Acute myocardial infarction in the obstetric patient

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Summary: Acute myocardial infarction (AMI) in the obstetric patient is a rare event, although the incidence is rising due to advancing maternal age and pre-existing cardiac risk factors and medical co-morbidities. While atherosclerotic disease is the leading cause of AMI, coronary artery dissection is an important consideration in pregnancy and in the postpartum period. The physiological changes of pregnancy as well as pregnancy-specific risk factors can predispose the obstetric patient to AMI. Diagnosis of AMI can be challenging as symptoms may be atypical. Furthermore, diagnostic tests must be interpreted in the context of pregnancy. While the overall management of the obstetric patient with AMI is similar to that outside of pregnancy, drug therapy requires modification as some medications may be contraindicated in pregnancy and breastfeeding. There is limited information about prognosis and risk stratification but it is anticipated that future studies will address this issue.

Keywords: myocardial infarction, cardiovascular disease, pregnancy, maternal morbidity

INTRODUCTION

The differential diagnosis of chest pain in the obstetric patient is broad. It includes conditions that are specific to pregnancy such as preeclampsia, conditions that are heightened in pregnancy such as gastroesophageal reflux and conditions where the frequency increases with pregnancy such as pulmonary embolism and aortic dissection.¹ There are also conditions that are not necessarily more frequent or worse in pregnancy but can occur due to the physiological changes of pregnancy like acute coronary syndrome (ACS).

Acute coronary syndrome, a term used when there is a suspicion of myocardial ischaemia, refers to unstable angina, non-ST elevation myocardial infarction (NSTEMI) and ST elevation myocardial infarction (STEMI). Acute myocardial infarction (AMI) is defined as a clinical or pathological event caused by myocardial injury or necrosis.² Unstable angina is considered to be present in patients with ischaemic symptoms suggestive of an ACS without elevation in biomarkers indicative of ischaemia.²

AMI is a relatively uncommon occurrence in the obstetric population. However, with the changing epidemiology of pregnancy, it can be anticipated that the numbers of women with AMI in pregnancy or the puerperium will increase. Rising maternal age and prepregnancy maternal weight, as well as a higher prevalence of pre-existing medical disorders such as hypertension and diabetes mellitus, are associated with cardiovascular disease. The Confidential Enquiry into Maternal and Child Health (CEMACH) has reported a trend towards an increase in the incidence of maternal death due to AMI in the last three triennia.³

The epidemiology of, and risk factors for, AMI in pregnancy and the puerperium are well defined in the literature. However,

there is limited information about potential complications, outcomes and prognosis of AMI in pregnancy. This is despite over 150 individual case reports⁴ on AMI in pregnancy and two population-based studies including 1010 women^{5,6}. The vast majority of the data are based on these population-based studies and a more recent 2008 systematic review included a new subset of eight patients previously not reported.⁷

The obstetric patient with AMI presents unique challenges for diagnosis, investigation and management. This review will discuss these in the context of the physiological changes in pregnancy and the implications for maternal and fetal outcomes.

CHANGES IN CARDIAC PHYSIOLOGY IN PREGNANCY

The normal physiology of pregnancy increases cardiac demands and can exacerbate underlying coronary artery (and other vascular) disease. Throughout pregnancy, myocardial oxygen demands are higher, primarily as a result of enhanced stroke volume, but to a lesser degree, an increase in heart rate.¹ The enhanced stroke volume also increases vascular shear forces in large vessels which may be structurally weakened by high levels of progesterone that produce biochemical and structural changes in vessel walls.⁸ Myocardial oxygen supply may be decreased by physiological anaemia and decreased diastolic blood pressure.⁸ In hypertensive patients, myocardial (subendocardial) oxygen supply may be further compromised.

