

**CLINICAL PRACTICE GUIDELINE**

**2016**



# **Heart Disease in Pregnancy**

**2<sup>nd</sup> Edition**



Ministry of Health Malaysia



Academy of Medicine Malaysia



National Heart Association of Malaysia

## **STATEMENT OF INTENT**

This guideline was developed to be a guide for best clinical practice in the management of cardiovascular diseases in pregnancy, based on the best available evidence at the time of development. Specific attempts were made to use local data and publications to ensure local relevance. Adherence to this guideline does not necessarily lead to the best clinical outcome in individual patient care. Every health care provider is responsible for the management of his/her unique patient based on the clinical presentation and management options available locally.

## **REVIEW OF THE GUIDELINE**

This guideline is issued in 2016 and will be reviewed in about 5 years or earlier if important new evidence becomes available.

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Available on the following websites:

<http://www.moh.gov.my>  
<http://www.acadmed.org.my>

This is an update to the Clinical Practice Guidelines on Heart Disease in Pregnancy published in 2001. This CPG supersedes the previous CPG.

# Message From The Director General of Health

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Malaysia, with a crude birth rate of 16.9 per 1000 population and an annual population growth rate of 1.3%, has also seen a significant growth in attendances at the Ministry of Health's antenatal clinics – from 5.7 million in 2013 to 6.1 million in 2014. Allied to the well documented rising prevalence of cardiovascular risk factors in the country over the last two decades, and the improved access of the population to healthcare facilities, it is reasonable to consider that there are greater numbers of pregnant women who are diagnosed or who are at risk of heart disease in Malaysia.

The Clinical Practice Guidelines on the management of heart disease in pregnancy in Malaysia was first published in 2001, so this 2<sup>nd</sup> edition is timely. These guidelines are intended to be an updated resource which is useful to all clinical practitioners and all those who are involved in the care of pregnant women. It incorporates updated knowledge on heart disease, contemporary diagnostic tools and strategies, and also on treatment options available, now over a decade since the first national guidelines was published on this subject.

The management of pregnant women in heart disease can be complex and often involves a multidisciplinary team, and particularly if the patient newly diagnosed with heart disease at the time of pregnancy. A multidisciplinary team is involved in the care of the pregnant women right through her pregnancy, and even beyond that. In recognition of this, I am proud to see the effort and coordination by the chairperson, Dr Robaayah Zambahari, to assemble an expert panel drawn from various clinical disciplines from different healthcare provider agencies. Their dedication and commitment have resulted in this comprehensive set of guidelines on how to manage heart disease in pregnancy in this modern era.

I would like to thank all those who contributed to the publication of these guidelines, which I am certain will be a document often referred to, so that pregnant women with heart disease will be managed optimally to ensure the best possible outcomes for both mother and child.

A handwritten signature in black ink, appearing to read "JHL".

Datuk Dr Noor Hisham Abdullah  
Director-General of Health Malaysia

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# International Reviewer

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*"Overall, I think these guidelines are really excellent and they clearly represent a great deal of very diligent work by those who compile them. I congratulate them on a first-class production."*

Professor Philip J Steer

Professor Emeritus

Imperial College London

(Currently an editor of 'High Risk Pregnancy – Management Options', 5<sup>th</sup> Ed,  
Co Editor 'Heart Disease in Pregnancy' 2<sup>nd</sup> Ed)

*"Excellent document! A pleasure to read. Your group is to be congratulated."*

Dr. Candice Silversides

Associate Professor of Medicine at the University of Toronto.

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Head of the Obstetric Medicine Program at the University of Toronto

Research Director of the Toronto Congenital Cardiac Center for Adults.

# Rationale and Process of Guideline Development

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## **Rationale:**

Cardiovascular disease (CVD) is a major cause of maternal morbidity and mortality in Malaysia. In the National Obstetrics Registry, CVD occurred in about 0.45 and 0.55% of pregnancies in 2013 and 2014 respectively. This is relatively common. Cardiovascular Disease however, accounted for 51% and almost 70% of indirect deaths in the period 2009-2011 and 2011 respectively from the Confidential Enquiries into Maternal Death Report 2009-2011.

This Clinical Practice Guidelines (CPG) on the management of Cardiovascular Disease in Pregnancy is the second edition. The first edition was published in 2001 and thus an update is timely. This CPG has been drawn up by a committee appointed by the National Heart Association of Malaysia, Ministry of Health and the Academy of Medicine. It comprises cardiologists, obstetricians, obstetric anaesthesiologists and general physicians from the public and private sectors and the Universities.

## **Objectives:**

The objective of this clinical practice guideline is to highlight to the healthcare provider how to:

- counsel the cardiac patient before pregnancy
- recognise cardiac disease in pregnancy
- identify high risk cardiac patients
- manage and refer these patients appropriately

## **Process:**

The Expert Panel formulated clinical questions that needed to be addressed. These were then divided into sections and each member was assigned one or more topics.

A review of current medical literature on Cardiovascular Disease in Pregnancy for the last 10 years was performed. Literature search was carried out using the following electronic databases – PubMed and Cochrane Database of Systematic Reviews. The following MeSH terms or free text terms were used either singly or in combination:

“Cardiovascular Disease in Pregnancy”, “Heart Disease in pregnancy”, “Myocardial Infarction in Pregnancy”, “Congenital heart disease in pregnancy”, “Hypertension in pregnancy”.

# Rationale and Process of Guideline Development

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The search was filtered to clinical trials and reviews, involving humans and published in the English language. The relevant articles were carefully selected from this huge list. In addition, the reference lists of all relevant articles retrieved were searched to identify further studies. Experts in the field were also contacted to obtain further information. International guidelines - the European Society of Cardiology - were also studied. All literature retrieved were appraised by members of the Expert Panel and all statements and recommendations made were collectively agreed by the group. The grading of evidence and the level of recommendation used in this CPG was adapted from the American College of Cardiology/ American Heart Association and the European Society of Cardiology (pg. 9).

After much discussion, the draft was then drawn up and submitted to the Technical Advisory Committee for Clinical Practice Guidelines, Ministry of Health Malaysia and key health personnel in the major hospitals of the Ministry of Health and the private sector for review and feedback.

## Clinical Questions Addressed:

- General considerations/issues in a pregnant patient with cardiac disease:
  - What are the haemodynamic changes and impact of the normal physiological changes in pregnancy on the cardiovascular system?
  - What are the effects/impact of the mother's existing cardiac disease on the pregnancy?
- What are the important issues/medications to emphasise during preconception counselling?
- What are the safe contraceptive methods in patients with cardiac disease?
- How do you diagnose patients suspected of cardiac disease in pregnancy?
- How do you risk stratify these patients?
- What are the indications for termination of pregnancy?
- What are the safe medications during pregnancy and lactation?
- Who and when do you refer to the relevant specialist(s)?
- How do you manage specific cardiac conditions?
  - Valvular heart disease
  - Congenital heart disease
  - Pulmonary hypertension and Eisenmenger syndrome
  - Marfan syndrome
  - Ischaemic heart disease and acute coronary syndromes

# Rationale and Process of Guideline Development

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- Peripartum and other cardiomyopathies
- Arrhythmias
- Heart failure
- Infective endocarditis
- Hypertension
- Diabetes mellitus
- What are the indications for cardiac intervention or surgery in these pregnant patients?
- What are the anaesthetic considerations during labour and delivery?

## **Target Group:**

This guideline is directed at all healthcare providers involved in the management of pregnant women with cardiac disease – general practitioners, general and family physicians, obstetricians and cardiologists.

## **Target Population:**

It is developed for the management of patients with cardiac disease planning for pregnancy and pregnant patients with underlying cardiac disease.

## **Period of Validity of the Guidelines:**

This guidelines needs to be revised at least every 5 years to keep abreast with recent developments and knowledge that is being learnt.

# Rationale and Process of Guideline Development

## **GRADES OF RECOMMENDATION AND LEVEL OF EVIDENCE**

GRADES OF RECOMMENDATION	
I	Conditions for which there is evidence and/or general agreement that a given procedure/therapy is beneficial, useful and/or effective.
II	Conditions for which there is conflicting evidence and/or divergence of opinion about the usefulness/efficacy of a procedure/therapy.
II-a	Weight of evidence/opinion is in favour of its usefulness/efficacy.
II-b	Usefulness/efficacy is less well established by evidence/opinion.
III	Conditions for which there is evidence and/or general agreement that a procedure/therapy is not useful/effective and in some cases may be harmful.

LEVELS OF EVIDENCE	
A	Data derived from multiple randomised clinical trials or meta analyses.
B	Data derived from a single randomised clinical trial or large non-randomised studies.
C	Only consensus of opinions of experts, case studies or standard of care.

