and benefit of delivery prior to cardiopulmonary bypass must be weighed and an individualised decision must be made.[2] As with other non-obstetric surgeries, meticulous anaesthetic technique to maintain haemodynamic stability, uteroplacental

perfusion and uterine relaxing is crucial in addition to adjusted cardiopulmonary parameters in pregnancy.[2]

Conclusion

Cardiac disease is the leading cause of morbidity and mortality in pregnant women. A good understanding of physiological changes in pregnancy is crucial to appreciate the additional impact of cardiac disease. The approach to management of a pregnant woman with cardiac disease warrants a multidisciplinary team to construct a clear plan for management of labour, vaginal or caesarean delivery and puerperium. Slow-onset epidural anaesthesia is highly recommended in most parturients with cardiac disease; however patients' anaesthetic goals should be individualised.

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