During labour and delivery, there are many factors that may further increase myocardial oxygen demands by up to three-fold, including maternal anxiety and pain, enhanced venous return resulting from uterine contractions, and in the immediate puerperium, augmented venous return resulting from relief of venocaval compression following evacuation of the pregnant

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uterus.⁷ Plasma volume peaks on days 3–6 after delivery and this mobilization into the central circulation (of extracellular fluid accumulated during pregnancy) may further augment venous return.⁹

EPIDEMIOLOGY

AMI is relatively rare in the obstetric patient with an estimated incidence ranging from 3 to 10 per 100,000 deliveries,^{7,10} with the most reliable estimate of 6.2 (95% confidence interval 3.0–9.4) per 100,000 deliveries derived from a population-based study.⁶ Despite these absolute rates, however, the relative risk of AMI in pregnancy is three- to four-fold higher compared with rates among non-pregnant women of reproductive age.^{5–7,11–13} Maternal mortality from AMI has been reported to be anywhere from 5.1% to 38%.^{5–7} Recent studies have documented rates at the lower end of this range (5–11%)^{6,7} Mortality is highest for women diagnosed with AMI peripartum compared with those who are diagnosed antepartum or postpartum.⁷

The majority of patients with AMI are older than 30 years. Not surprisingly, the risk of AMI in pregnancy increases significantly with age (i.e. 8.8, 19.0 and 30.2 per 100,000 deliveries among women aged 30–34 years, 35–39 years and 40 years or older, respectively).⁶ Most obstetric patients with AMI have traditional cardiovascular disease risk factors. Smoking (45%), hyperlipidaemia (24%), a family history of myocardial infarction (MI) (22%), pre-existing hypertension (15%) and/or pre-existing diabetes (11%).⁶ Multiparity and ethnicity are also associated with AMI.^{6,7} Black women appear to be at highest risk (11.4 AMI per 100,000 deliveries), Hispanic women at lowest risk (4.2 AMI per 100,000 deliveries) and Caucasian women at intermediate risk (i.e. 7.6 per 100,000 deliveries).⁶ The CEMACH reported that six of the eight women who died due to ischaemic heart disease were obese with a body mass index ≥ 35 kg/m.¹ Pregnancy-specific risk factors include preeclampsia, blood transfusion and postpartum infection.^{6,7}

CAUSES OF AMI

It is widely appreciated that AMI, both outside and during pregnancy, is most commonly caused by coronary atherosclerosis.^{6,7,14} This is consistent with the risk factor profile of most patients. However, there are non-atherosclerotic causes of AMI and these bear particular consideration in women of child-bearing age (Table 1). In particular, coronary dissection is a significant cause of AMI in the antepartum (11%), peripartum (50%) and postpartum (39%) periods. When coronary angiography has been performed in postpartum patients, causes of AMI other than coronary atherosclerosis or coronary dissection include thrombus (15%), coronary artery spasm (less than 5%) and no abnormality identifiable (10%).⁷

Coronary artery dissection

Coronary artery dissection is rare and is found in approximately 0.2% of all coronary angiograms outside pregnancy.¹⁵ These cases occur primarily in women almost all of whom are premenopausal and without traditional cardiovascular risk factors.^{16–18} It is usually due to mechanical disruption of

Table 1 Non-atherosclerotic causes of myocardial infarction¹³

Arteritis
Kawasaki's syndrome
Takayasu's arteritis
Polyarteritis nodosa
Churg–Staruss syndrome
Syphilis Coronary
Collagen vascular disease
Systemic lupus erythematosus
Systemic sclerosis
Mixed connective tissue disorder
Mural thickening or intimal proliferation
Mucopolysaccharidose
Homocystinuria
Fabry's disease
Pseudoxanthoma elasticum
Intimal hyperplasia associated with contraceptive
Corticosteroids or with postpartum
Spasm
Prinzmetal's angina
Cocaine
Dissection
Mechanical
Spontaneous
Thrombosis
Inherited hypercoagulable states
Acquired hypercoagulable states
Increased viscosity
Embolism
Mural thrombus
Valvular source (e.g. endocarditis, thrombus)
Cardiac tumour
Paradoxical embolism
Trauma
Laceration
Compression
Thrombosis
Congenital
Anomalous origin from pulmonary artery
Arteriovenous and arteriocanal fistula
Myocardial bridge
Anuerysm
Other causes of myocyte necrosis
Myocardial oxygen supply-and-demand mismatch
Myocarditis
Stress cardiomyopathy
Myocardial contusion

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the vessel wall and may be associated with a number of other conditions.¹⁴ There is limited experience with its management even outside of pregnancy.