*Adapted from the American College of Cardiology Foundation/American Heart Association and the European Society of Cardiology*

*(Available at: [http://assets.cardiosource.com/Methodology\\_Manual\\_for\\_ACC\\_AHA\\_Writing-Committees.aspx](http://assets.cardiosource.com/Methodology_Manual_for_ACC_AHA_Writing-Committees.aspx) and at <http://www.escardio.org/guidelines-surveys/escguidelines/about/Pages/rules-writing.aspx>).*

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# Abbreviation

ABPM	Ambulatory Blood Pressure Monitoring
APPT	Activated Partial Thromboplastin Time
AR	Aortic Regurgitation
ARM	Artificial Rupture of Membrane
ASD	Atrial Septal Defect
AVA	Aortic Valve Area
AVRT	Atrioventricular Reentrant Tachycardia
AVNRT	Atrioventricular Nodal Reentrant Tachycardia
BNP	Brain Natriuretic Peptide
BP	Blood Pressure
CCT	Control Cord Traction
CCU	Coronary Care Unit
CEMD	Confidential Enquiries into Maternal Death
CHD	Congenital Heart Disease
CHD-PAH	Pulmonary Arterial Hypertension Associated with Congenital Heart Disease
c-MRI	Cardiac Magnetic Resonance Imaging
COA	Coarctation of Aorta
COC	Combined oral contraceptive
CPB	Cardiopulmonary Bypass
CPG	Clinical Practice Guidelines
CTG	Cardiotocography
CV	Cardiovascular
CVD	Cardiovascular Disease
DAPT	Dual Antiplatelet Therapy
DBP	Diastolic Blood Pressure
DCCV	Direct Current Cardioversion
DCM	Dilated Cardiomyopathy
DES	Drug-Eluting Stents
ECG	Electrocardiogram
ECMO	Extracorporeal Membrane Support
FDA	The United States Food and Drug Administration
FGR	Fetal Growth Restriction
FMS	Family Medicine Specialist
GDM	Gestational Diabetes
GH	Gestational Hypertension
HCM	Hypertrophic Cardiomyopathy
HDU	High Dependency Unit
HF	Heart Failure
ICU	Intensive Care Unit
IE	Infective Endocarditis
IM	Intramuscular
iPAH	Idiopathic Pulmonary Arterial Hypertension

# Abbreviation

ISSHP	International Society for Study of Hypertension in Pregnancy
IUD	Intrauterine Contraceptive Device
IUS	Intrauterine System
IV	Intravenous
LMWH	Low Molecular Weight Heparin
LSCS	Elective Lower Section Caesarean Section
LV	Left Ventricular
LVEF	Left Ventricular Ejection Fraction
LVOTO	Left Ventricular Outflow Tract Obstruction
MFM	Maternal Fetal Medicine
MI	Myocardial Infarction
MVA	Mitral Valve Area
NYHA	New York Heart Association
OAC	Oral Anticoagulants
OGTT	Oral Glucose Tolerance Test
oPAH	PAH Associated with Other Causes
PAH	Pulmonary Arterial Hypertension
PCA	Patient Controlled Analgesia
PCEA	Patient Controlled Epidural Analgesia
PCI	Percutaneous Coronary Intervention
PDA	Patent Ductus Arteriosus
PE	Pre-Eclampsia
PH	Pulmonary Hypertension
PIH	Pregnancy Induced Hypertension
PPCM	Peripartum Cardiomyopathy
PPH	Postpartum Haemorrhage
PSVT	Paroxysmal Supraventricular Tachycardia
PTMC	Percutaneous Mitral Commissurotomy
RVOT	Right Ventricular Outflow Tract
SBP	Systolic Blood Pressure
STEMI	ST Elevation Myocardial Infarction
SVT	Supraventricular Tachycardia
TOF	Tetralogy of Fallot
TOP	Termination of Pregnancy
UFH	Unfractionated Heparin
VSD	Ventricular Septal Defect
VT	Ventricular Tachycardia
VTE	Venous Thromboembolism
WHO	World Health Organisation

# Summary

- Cardiac disease in pregnancy is relatively common, accounting for 0.55% and 0.45% of all pregnancies in 2013 and 2014 respectively. It is a major cause of non-obstetric morbidity and maternal mortality.
- All women in the reproductive age group who have cardiac disease should undergo preconception cardiac assessment and counselling by their family physicians, cardiologists, obstetricians, maternal fetal medicine specialists and/or geneticists. (Flowchart 1, pg. 27)
- Counselling should be initiated early at puberty and re-emphasised at age 16-18 and prior to marriage. It should continue until they have completed their family.
- They should be risk stratified using the modified WHO and NYHA classification (Table 1A, 1B & 2, pg. 18-21)

Maternal CV Risk	WHO class	NYHA functional class
Low Risk	I & II	I & II
Moderate Risk	II-III & III	-
High Risk	IV	III & IV

- All patients should be counselled on appropriate contraceptive methods.
- Once pregnancy is confirmed, the patient should go to the nearest antenatal clinic for booking. The patient should be referred as soon as possible for cardiac assessment and risk stratification.
- The clinical pathways for antepartum, intrapartum and postpartum care is as outlined in Table 3-6, pg. 22-26, Flowcharts 2, 3 & 4, pg. 28-32.
- Each patient should have an individualised pregnancy care plan depending on the maternal risk. (pg. 29)
- Level of Care will depend on the maternal CV risk.
  - **Low risk:** can be managed at their local centre after review by a family medicine specialist/physician or cardiologist.
  - **Moderate risk:** should be managed at a tertiary centre by a multidisciplinary team with cardiac expertise.
  - **High risk:** should be referred early to the tertiary centre for assessment. If termination of pregnancy is considered, it can be performed up to 22 weeks.
- Commonly encountered cardiac diseases in pregnancy include:
  - **Valve disease:** Most patients tolerate pregnancy well. Patients with severe obstructive lesions (mitral and aortic stenosis) should undergo cardiac intervention prior to pregnancy.

# Summary

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- **Congenital Heart Disease:** Most acyanotic and repaired/corrected patients tolerate pregnancy well. Patients with pulmonary hypertension and Eisenmenger syndrome are High Risk and termination of pregnancy should be considered.
- **Peripartum cardiomyopathy:** Obstetric and cardiac risk will depend upon the baseline left ventricular (LV) function. Most patients recover within 6 months of diagnosis.
- Commonly encountered cardiac issues are:
  - Anticoagulation especially in patients with mechanical heart valves (Summary for Management of Anticoagulation in Pregnancy, pg. 17 & 18 and section 4.9, pg. 114)
  - Cardiac failure
  - Arrhythmias
  - Hypertension – both chronic hypertension (before 20 weeks) and pregnancy induced hypertension (after 20 weeks)
- Antibiotic prophylaxis is not advocated during normal vaginal delivery except in high risk patients (section 4.10.3, pg. 120).

## SUMMARY FOR MANAGEMENT OF ANTICOAGULATION IN PREGNANCY

### Mechanical Heart Valves

- The goal is to prevent valve thrombosis which is a lethal event for the mother and the fetus. This risk is:
  - Lowest with the use of oral anticoagulants (OAC) throughout pregnancy. (< 4%)
  - About 5-10% with the use of unfractionated heparin (UFH) in the first trimester and OAC in the 2<sup>nd</sup> and 3<sup>rd</sup> trimesters.
  - As high as 33% in those receiving subcutaneous UFH throughout pregnancy.
- All anticoagulation regimens (both OAC and heparin based therapy) carry an increased risk of fetal teratogenicity, fetal wastage, miscarriage and haemorrhagic complications. These risks are higher with OAC than with heparin based therapies.
- Preconception counselling is mandatory and the following issues should be addressed:
  - Risk of warfarin embryopathy during the 1<sup>st</sup> trimester depending on the daily dosage:
    - ≤ 5 mg - the risk of embryopathy is low.
    - > 5 mg/day, there is a potential for fetal adverse events.
  - Risk of valve thrombosis which is higher with heparin based therapy - both UFH and low molecular weight (LMWH):
    - UFH regime - this should be given IV with regular aPTT monitoring. This should be kept at > 2x control.
    - Self-injected adjusted-dose LMWH with regular monitoring of anti-Xa levels (target anti-Xa level 0.8-1.2 U/mL 4-6 hours post dose). If monitoring of anti-Xa levels cannot be done, LMWH should not be used. It should not be dosed according to weight. Ideally, a haematologist should be involved in the management.
- Considering the risk : benefit ratio, in all high-risk patients with mechanical valves, warfarin is advocated throughout pregnancy up to 36 weeks.
- The alternative regime is warfarin in the 2<sup>nd</sup> and 3<sup>rd</sup> trimester up to 36 weeks with bridging heparin based therapy (IV UFH or LMWH) in the 1<sup>st</sup> trimester.
- The patients' and family's preferences should be clearly documented.

## **Anticoagulation for other indications**

- The choice of anticoagulation for other indications would depend upon the risk of thrombosis, patients' preference and the consensus of the multidisciplinary team. Either:
  - Regime A – warfarin throughout pregnancy till 36 weeks or
  - Regime B – UFH or LMWH therapy in the 1<sup>st</sup> trimester and warfarin in the 2<sup>nd</sup> and 3<sup>rd</sup> trimester
- Depending on the indication(s) (e.g. venous thrombosis, non-valvular Atrial Fibrillation) and the risk of thrombosis, LMWH may be given as a weight based regime without anti-Xa monitoring.
- In patients where the risk of thrombosis is high (e.g. PH due to thromboembolic disease, recent pulmonary embolism, valvular AF) Regime A (warfarin throughout pregnancy till 36 weeks) is advocated.
- If Regime B – bridging therapy with LMWH in the 1<sup>st</sup> trimester is chosen – then efforts should be taken to monitor anti-Xa levels in these high risk patients.

## **Management from 36 weeks gestation till Delivery**

- At 36 weeks, warfarin should be switched to:
  - LMWH or UFH
  - Women on LMWH should be switched to IV UFH at least 36 hours before induction of labour or caesarean section. This should be discontinued 4-6 hours before planned delivery and restarted 4-6 hours after vaginal delivery or 6-12 hours after LSCS if there are no bleeding complications.
- Oral anticoagulation can be resumed after 24 hours if there are no bleeding concerns.
- For patients with mechanical heart valves, a stable INR should be achieved prior to discharge.

**Table 1A: Maternal Mortality Risk Based on Modified WHO Classification**

WHO Class	Maternal Mortality
I	Insignificant
II	< 1%
II-III	1-5%
III	5-15%
IV	25-50%

# Summary

**Table 1B: Modified World Health Organization Maternal Cardiovascular Risk Assessment<sup>a-f</sup>**

<b>WHO Class I: No Increase or a Mild Increase in Morbidity</b>
<ul style="list-style-type: none"><li>• Uncomplicated, small or mild<ul style="list-style-type: none"><li>➢ pulmonary stenosis</li><li>➢ patent ductus arteriosus</li><li>➢ ventricular septal defect</li><li>➢ mitral valve prolapse (with no more than trivial mitral regurgitation)</li></ul></li><li>• Successfully repaired simple lesions (secundum atrial or ventricular septal defect, patent ductus arteriosus, anomalous pulmonary venous drainage)</li><li>• Isolated Atrial ectopic beats or ventricular extrasystoles</li></ul>
<b>WHO CLASS II: (If otherwise well and uncomplicated)</b> <b>Moderate Increase in Maternal Morbidity</b> <b>Small Increase in Maternal Mortality (&lt; 1%)</b>
<ul style="list-style-type: none"><li>• Unoperated atrial or ventricular septal defect (moderate size, velocity &lt; 4 m/s)</li><li>• Repaired tetralogy of Fallot (without significant residual lesions)</li><li>• Most asymptomatic arrhythmias without cardiac decompensation - atrial fibrillation, supraventricular tachycardia, Wolff Parkinson White syndrome, long QT syndrome without any cardiac decompensation</li></ul>
<b>WHO CLASS II-III: Maternal Mortality, (1-5%) depending on the individual or other co-existing conditions</b>
<ul style="list-style-type: none"><li>• Mild left ventricular dysfunction (LVEF 40-50%)</li><li>• Hypertrophic cardiomyopathy<ul style="list-style-type: none"><li>➢ No LV outflow tract obstruction: WHO II</li><li>➢ LV outflow tract obstruction present: WHO III</li></ul></li><li>• Marfan syndrome without aortic dilation</li><li>• Aorta &lt; 45 mm in aortic disease associated with bicuspid aortic valve</li><li>• Native or tissue valve disease not considered WHO I or IV</li><li>• Mild native or repaired coarctation of aorta (without hypertension or significant obstruction)</li></ul>

**Table 1B: Modified World Health Organization Maternal Cardiovascular Risk Assessment (cont'd)**

<p><b>WHO CLASS III: Severe Increase in Maternal Morbidity</b>  <b>Significant Increase in Maternal Mortality (5-15%)</b>  <b>Expert counselling required. If pregnancy is decided upon, needs an individualised pregnancy care plan with a multidisciplinary team management.</b></p>
<ul style="list-style-type: none"> <li>Left ventricular dysfunction (LVEF 35-40%)</li> <li>Mechanical valve</li> <li>Systemic right ventricle (cCTGA, post Senning/Mustard)</li> <li>Fontan circulation</li> <li>Repaired Tetralogy of Fallot with severe pulmonary regurgitation, right ventricular failure, right ventricular outflow tract obstruction</li> <li>Cyanotic heart disease (unrepaired)</li> <li>Other complex congenital heart disease</li> <li>Aortic dilatation 40-45 mm in Marfan syndrome</li> <li>Aortic dilatation 45-50 mm in aortic disease associated with bicuspid aortic valve</li> </ul>
<p><b>WHO CLASS IV: Maternal mortality is 25-50%</b>  <b>Pregnancy Is Not Recommended or Is Contraindicated.</b>  <b>If pregnancy occurs, termination should be discussed.</b>  <b>If pregnancy continues, care as for class III.</b></p>
<ul style="list-style-type: none"> <li>Severe pulmonary arterial hypertension of any cause (mortality 17-33%)</li> <li>Severe systemic ventricular dysfunction (LVEF &lt; 30%, NYHA III-IV)</li> <li>Previous peripartum cardiomyopathy with any residual impairment of left ventricular function</li> <li>Severe mitral stenosis (<math>MVA &lt; 1.0 \text{ cm}^2</math>), severe symptomatic aortic stenosis (<math>AVA &lt; 1.0 \text{ cm}^2</math>)</li> <li>Marfan syndrome with aorta dilated <math>&gt; 45 \text{ mm}</math></li> <li>Aortic dilatation <math>&gt; 50 \text{ mm}</math> in aortic disease associated with bicuspid aortic valve</li> <li>Uncorrected severe coarctation</li> </ul>

Modified from:

- a. Thorne S, MacGregor A, Nelson-Piercy C. Risks of contraception and pregnancy in heart disease. *Heart* 2006; 92:1520-5.
- b. Regitz-Zagrosek V, Blomstrom Lundqvist C, Borgh C et al. European Society of Cardiology guidelines on the management of cardiovascular diseases during pregnancy. *Eur Heart J* 2011; 32:3147-97.
- c. Siu SC, Sermer M, Colman JM, Alvarez AN, Mercier LA et al. Prospective multicentre study of pregnancy outcomes in women with heart disease. *Circulation* 2001; 104: 515-521.
- d. Drenthen W, Boersma E, Balci A, Moons P, Roos-Hesselink JW et al. Predictors of pregnancy complications in women with congenital heart disease. *Eur Heart J* 2010; 31: 2124-2132.
- e. Khairy P, Ouyang DW, Fernandes SM, Lee-Parritz A, Economy KE, Landzberg MJ. Pregnancy outcomes in women with congenital heart disease. *Circulation* 2006; 113:517-524.
- f. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP 3rd, Guyton RA, O'Gara PT, Ruiz CE, Skubas NJ, Sorajai P, Sundt TM 3rd, Thomas JD; ACC/AHA Task Force Members. 2014 AHA/ACC Guideline for the Management of Patients with Valvular Heart Disease: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129:2440-2492.

**Table 2: New York Heart Association Functional Classification**

Functional Class	Symptoms	Maternal cardiovascular risk
<b>CLASS I</b>	No limitation. Ordinary physical activity does not cause undue fatigue, dyspnoea or palpitation.	Low
<b>CLASS II</b>	Slight limitation of physical activity. Such patients are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnoea or angina.	Low
<b>CLASS III</b>	Marked limitation of physical activity. Although patients are comfortable at rest, less than ordinary activity will lead to fatigue, palpitation, dyspnoea or angina.	High
<b>CLASS IV</b>	Inability to carry on any physical activity without discomfort. Symptoms of congestive heart failure are present at rest. With any physical activity, increased discomfort is experienced.	High

Modified from:

The Criteria Committee of the New York Heart Association. Nomenclature and Criteria for Diagnosis of Diseases of the Heart and Great Vessels. 9<sup>th</sup> ed. Boston, Mass: Little, Brown & Co; 1994:253-256.