Antepartum coronary artery dissection usually occurs at the end of the third trimester, within four weeks after delivery.⁶ However, approximately 75% of coronary artery dissection cases associated with pregnancy have occurred postpartum¹⁹ usually in the first two weeks following delivery, but dissection has occurred up to three months postpartum.²⁰

Pregnancy is listed as a cause of spontaneous coronary artery dissection, but pregnancy as a cause is a diagnosis of exclusion. Other potentially modifiable causes include: structural vessel wall disease (due to arteritis or a connective tissue disorder), underlying atherosclerosis (although this occurs primarily in men and as a result of plaque rupture and intimal disruption) or haemodynamic stressors.¹⁴ Pregnancy may unmask an underlying predisposition to dissection so it is not mutually exclusive of the diagnoses listed.

Advancing maternal age and multiparity are non-modifiable risk factors for spontaneous coronary artery dissection in pregnancy,¹⁴ but the coronary arteries are almost always normal. Recognized underlying coronary arteritis and connective tissue defects are rarely associated with spontaneous coronary artery dissection, but dissection of other vessels is possible (albeit rare).¹⁴ These women are usually considered for beta-blocker therapy in pregnancy to decrease vascular shear forces.

Is there a specific presentation of coronary artery dissection in pregnancy? Unfortunately, there is not. A picture of anterior wall ischaemia is more suggestive given that 87% of peripartum coronary dissections involve the left coronary tree.¹⁴ However, 40% of dissections involve multiple coronary arteries and one-third affect both the left and right coronary arteries.¹⁴ This diffuse picture should not be surprising given that most of the causes of spontaneous coronary dissection are based on a diffuse vascular predisposition that weakens vessel walls.

DIAGNOSIS

The criteria for diagnosis of AMI in pregnancy are the same as in non-pregnant patients. The diagnosis rests on demonstration of an elevation in cardiac biomarkers, with either supportive symptoms, electrocardiogram (ECG) abnormalities or findings on cardiac imaging.

Women may be considered for a diagnosis of AMI in pregnancy based on complaints of chest pain or dyspnoea, abnormal ECG findings, haemodynamic instability or an elevated value of cardiac troponin even in the absence of chest pain. As such, it is important to carefully consider the differential diagnosis of each component of the AMI diagnostic criteria when evaluating these women.

Symptoms of ischaemia

The classic symptoms of ischaemia include retrosternal chest pain, dyspnoea and diaphoresis. However, a higher proportion of young patients as compared with older patients do not experience angina.²⁰ Outside pregnancy, it is well recognized that women often present with atypical chest pain rather than retrosternal chest pain.²¹ Furthermore, MI can present with atypical features in pregnancy such as abdominal or epigastric pain and vomiting.³ In pregnancy, chest pain and/or dyspnoea have a broad differential diagnosis including preeclampsia. The recently published PERS (Pre-eclampsia Integrated Estimate of RiSk) score highlighted that not only is chest pain and/or dyspnoea a common complaint among women admitted to hospital with preeclampsia (41%), but it is independently predictive of adverse outcomes.²² Of course, AMI can also present with haemodynamic compromise, arrhythmia, cardiogenic shock, tamponade and sudden cardiac death. This is the rationale for ordering cardiac troponin and ECG in the operating room when women have haemodynamic instability.

ECG findings

There are ECG changes associated with normal pregnancy as well as with caesarean section (Table 2) but these changes do not include ST elevation. Ectopic beats should not necessarily be interpreted to reflect ischaemia. ST segment depression

Table 2 Normal findings on ECG in pregnancy¹

- Atrial and ventricular ectopics
- QRS axis leftward shift
- Q-wave (small) and inverted T-wave in lead III
- ST segment depression and T-wave inversion inferior and lateral leads

ECG, electrocardiogram

and T-wave inversion may occur in the inferior and lateral leads as part of normal pregnancy, and these changes could be confused with NSTEMI in pregnancy.⁸ In those circumstances, the cardiac troponin I would be normal. The other situation in which ST and T-wave abnormalities may occur is with caesarean section. ST depression is common with caesarean section in up to 25% of women either during caesarean section or more commonly within 30 minutes following the procedure.²³ ST depression occurs irrespective of the type of anaesthetic used but may be associated with increasing doses of oxytocin.²⁴ There is no evidence as to how long the ST segment depression may last, although it is presumably transient following the caesarean section. In contrast, ST segment elevation is not associated with normal pregnancy or delivery. The differential diagnosis includes STEMI pericarditis, hyperkalaemia, left ventricular hypertrophy and pulmonary embolism.