# Summary

**Table 3: Maternal Cardiovascular Risk assessment and Level of Care\***

Maternal Cardiovascular Risk Assessment		
<b>Risk Assessment</b>	<ul style="list-style-type: none"> <li>WHO Risk Classification</li> <li>NYHA Functional Classification</li> </ul>	
<b>Laboratory investigation and physical examination</b>	<ul style="list-style-type: none"> <li>BP</li> <li>Fasting blood glucose</li> <li>ECG</li> <li>CXR (if indicated)</li> <li>Echocardiography</li> <li>Renal profile</li> </ul>	
Level of Care Depending on Maternal Cardiovascular Risk		
<b>Classification</b>	<b>WHO/ NYHA Class I &amp; II</b>	<b>WHO/ NYHA Class II-III, III &amp; IV</b>
<b>Level of Personnel</b>	<ul style="list-style-type: none"> <li><b>Primary care:</b> MO &amp; FMS</li> </ul>	<ul style="list-style-type: none"> <li><b>Tertiary care:</b> Physician/ Cardiologist/ Obstetrician/ MFM</li> </ul>
<b>Level of Care</b>	<ul style="list-style-type: none"> <li><b>Primary care:</b> Health Clinic</li> </ul>	<ul style="list-style-type: none"> <li><b>Tertiary care:</b> Hospital with multidisciplinary team</li> </ul>
<b>Frequency of visits: Primary care by MO/FMS</b>	<ul style="list-style-type: none"> <li>1 visit for 1<sup>st</sup> trimester (if indicated, to refer to a centre which provides nuchal translucency scan)</li> <li>3 visits for 2<sup>nd</sup> trimester</li> <li>6 visits for 3<sup>rd</sup> trimester (weekly &gt; 36 weeks)</li> </ul>	-
<b>Tertiary care by: ➤ obstetrician/MFM ➤ cardiologist/ multidisciplinary team</b>	<ul style="list-style-type: none"> <li>Once, at 18-22 weeks for fetal anomaly scan</li> <li>Once, preferably within the 1<sup>st</sup> trimester and &lt;18 weeks (to formulate individualised pregnancy care plan)</li> </ul>	<ul style="list-style-type: none"> <li>1 for 1<sup>st</sup> trimester</li> <li>3 for 2<sup>nd</sup> trimester</li> <li>6 for 3<sup>rd</sup> trimester (weekly &gt; 36 weeks)</li> </ul>

\*frequency of visits and level of care will depend upon the individualised pregnancy care plan

Adapted from: Ministry Of Health, Perinatal Care Manual 3<sup>rd</sup> Ed. 2013

**MO:** Medical Officer

**FMS:** Family Medicine Specialist

**MFM:** Maternal Fetal-Medicine Specialist

# Summary

**Table 4: Antenatal Visits Depending on Maternal Cardiovascular Risk  
(WHO & NYHA I & II)**

Frequency of visit at primary care by MO/FMS	Frequency of visit at tertiary centre by obstetrician/ MFM	Frequency of visit by cardiologist/ multidisciplinary team
Once confirmed pregnancy	<ul style="list-style-type: none"><li>Confirm viability and gestational age of pregnancy</li><li>For risk stratification</li></ul>	-
By week 12	<ul style="list-style-type: none"><li>For nuchal translucency scan, if indicated</li></ul>	<ul style="list-style-type: none"><li>To determine individualised pregnancy care plan</li></ul>
Week 18 - 22	<ul style="list-style-type: none"><li>For detailed anomaly scan</li><li>In mothers with congenital heart disease, a detailed fetal echocardiogram should be offered</li></ul>	-
Week 22 - 28	2 visits	
Week 28 - 32	-	<ul style="list-style-type: none"><li>For assessment and to establish a plan of management for delivery and postpartum care</li></ul>
Week 36 - 40	<ul style="list-style-type: none"><li>Weekly visits</li><li>Number and timing of further appointments will be dependent on the nature and severity of cardiac disease</li><li>Some appointments may be with the family medicine specialist / Medical officer at primary care.</li></ul>	-

# Summary

**Table 5: Antenatal Visits Depending on Maternal Cardiovascular risk  
(WHO & NYHA III & IV)**

Frequency of visit at primary care by MO/FMS	Frequency of visit at tertiary centre by obstetrician/ MFM	Frequency of visit by cardiologist/ multidisciplinary team
Once confirmed pregnancy	-	*Advice TOP
By week 12	<ul style="list-style-type: none"> <li>If pregnancy continues, for a nuchal translucency scan if indicated</li> </ul>	<ul style="list-style-type: none"> <li>For individualised pregnancy care plan if pregnancy continues</li> </ul>
Week 18 - 22	<ul style="list-style-type: none"> <li>For a detailed fetal anomaly scan</li> <li>In mothers with congenital heart disease, a detailed fetal echocardiogram should be offered</li> </ul>	-
Week 22 - 28	<ul style="list-style-type: none"> <li>Once in 2 weeks</li> <li>Number and timing of further appointments will be dependent on the nature and severity of cardiac disease</li> </ul>	-
Week 28 - 32	<ul style="list-style-type: none"> <li>Weekly visits</li> <li>Number and timing of further appointments will be dependent on the nature and severity of cardiac disease</li> </ul>	<ul style="list-style-type: none"> <li>For assessment and to establish timing, mode of delivery and postpartum care</li> </ul>
Week 32 - 40		<ul style="list-style-type: none"> <li>Consider admission</li> <li>Anaesthetic review</li> </ul>

\*The following High Risk patients should be offered TOP: Severe pulmonary hypertension, Eisenmenger syndrome, Marfan syndrome with aortic root dilatation > 45 cm, previous peripartum cardiomyopathy with residual impairment of left ventricular function, LVEF < 30%, NYHA III-IV, severe mitral stenosis (MVA < 1.0 cm<sup>2</sup>), severe symptomatic aortic stenosis (AVA < 1.0 cm<sup>2</sup>)

# Summary

**Table 6: Specialist Referral and Pregnancy Care Plan**

Maternal Risk	Timing of Specialist Referral	Special Considerations
<b>All women with known cardiac disease</b>	Preconception	Needs detailed assessment to determine the maternal cardiovascular risk.
	Early in pregnancy	To do antenatal booking at the nearest healthcare facility as soon as pregnancy is suspected. When pregnant, an individualised care plan should be developed. (pg. 29)
<b>Women with suspected cardiac disease (symptoms/ clinical findings or history of heart disease/ surgery)</b>	As soon as pregnancy is confirmed.	To confirm the diagnosis and for risk stratification.
<b>Women &amp; spouses with congenital heart disease (CHD) and/or family history of CHD</b>	Preconception referral to obstetrician/ maternal fetal medicine (MFM) specialist recommended. If pregnant, early referral to MFM recommended.	To determine risk of CHD in the fetus of parents with CHD. (section 3.2.1, pg. 48)
<b>Women &amp; spouses and/or family history of genetic diseases with cardiac lesions</b>	Preconception referral to MFM/ geneticist recommended. If pregnant, early referral to MFM.	To determine risk of disease transmission to the fetus. (section 3.2, pg. 47)
<b>Fetuses with critical CHD*/ major congenital anomalies</b>	Once diagnosis has been made, to refer to a tertiary centre with the appropriate expertise. (e.g. Paediatric cardiologist, paediatric surgeon with expertise in congenital malformations, neonatal intensive care with expertise to manage very low birth weight and severe prematurity).	Once diagnosis made, a tailored pregnancy care plan (pg. 29) by a multidisciplinary team.

\*Critical congenital heart disease/defects (CCHD) are serious congenital heart defects that present with symptoms soon after birth and need early intervention. They are usually duct dependant lesions and may have hypoxaemia. (E.g. coarctation of aorta, transposition of the great arteries, hypoplastic left heart syndrome, pulmonary atresia with intact ventricular septum)

Definition from: Frank LH, Bradshaw E, Beekman R, Mahle WT, Martin GR. Critical congenital heart disease screening using pulse oximetry. *Journal of Pediatrics*. 2013; 162(3): 445–453

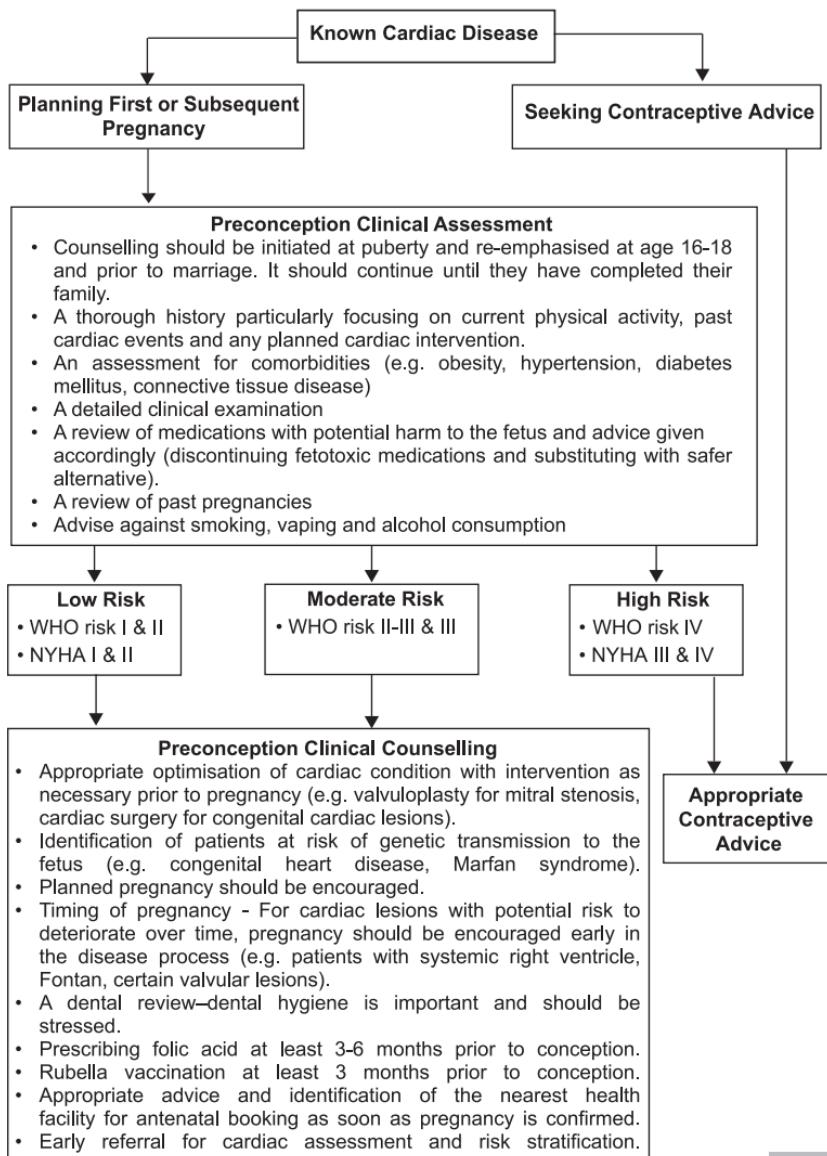
# Summary

**Table 6: Specialist Referral and Pregnancy Care Plan (cont'd)**

Maternal Risk	Timing of Specialist Referral*	Special Considerations
<b>WHO Class I-II NYHA I-II</b>	At least once during the pregnancy Can be followed up at local centre	<ul style="list-style-type: none"> <li>Individualised pregnancy care plan (pg. 29)</li> <li>Advice given on potential complications Postpartum:</li> <li>Appropriate contraception, cardiac referral/follow-up where indicated</li> </ul>
<b>WHO Class II-III WHO Class III</b>	Referral for preconception counselling Early referral if pregnant Multidisciplinary team with cardiac expertise	Follow up in a tertiary centre at least one visit per trimester: <ul style="list-style-type: none"> <li>An agreed individualised pregnancy care plan (pg. 29) formulated by the multidisciplinary team needs to be disseminated to all caregivers.</li> <li>Anaesthetic review in advance Postpartum:</li> <li>Followed up in combined clinic at least once at 6 weeks and up to 3-6 months where indicated.</li> <li>Appropriate contraception</li> <li>Cardiac specialist review to plan the cardiac follow up and interventions where needed.</li> </ul>
<b>WHO Class IV NYHA III &amp; IV</b>	Referral for preconception counselling	Pregnancy contraindicated and appropriate contraception advice given*
	Urgent referral if pregnant	If termination of pregnancy is considered, it can be performed up to 22 weeks (section 6, pg. 143)
	Multidisciplinary team with cardiac expertise	If pregnancy continues: <ul style="list-style-type: none"> <li>An agreed individualised pregnancy care plan (pg. 29) formulated by the multidisciplinary team needs to be disseminated to all caregivers.</li> <li>Close maternal - fetal surveillance</li> <li>Anaesthetic review in advance</li> <li>If patient symptomatic/develops complications, admission into a tertiary centre with close monitoring.</li> <li>When considering delivery, maternal health should take precedence over fetal outcome.</li> </ul> Postpartum: <ul style="list-style-type: none"> <li>Cardiac review (including medications) before discharge</li> <li>Customised home visits to be arranged</li> <li>Followed up in combined clinic at least once at 6 weeks</li> <li>Appropriate contraception</li> </ul>

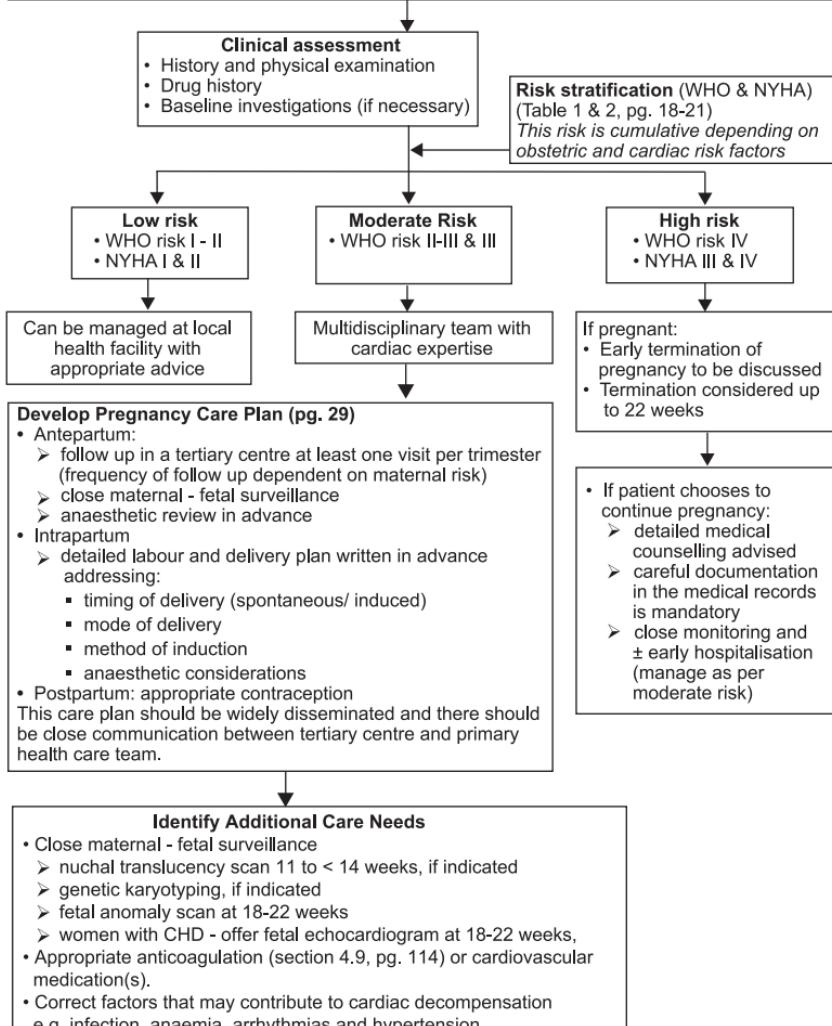
\*The following High risk patients should be advised TOP: Severe pulmonary hypertension, Eisenmenger Syndrome, Marfan syndrome with aortic root dilatation > 45 cm, previous peripartum cardiomyopathy with residual impairment of left ventricular function, LVEF < 30%, severe obstructive lesions, NYHA functional class III & IV

## FLOWCHART 1: PRECONCEPTION COUNSELLING AND CONTRACEPTIVE ADVICE



**FLOWCHART 2: ANTENATAL CARE PLAN FOR WOMEN WITH CARDIAC DISEASE**  
**(no later than end of 1<sup>st</sup> trimester)**

- To do antenatal booking at the nearest healthcare facility as soon as pregnancy is suspected
- The patient should be referred as soon as possible for cardiac assessment and risk stratification