Is ECG presentation specific for an underlying cause of the AMI? In short, in an acute STEMI, ECG changes reflect the location of the infarct, although this is not always the case for NSTEMI.²⁵

Biochemical markers

The maternity care provider should not rely on creatinine kinase (CK) or its more (but not entirely) cardiac-specific subtype, CK-MB. The uterus and placenta contain large amounts of CK and CK-MB which increase in concentration by nearly two-fold within 30 minutes after normal delivery, with levels continuing to rise thereafter, peaking at 24 hours after delivery.²⁶

The cardiac biomarker measured most frequently, because of its sensitivity and specificity for myocardial damage, is cardiac troponin I.²⁷ This is also the case in pregnancy. Cardiac troponin should rise within three hours of an AMI so a negative result does not rule out an AMI within three hours of presentation. Three serial troponins can be performed 6–8 hours apart if the initial values are indeterminate, if the ECG remains non-diagnostic and/or clinical suspicion remains high. Following labour and delivery, troponin I increases only slightly (0.03) and levels remain below the upper limit of normal, making interpretation possible using the normal range established outside pregnancy.²⁷ An elevated troponin indicates the presence of myocardial damage but not the mechanism as there are many causes other than ischaemia. Cardiac troponin may be elevated in isolation or in conditions (such as pulmonary embolism and pericarditis) that may present with similar symptoms (chest pain and dyspnoea).²⁸ It should be noted that it is possible to have a falsely positive elevation in the presence of factors (e.g. heterophile antibodies) that interfere with the troponin I assay.^{29–31} Therefore, interpretation of an elevated troponin relies heavily on the clinical context.

MANAGEMENT

Initial medical management of AMI (STEMI or NSTEMI)

Ideally, the patient should be cared for in a critical care setting with a multidisciplinary team including obstetrician, internist cardiologist and other subspecialists. Frequent clinical assessment along with serial ECG and biomarkers should be performed. During pregnancy, the fetus(es) of women with AMI should be closely monitored at least until these women have been stabilized and their treatment plan implemented. All of the following interventions are considered safe in pregnancy and should be used regardless of the type of MI and its cause:

- Oxygen;
- Pain relief (with narcotics);
- Nitrates if required to relieve chest pain;
- Aspirin 16–325 mg;
- Heparin (unfractionated, intravenous or low molecular weight in therapeutic dosage) to prevent further thrombosis;
- Beta-blockers to decrease myocardial oxygen demands.

In addition to the above, clopidogrel (discussed below) is also often used in the initial management for additional antiplatelet effect.

Method of establishing reperfusion in STEMI

The initial management of STEMI is medical therapy. In STEMI, prompt restoration of myocardial blood flow is essential to optimize myocardial salvage and to reduce mortality.³² A decision must be made as soon as possible as to whether reperfusion will be achieved with empiric thrombolysis without coronary angiography, or coronary angiography with primary percutaneous coronary intervention (PPCI) consisting of either angioplasty or stenting. This decision should be made in consultation with a cardiologist.