# Summary

## PREGNANCY CARE PLAN

Name of Patient: \_\_\_\_\_ IC No.: \_\_\_\_\_

Age: \_\_\_\_\_ Gravida/Para: \_\_\_\_\_

Period of Gestation: \_\_\_\_\_ EDD: \_\_\_\_\_

Date: \_\_\_\_\_

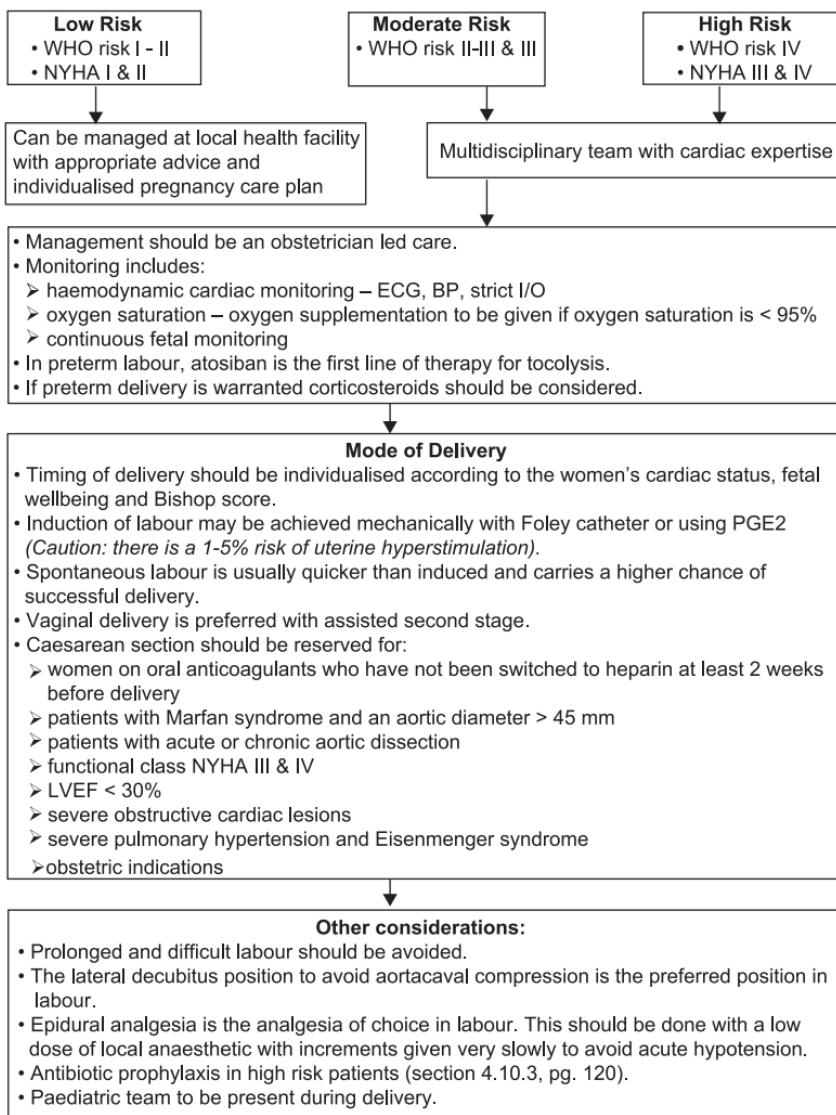
<b>Planned Pregnancy:</b>	<b>Yes</b>	<b>No</b>
<b>Cardiac Diagnosis:</b>		
<b>Echocardiogram Diagnosis/ Findings:</b> <i>(attach most recent report)</i>		<b>Date:</b>
<b>WHO Class:</b>	<b>NYHA Class:</b>	
<b>Possible CV Complications:</b>	<b>Maternal Obstetrics Risk:</b>	
<b>Associated Medical Conditions:</b>		
<b>Antepartum</b>		
<b>Level of Care:</b>		
<b>Level of Personnel:</b>		
<b>Intrapartum</b>		
<b>Timing of Delivery</b>	<b>Spontaneous</b>	<b>Planned/ Induced</b>
<b>Mode of Delivery</b>	Vaginal Delivery	Trial of Vaginal Delivery
<b>Place of Delivery</b>	Hospital with Obstetrician:	Tertiary Hospital:
<b>Anaesthetic Considerations</b>	Yes: _____ No: _____ If yes, see <i>anaesthetic care plan</i>	
<b>Postpartum</b>		
<b>Level of Care</b>	Critical Care (ICU/CCU/HDU)	Normal Ward
<b>Contraception</b>		

*Filled by:*

Physician/Cardiologist: \_\_\_\_\_ Obstetrician/MFM: \_\_\_\_\_

This form should be filled at the first specialist visit and revised (if necessary) at every specialist review. If there are changes, a new form needs to be filled and stapled to the preceding form(s).

## FLOWCHART 3: INTRAPARTUM AND EARLY (< 24 HOURS) POSTPARTUM CARE PLAN



# Summary

## CARDIAC DISEASE IN PREGNANCY: INTRAPARTUM CARE

Name of Mother: \_\_\_\_\_

Date: \_\_\_\_\_

Date of Birth: \_\_\_\_\_

Time: \_\_\_\_\_

RN Number: \_\_\_\_\_

Cardiac diagnosis:					
When admitted, to inform:		Registrar (Name)		Consultant (Name)	
Cardiologist/ Physician:					
Obstetrician:					
Anaesthetist <sup>#</sup> :					
Mode of delivery		LSCS		Vaginal delivery	
		Elective		Emergency	
ECG monitoring*	BP/arterial line*	O <sub>2</sub> saturation* (to give O <sub>2</sub> if SpO <sub>2</sub> < 95%)		I/O chart*	CTG monitoring*
Vaginal delivery – First stage	Prophylactic antibiotics		*		
	Medications		*		
	Epidural analgesia		*		
	Augmentation		*		
Vaginal delivery – Second stage	Normal		*		
	Shorten 2 <sup>nd</sup> stage		*		
Vaginal delivery – Third stage	Facilitated second stage of labour		*		
	Oxytocin infusion		*		
LSCS	Prophylactic antibiotics		*	Oxytocin infusion (prophylaxis against PPH)	
	Oxytocin IM/IV		*		
Post delivery	HDU/CCU/ICU		*		

\*Mark appropriately: [x] if not done; [✓] if done; [N] not indicated

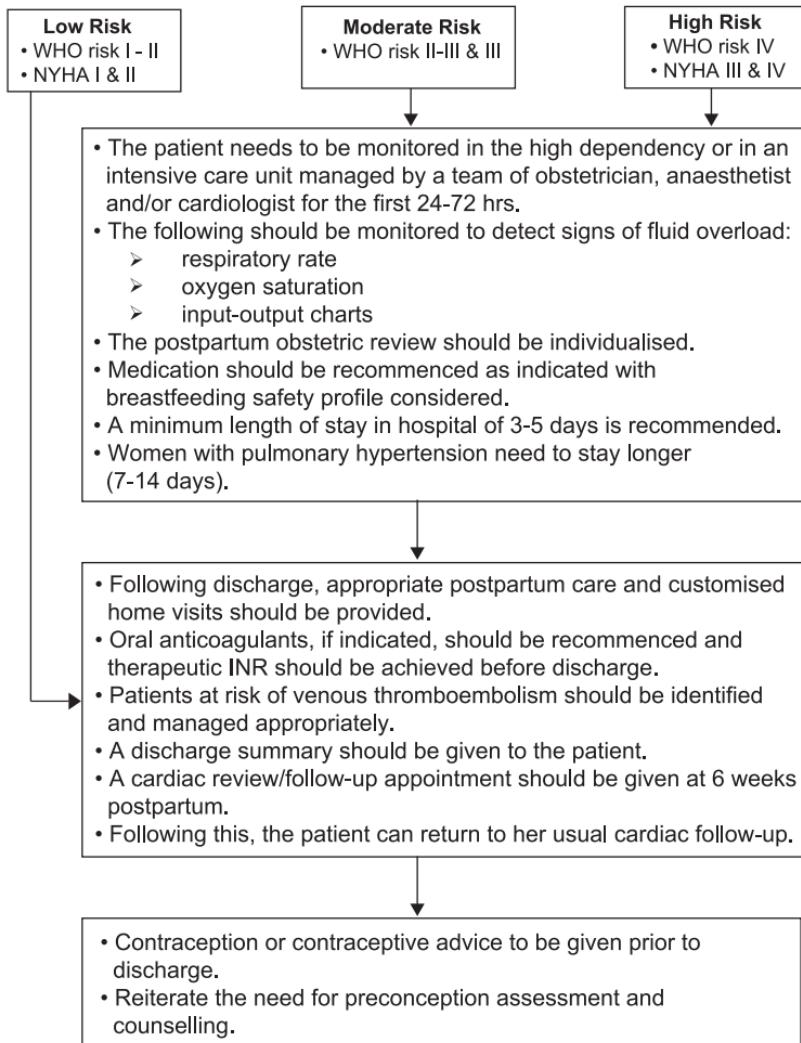
Oxytocin is the drug of choice for:\*\*

- Active management during the 3<sup>rd</sup> stage of labour:
  - IM 5 IU oxytocin and control cord traction (CCT)
- Prophylaxis against postpartum haemorrhage (PPH):
  - Low-dose infusion (12 mU/minute): use either 5 IU in 50 ml at 7 ml per hour or 10 IU in 500 ml at 36 ml per hour. Continue for 4 hours (longer if required)
- If postpartum haemorrhage occurs:
  - Avoid prostaglandin 2α – carboprost (Hemabate®)
  - Avoid high dose oxytocin
  - Avoid carbetocin (Durotocin®)
  - Use low dose oxytocin as in prophylaxis in PPH
  - Avoid ergometrine - this can cause hypertension and coronary artery spasm.

# see anaesthetic care plan

\*\* Royal College of Obstetricians and Gynaecologists. Good Practice No 13. Cardiac disease in pregnancy. June 2011

## FLOWCHART 4: POSTPARTUM CARE PLAN



# 1. INTRODUCTION

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# Introduction

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## 1. Introduction

Cardiovascular disease (CVD) generally affects approximately 0.2% to 4% of pregnant women.<sup>1</sup> According to the Report of the National Obstetrics Registry, the incidence of cardiac disease in pregnancy in Malaysia was 0.55% in 2013 and 0.45% in 2014.<sup>2</sup> This data was based on deliveries from 14 tertiary public hospitals. Based on these figures, CVD in pregnancy is relatively common. It accounted for 51% and almost 70% of indirect deaths in the period 2009-2011 and 2011 respectively.<sup>3</sup> (Table 7, pg. 36)

Cardiac disease is a leading cause of maternal mortality in many developed countries. Similarly, in Malaysia, since 1997, the Confidential Enquiries into Maternal Death (CEMD) reports have shown that maternal deaths due to cardiac disease were the main non-obstetric cause of maternal mortality. In the 3-year period (2006-2008), there were 49 cases of maternal deaths due to heart disease.<sup>4</sup> In the following 3-year period (2009-2011), there was a 33% increase in maternal cardiac deaths. Chronic rheumatic heart disease remains the commonest aetiology, accounting for 29% of all deaths due to maternal cardiac disease in the period 2009-2011.<sup>3</sup>

Diagnosis and assessment of cardiac disease in pregnancy remains a challenge for health care personnel. From the inquiry into maternal deaths, inadequate history and physical examination during the antenatal period were major contributory factors in delayed and misdiagnosis.

The symptoms of heart disease such as dyspnoea, reduced effort tolerance, palpitations and tachycardia could mimic the physiological changes during pregnancy. Many of these symptoms and signs were dismissed as “benign” after physical examination. Often, the presence of physiological flow murmurs may add to the confusion. This is further compounded by the inaccessibility to diagnostic tools (echocardiography) and expertise. Other socio-economic factors may also be contributory.

The objective of this clinical practice guideline is to highlight to the healthcare provider how to:

- counsel the cardiac patient before pregnancy
- recognise cardiac disease in pregnancy
- identify high risk patients
- manage and refer these patients appropriately

# Introduction

This guideline provides evidence-based recommendations on how best to manage pregnant patients with cardiac disease. Patient care should be individualised and sound clinical judgement plays an important role in decision making.

**Table 7: Cardiovascular Disease as a Cause of Maternal Deaths in Malaysia\***

CVD	2009-2011	2012***	2013***	2014***
% of total maternal deaths**	15.3% (66/430)	16.1% (18/112)	13.9% (15/108)	12.1% (14/116)
% of indirect deaths	51.2% (66/129)	50% (18/36)	50% (15/30)	53.8% (14/26)

\*Based on data from Confidential Enquiries into Maternal Deaths

\*\*Refers to Indirect and Direct (obstetric) deaths

\*\*\*Unpublished data

## **2. PHYSIOLOGICAL CHANGES IN THE CARDIOVASCULAR SYSTEM IN PREGNANCY**

# Physiological Changes in the Cardiovascular System in Pregnancy

The impact of the physiological changes of pregnancy in women with cardiac disease will vary according to the type and severity of the cardiac lesion. Women with the least ability to increase cardiac output are at risk of decompensation earlier on in the pregnancy while those who tolerate the increase during pregnancy will be at risk at the time of delivery and immediate postpartum.<sup>5</sup>

These physiological changes are summarized in Table 8 & Fig 1, pg. 40-41. They may produce a number of changes in the physical findings of normal pregnant women and also in some common cardiac investigations. (Table 9, pg. 42)

These normal physiological changes may result in the following deleterious effects in the pregnant patient with cardiac disease:<sup>6,7,8</sup>

- The rise in cardiac output may cause women with limited cardiac function or reserve to develop congestive cardiac failure.
- The increased preload is a problem for patients with obstructive lesions (such as severe mitral or aortic stenosis) and/or ventricular dysfunction.
- Tachycardia causes palpitations and may impair ventricular filling especially in women with severe mitral stenosis.
- The hypercoagulable state due partly to an increase in clotting factors, may predispose to thromboembolism.
- The changes in renal blood flow may have an impact on drug excretion and changes in the volume of distribution of drugs. Thus some drug dosages may need to be modified during pregnancy.
- Compression of the inferior vena cava by the uterus can lead to venous stasis and supine hypotensive syndromes.

During labour and delivery, haemodynamic fluctuations can be intense. Most of these changes are due to uterine contractions and are related to the pain of contractions. These can be largely obtunded by using regional anaesthesia.

- Each contraction displaces 300-500 ml of blood into the general circulation.
- Stroke volume increases resulting in an increase in cardiac output by 50% with each contraction. It can be as high as 75% above baseline during labour and delivery.
- Blood loss is estimated to be about 300-400 ml for a vaginal delivery and 500-800 ml for a caesarean section. These changes can contribute to haemodynamic stress.

The haemodynamic changes return to pre-pregnant levels within 2-4 weeks following vaginal delivery and 4 to 6 weeks following caesarean section.<sup>7</sup>

# Physiological Changes in the Cardiovascular System in Pregnancy

## Key Message:

- The impact of the physiological changes of pregnancy in women with cardiac disease will vary according to the type and severity of the cardiac lesion.

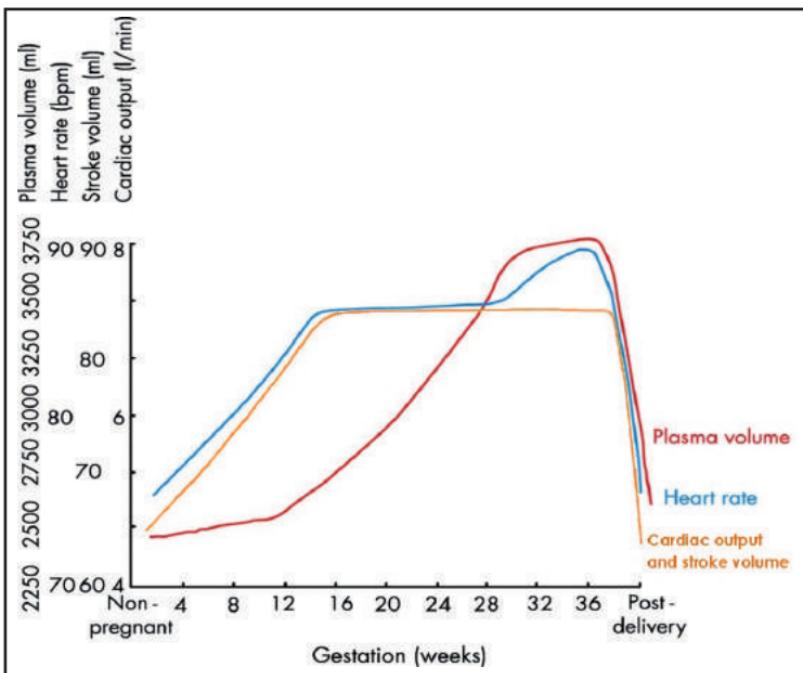
**Table 8: Summary of Hemodynamic Changes During Pregnancy\***

Haemodynamic parameter	Changes during normal pregnancy	Changes during labour and delivery	Changes during postpartum
Systemic vascular resistance	↓ 15-20% (lowest at 20-24 <sup>th</sup> week)	↑	↓
Stroke volume	↑ 1 <sup>st</sup> & 2 <sup>nd</sup> trimester (maximum at 20 <sup>th</sup> week) ↓ 3 <sup>rd</sup> trimester	↑ (300-500 ml/ contraction)	↓
Plasma volume	↑ 40-50% (starts at 4 <sup>th</sup> week and peaks at 24 <sup>th</sup> week)	↑	↓
Cardiac output	↑ 35-50% (75% of ↑ occurs by end of 1 <sup>st</sup> trimester. Plateaus by 28 <sup>th</sup> -32 <sup>nd</sup> week)	↑ Additional 50%	↓
Heart rate	↑ 10-15 beats/min Peaks in 3 <sup>rd</sup> trimester	↑	↓
Blood pressure	↓ 10 mmHg in DBP in 2 <sup>nd</sup> trimester	↑	↓

\*Adapted from Costantine MM. Physiologic and pharmacokinetic changes in pregnancy. *Front Pharmacol.* 2014; 5: 65

# Physiological Changes in the Cardiovascular System in Pregnancy

Figure 1: Physiological changes in pregnancy.