Coronary angiography requires the use of fluoroscopy, but the fetal radiation exposure is less than one rad. This is well below the threshold associated with any increase in the risk of either birth defects or fetal loss. At this radiation dose there is very small increase in childhood malignancy (1 in 1700 additional cancer deaths).³³ A large amount of coronary intervention is now undertaken via the radial route rather than the femoral route, and hence access is easier in the gravid patient. Regardless, there appears to be a general reluctance to perform angiography. In a prospective study of 859 women with AMI in pregnancy or postpartum, only 45% underwent cardiac catheterization.⁶

Coronary angiography may define the cause of the AMI. Most coronary artery dissections involve the proximal segment of the coronary arteries and in particular, the left coronary artery.¹⁴ The typical appearance is that of an intimal flap. However, as previously discussed, dissection may occur in multiple vessels (both left and right) and an intimal flap may be mistaken for coronary stenosis if intramural haematoma is present.³⁴ Coronary artery dissection may also take on various other appearances, such as spasm, and no abnormality may be seen if angiography is delayed and a dissection has healed.¹⁴

Primary percutaneous coronary intervention

Multiple randomized trials have shown that PPCI is superior to thrombolysis with respect to coronary reperfusion, mortality,

intracranial haemorrhage and recurrent MI.³⁵ The American College of Cardiology (ACC)/American Heart Association (AHA) guidelines recommend percutaneous coronary intervention (PCI) for ALL patients who can undergo the procedure within 90 minutes of making contact with medical personnel who are capable of providing PCI.³⁶ This also seems a reasonable approach to take in pregnant or postpartum women with STEMI. For patients presenting 12–24 hours after symptom onset, the performance of primary PCI is reasonable if the patient has severe heart failure (HF), haemodynamic or electrical instability, or persistent ischaemic symptoms.³⁷

Younger patients have a higher incidence of normal coronary arteries, mild luminal irregularities and single-vessel coronary artery disease than do older patients.³⁸ At the time of PPCI, a higher initial dose of clopidogrel, in addition to a glycoprotein (GP) IIb/IIIa inhibitor may be recommended for women undergoing planned PCI. Clopidogrel improves both short-term and long-term cardiovascular outcomes when given in addition to aspirin.³⁹ Experience with its use in pregnancy and in breast-feeding women is limited although there are no reports of adverse fetal effects.^{40–46} However, given the benefits of clopidogrel, it should be strongly considered. Similarly, there is no literature about the use of GP IIb/IIIa inhibitors in pregnancy or lactation. However, early administration of GP IIb/IIIa inhibitors is associated with a trend towards lower mortality.⁴⁷ Triple therapy with heparin, aspirin and clopidogrel along with the addition of a GP IIb/IIIa inhibitor has the potential to increase bleeding risk at the time of delivery, be it vaginal or caesarean section.

Outcome data following PPCI in pregnancy/postpartum are limited. The population-based study of 135 women with AMI described 127 women who underwent coronary artery stenting.⁶ There was no information presented on the timing of the angiography relative to the AMI or maternal and perinatal outcomes. All stents placed were bare metal (as opposed to drug-eluting).

Additional data are available for another 92 women who underwent coronary angiography in pregnancy, 38 of whom underwent PCI consisting of angioplasty or stenting.⁷ The majority were in the third trimester. The rate of procedural complications was low; one woman developed a coronary artery dissection complicated by a stillbirth and the need for coronary artery bypass surgery.⁷

Thrombolysis

If primary PCI is not available on site, or rapid transfer to a PCI centre cannot be achieved within 90 minutes of presentation to hospital, then thrombolysis must be considered for a woman with a STEMI in pregnancy/postpartum.

Is thrombolysis appropriate in STEMI in pregnancy given the possibility of coronary artery dissection as the underlying aetiology of the AMI? There is no clear answer to this question given that there are potential benefits and risks associated with this approach. On the one hand, thrombolytic therapy may lyse a thrombus in the true lumen of the affected coronary artery(ies), restore vessel patency and improve flow.¹³ On the other hand, thrombolysis could also lyse a thrombus in the false lumen within the arterial wall; although this may relieve compression of the true lumen and improve antegrade coronary flow, it could also extend the dissection within the vessel wall.¹³ As such, empirical thrombolytic therapy should probably be avoided when coronary artery dissection is strongly

suspected. It would be best for these women to proceed to coronary angiography on an urgent basis for angioplasty or stenting as appropriate.

For women considered for thrombolysis, the general relative and absolute contraindications to thrombolysis are the same as in the non-pregnant population. None of those likely to be relevant to women discussed in this review are absolute contraindications to thrombolysis. Pregnancy itself is a relative contraindication to thrombolysis based on the paucity of experience with this intervention and the fact that many do not cross the placenta.⁴⁸ Additional relative contraindications include major surgery (such as caesarean section) within the preceding three weeks or uncontrolled hypertension.

The use of thrombolysis in pregnancy dates back to the 1960s, primarily for thromboembolic disease, thrombosed cardiac valves or stroke. There are only two case reports of thrombolysis for AMI in the obstetric population.^{49,50} Both women received thrombolysis early in the second trimester, remote from delivery, and had good maternal and neonatal outcomes. The broader thrombolysis literature in pregnancy has described predictable maternal complications, such as minor vaginal bleeding, spontaneous haematomas (puncture sites and intra-abdominal), antepartum haemorrhage, placental abruption and postpartum haemorrhage.⁴⁸ Overall, however, the incidence of serious antepartum and postpartum complications has been surprisingly low ($\leq 20\%$), such that antenatal thrombolysis should be supported under the appropriate circumstances.⁵¹

Surgical re-vascularization

There is very little information about the implications of performing surgical re-vascularization in pregnancy or the early puerperium. Sixty-one women with AMI have been documented to have undergone coronary artery bypass grafting (CABG) but no outcomes were reported.⁶ Nine of these women underwent CABG for coronary artery dissection, four of whom were in the first trimester.⁷ Outcomes were not reported except for one fetal death.⁷ There are no concerns about fetal harm associated with general anaesthesia, antiemetics or narcotics; however, surgery, particularly in the late second or third trimesters and may precipitate preterm labour and associated haemodynamic changes that may adversely affect the fetus.

Early risk stratification

Early risk stratification in patients with AMI is essential to identify those patients at highest risk for further cardiac events who may benefit from a more aggressive therapeutic approach and early transport to an appropriate centre. Patients who may benefit from an early invasive approach with coronary angiography and possible PCI are those with STEMI (within 90 minutes of presentation, as discussed), STEMI who underwent thrombolysis but who have ongoing risk markers for poorer outcomes and NSTEMI depending on the presence and extent of ST segment depression.⁵² High-risk features include advanced age, low blood pressure, tachycardia, HF and an anterior MI. Specific scoring systems permit a fairly precise determination of the risk of in-hospital mortality. Examples include the TIMI risk score or GRACE risk model for any ACS, Zwolle for primary PCI or CADILLAC risk score for patients post STEMI or primary PCI.^{53–56}

Evaluation of cardiac function will, at minimum, involve echocardiography, findings of which may be changed by

pregnancy. These changes are outlined in Table 3. Stress echocardiography can assess wall motion abnormalities and left ventricular ejection fraction and may be useful for continuing care rather than for diagnosis. A submaximal exercise protocol with fetal monitoring is recommended as fetal bradycardia has been reported with maximal exercise in healthy women.⁵⁷ Nuclear studies like persantin myocardial perfusion scan or MIBI (methoxyisobutylisonitrile) provide information about reversible areas of ischaemia but are generally avoided in pregnancy. If women are breastfeeding at the time, they may express and discard their milk for 24 hours after the test.⁵⁸

Therapy to initiate in the first 24 hours and postdischarge care

In both STEMI and NSTEMI, medical therapy improves long-term prognosis based on data from outside pregnancy. Angiotensin-converting enzyme inhibitors (ACEI) started within hours to days following AMI decrease mortality,⁵⁹ and improve cardiac function by reducing left ventricular re-modelling. In pregnancy, however, they are controversial as they may be considered teratogenic and are contraindicated in the first trimester of pregnancy. In later pregnancy, the use of ACEI has been associated with fetotoxicity such as fetal renal failure.⁶⁰ ACEI should be started as soon the patient has delivered. While ACEI cannot be used in pregnancy, there are reassuring data on captopril, enalapril and quinapril use during breastfeeding and the American Academy of Pediatrics considers their use during breastfeeding to be acceptable.⁶¹

It is important to initiate statins early after an ACS as they have short-term benefits, including plaque stabilization, reversal of endothelial dysfunction, decreased thrombogenicity and reduced inflammation.⁶² Long-term benefits include significant reductions in the combined incidence of coronary death and non-fatal MI and the need for re-vascularization with PCI or CABG.⁶³ Animal studies indicate that many statins are associated with adverse fetal outcomes but at maternally toxic doses.⁶⁴ The limited human data suggest that statins are not major human teratogens if women are inadvertently exposed to statins before recognition of pregnancy.⁶¹ Interestingly, there is now an ongoing randomized controlled trial of statin therapy for preeclampsia amelioration in women between 24 and 31⁺ weeks' gestation: so these drugs can be considered for women post MI.⁶⁵

Beta-blockers are an essential component in the management of ACS. The administration of a beta-blocker following an AMI reduced morbidity and mortality in multiple trials.⁶⁶ There are several beta-blockers that have been used in pregnancy such as labetalol and metoprolol. In pregnancy beta-blockers should be continued indefinitely. Ongoing use of beta-blockers in pregnancy may increase the risk of intrauterine fetal growth restriction, based on data from randomized controlled trials for hypertension in pregnancy.^{67,68} However, the potential risks

Table 3 Normal anatomical changes of pregnancy seen on ECHO⁷¹

- All four cardiac chambers increase in size
- Increased left ventricular wall thickness and mass
- Increases in mitral, tricuspid and pulmonic annular diameters lead to increasing degrees of mitral, tricuspid and pulmonic regurgitation
- Small pericardial effusion

are outweighed by the benefits of their use in women with AMI.

Patients with STEMI or NSTEMI are also usually continued on aspirin indefinitely and clopidogrel if they have received coronary stents. Clopidogrel is continued for at least one month if it is a bare metal stent and at least one year with a drug-eluting stent to prevent stent thrombosis. Discontinuing clopidogrel prematurely carries a significant risk of stent thrombosis. Table 4 summarizes the medications and their acceptability for use in the antepartum, intrapartum and postpartum periods.

Particular attention should be paid to blood pressure and fluid management especially in the postpartum period. The physiological increase in plasma volume, iatrogenic fluids and low oncotic pressure creates a period of susceptibility to pulmonary oedema. A number of drugs can be used for the management of hypertension including beta-blockers, calcium channel blockers and ACEI in the postpartum period. A reasonable target blood pressure for these patients is 135/85 mmHg.

MODE OF DELIVERY

The mode of delivery following antenatal AMI should be determined by obstetric indications and the maternal status. In one population study, only 10 of 103 patients were delivered by caesarean section, a rate lower than contemporary rates.⁷ An elective caesarean section may avoid a long labour, increases in preload from uterine contractions and allow for the appropriate multidisciplinary team to be present at delivery, during the day and during the normal work week.⁸ However, expert opinion favours a vaginal delivery with regional analgesia/

anaesthesia, in order to minimize blood loss, postoperative infection and respiratory complications. All women with a history of AMI, prepregnancy or during the index pregnancy should be reviewed by a consultant anaesthetist and monitored closely on delivery suite.

FUTURE PLANNING

There is limited literature about outcomes in subsequent pregnancies of women with a history of AMI, although pregnancy in these women is not considered to be contraindicated. Prognostication of outcome in future pregnancies is currently not possible with any accuracy. A prediction rule for primary cardiac events in women with heart disease in general has been proposed by Siu *et al.*⁶⁹ based on a prospective, multicentre study. However, only 11 of the 562 women enrolled in this cohort had ischaemic heart disease. Prior MI was not studied as a predictor for future events, most likely due to the small number of women in the study with ischaemic heart disease. Furthermore, AMI was not included in the composite outcome of primary cardiac events during subsequent pregnancy.

Preconception counselling is essential and must cover the following:

- A full cardiac evaluation preconception including ECG, stress test, echocardiography and/or nuclear studies. Invasive testing may be required and will depend on the patient's current symptoms, functional status, previous anatomy and procedures;
- Adequate control of vascular risk factors should be achieved before conception. Antihypertensives may need to be

Table 4 Treatment considerations for the antepartum, intrapartum and postpartum period

	Antepartum	Intrapartum	Postpartum	Lactation
Oxygen	*	*	*	*
Morphine	*	*	*	*
				Monitor infant for apnoea and bradycardia
Nitrates	*	*	*	*
	Monitor for maternal hypotension	Monitor for maternal hypotension	Monitor for maternal hypotension	
Low-dose aspirin	*	*	*	*
Heparin	*	*	*	*
	Minimal bleeding risk	Timing of anaesthesia, vaginal delivery and caesarean section need to be considered in relation to heparin use	Risk of postpartum haemorrhage; timing from delivery should be considered	
Clopidogrel	Limited information [†]	Limited information [†]	Limited information [†]	Limited information [†]
Beta-blockers	*	*	*	*
	Monitor for maternal hypotension	Monitor for maternal hypotension	Monitor for maternal hypotension	
Glycoprotein IIa/IIIb inhibitors	Limited information [†]	Limited information [†]	Limited information [†]	Limited information [†]
Thrombolysis	*	*	*	No information available but with the short half-life, it would be reasonable to pump and discard for 12–24 hours
	Risks include haematomas, antepartum haemorrhage and abruption but are likely <10%	Timing of anaesthesia, vaginal delivery and caesarean section need to be considered in relation to thrombolysis	Risk of postpartum haemorrhage; timing from delivery should be considered	
ACE inhibitor	Not recommended	Not recommended	*‡	*‡
Statin	Limited information	Limited information	Limited information	Limited information

ACE, angiotensin-converting enzyme

*Acceptable for use

[†]In consultation with cardiology

[‡]Particularly captopril, enalapril and quinapril

changed to those that are acceptable in pregnancy such as methyldopa, labetalol, other beta-blockers (e.g. metoprolol) or calcium channel blockers (e.g. nifedipine).⁹ Low-dose aspirin and beta-blockers should be continued. ACE inhibitors should be stopped prior to pregnancy if possible. Statin therapy in pregnancy remains controversial;

- *Ideal inter-pregnancy interval*: advice is based on common sense. Adequate contraception should be ensured until risk stratification and follow-up have been completed. Expert opinion would suggest at least 18–24 months in between pregnancies.

During prepregnancy planning and pregnancy itself, the woman should be followed by a team of specialists with representation from obstetrics, obstetric medicine and cardiology. Ideally, the patient should be managed at a tertiary care centre with experience in obstetric cardiology.

CONCLUSIONS

The incidence of AMI in the obstetric population is low, although pregnancy increases the risk by three- to four-fold. The incidence is climbing due to rising maternal age, weight and the prevalence of pre-existing cardiovascular risk factors. In addition to traditional cardiovascular risk factors, pregnancy-specific risk factors include preeclampsia, transfusion and postpartum infection.

Atherosclerotic disease accounts for the majority of AMI, although coronary artery dissection is an important consideration in pregnancy that may change acute management. Investigations for diagnosis and risk stratification should be interpreted in the context of pregnancy-related changes. Therapy, both in the short and long term, requires modification as some medications may be contraindicated in pregnancy and breastfeeding. With advances in diagnostic modalities and treatment, it is anticipated to improve the prognosis and outcome.

FUTURE DIRECTIONS

THE UK Obstetric Surveillance System (UKOSS) will perform a five-year review of at least 140 AMI cases in the UK and will address the following questions:⁷⁰

- (1) What is the current incidence of MI during pregnancy?
- (2) What is the prevalence of known risk factors for coronary heart disease?
- (3) How is MI in pregnancy managed?
- (4) What are the outcomes following MI in pregnancy for both mother and infant?

This study is particularly important because it will provide more information about management and outcomes in women with AMI. Research is also needed about risk stratification and subsequent pregnancy in a patient with a previous history of MI.

DECLARATIONS

Competing interests: None.

Funding: Dr. Firoz is supported by the University of British Columbia Clinician Investigator Program.

Guarantor: None.

Contributorship: TF and LAM are responsible for the concept and design of the manuscript. TF executed the manuscript. LAM edited the manuscript.

Acknowledgements: None.

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(Accepted 18 December 2011)