Adapted: Thorne SA. *Pregnancy in heart disease*. Heart. 2004; 90: 450-456

# Physiological Changes in the Cardiovascular System in Pregnancy

**Table 9: Physical Findings and Changes Seen in Common Cardiac Investigations in Normal Pregnancy**

Clinical examination	<ul style="list-style-type: none"><li>Peripheral oedema is a common finding</li><li>Pulse rate may be increased</li><li>Pulse may be bounding</li><li>Occasional ectopics are common and are often benign</li><li>Apex beat may be shifted more laterally</li><li>Ejection systolic murmurs and continuous flow murmurs due to mammary soufflé and venous hum are common*</li><li>Splitting of the first heart sound is common</li><li>The intensity of the pulmonary second sound (P2) may be accentuated</li><li>Physiological third heart sound may be present</li><li>A fourth heart sound is seldom heard</li></ul>
ECG	<ul style="list-style-type: none"><li>Heart rate may be increased</li><li>Occasional atrial or ventricular ectopics may be present</li><li>There may be a shift of the QRS plane axis to the left</li><li>Minor T wave changes</li></ul>
CXR	<ul style="list-style-type: none"><li>Heart size is normal</li><li>The heart may be shifted to a more horizontal position late in pregnancy</li><li>Pulmonary blood vessels may become more prominent due to the increased blood flow</li></ul>
Echocardiogram	<ul style="list-style-type: none"><li>There may be an increase in the left and right ventricular end-diastolic dimensions compared with a previous echo done in the non-pregnant state</li><li>The left ventricular mass may be increased</li></ul>

\*Diastolic murmurs almost always indicate pathological cardiac disease

Adapted from: Alpert JS, Ewy GA. (Ed). Manual of Cardiovascular Diagnosis and Therapy. 5<sup>th</sup> Ed. Pregnancy and Heart disease. Chap 26. Lippincott Williams & Wilkins. Philadelphia 2002

### **3. GENERAL PRINCIPLES IN THE MANAGEMENT OF CARDIAC DISEASE IN PREGNANCY**

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# General Principles in the Management of Cardiac Disease in Pregnancy

## 3.1 Risk stratification

### 3.1.1 Maternal risk

Pregnant women with cardiac disease are at risk of adverse maternal and fetal outcomes.

I, C Their risk should be assessed before conception or early in the pregnancy to optimise the outcome of the pregnancy.

Maternal cardiovascular risk can be assessed using the modified World Health Organisation (WHO) classification.<sup>9</sup>

- **WHO Class I** – No detectable increased risk of maternal mortality and no/ mild increase in morbidity.
- **WHO Class II** – Small increased risk of maternal mortality or moderate increase in morbidity.
- **WHO Class II-III & III** – Significantly increased risk of maternal mortality or severe morbidity. Expert counselling required. If pregnancy is decided upon, intensive specialist cardiac and obstetric monitoring needed throughout pregnancy, childbirth, and the puerperium.
- **WHO Class IV** – Extremely high risk of maternal mortality or severe morbidity; pregnancy contraindicated. If pregnancy occurs, termination should be discussed. If pregnancy continues, care as for class II-III & III.

The functional capacity of the patient can be classified using the NYHA functional class.<sup>10</sup> (Table 2, pg. 21)

Risk stratification is accomplished by considering disease specific outcome predictors<sup>11</sup> and risk scores from large studies of pregnant women with heart disease.<sup>12,13</sup> The maternal and fetal risk magnifies if the disease complexity increases and when there are additional cumulative risk factors.<sup>13,14</sup>

Hence a comprehensive risk assessment of maternal and fetal outcomes taking into consideration the factors listed below should be undertaken.

Factors to be considered during maternal cardiovascular risk assessment include:

- Lesion specific outcome, e.g. Ventricular septal defect (VSD)
- Complexity of the disease, e.g. VSD with aortic regurgitation (AR)

# General Principles in the Management of Cardiac Disease in Pregnancy

- Additional or combination of risk factors, e.g. VSD with AR and poor left ventricle (LV) function
- Preconception clinical status (NYHA Functional Class) and investigations (elevated BNP)<sup>15</sup>
- Non cardiac/ obstetric factors e.g. hypertension, obesity, diabetes mellitus<sup>16</sup>
- Fetal outcomes, e.g. fetotoxic drugs, genetic transmission<sup>17,18</sup>
- Individual variations

Based on these considerations, maternal cardiovascular risk assessment using Tables 1A, 1B & 2, pg. 18-21 is recommended.

## 3.1.2 Fetal outcomes and risk

Fetal outcome should also be considered when planning the pregnancy. Prematurity, fetal growth restriction (FGR), small for gestational age and fetal loss is increased in pregnant patients with cardiac disease. Fetal complications range between 20–27.8%.<sup>12,13,16</sup> Neonatal mortality is 4 times higher compared to a normal pregnancy.<sup>12</sup>

The maternal predictors of poor neonatal/fetal outcome in women with cardiac disease are as follows:<sup>12,19,20</sup>

- NYHA Functional Class III & IV
- Cyanosis (oxygen saturation < 85%)
- Mechanical prosthetic valves
- Use of heparin or warfarin during pregnancy
- Left heart obstructive lesions
- Smoking during pregnancy
- Twin/ multiple pregnancy

Some maternal cardiac conditions have an increased risk of genetic transmission to the fetus (e.g. Marfan syndrome).<sup>17,18</sup> There is also an increased risk of congenital heart disease (CHD) in the fetus if either parent has CHD. (Section 3.2.1, pg. 48)

### Key Message:

- All pregnant women with cardiac disease should be risk stratified.
- This can be done using the modified WHO risk score and the NYHA Functional Class (Tables 1A, 1B & 2, pg. 18-21).
- Fetal risks are higher in women with cardiac disease.

# General Principles in the Management of Cardiac Disease in Pregnancy

## 3.2 Preconception and genetic counselling

Pregnant women with cardiac disease are at risk of significant obstetric complications.<sup>21</sup>

**I, c** It is important for these women to have preconception counselling. Unfortunately counselling on pregnancy and contraception is still inadequate.<sup>22</sup>

Preconception counselling should be initiated with the focus that every pregnancy is a planned pregnancy.

**I, c** All women in the reproductive age with suspected or known cardiac disease should be referred for a proper cardiac and maternal cardiovascular risk assessment.

Counselling should be initiated at puberty and re-emphasised at age 16-18 and prior to marriage. For those planning to get pregnant, this should be done at least 6 months before planned conception. This primary assessment can be done by general practitioners and family physicians.

Preconception counselling involves:<sup>23</sup>

- A thorough history particularly focusing on exercise capacity and past cardiac events.
- A detailed clinical examination.
- Prior relevant cardiac imaging studies such as echocardiography, Computed Tomography (CT) and magnetic resonance imaging scans should be reviewed.
- A review of medications with potential harm to the fetus and advice given accordingly (discontinuing fetotoxic medications and substituting with safer alternative). Appendix B-D, pg. 152-155
- Women with treated hypertension and of child bearing potential should be informed about anti-hypertensive medications that are safe in pregnancy preferably at every medical review or at least annually.
- An assessment for comorbidities (e.g. obesity, hypertension, diabetes mellitus, connective tissue disease).
- A review of past pregnancies.
- Advising against smoking, vaping and alcohol consumption,
- A dental review - good dental hygiene is important and should be stressed.
- Prescribing folic acid at least 3-6 months prior to conception.<sup>24</sup>
- Rubella vaccination at least 3 months prior to conception.

# General Principles in the Management of Cardiac Disease in Pregnancy

If necessary, they should be referred for further cardiac evaluation (ECG, echocardiogram, stress test, etc).

**I, c** Those at moderate to high maternal cardiovascular risk (Table 1A, 1B & 2, pg. 18-21) should be referred to a tertiary centre. For these patients, the counselling should involve the patient, spouse and family members with a multidisciplinary team consisting of an obstetrician, cardiologist and anaesthetist with expertise in the management of pregnant women with cardiac disease.

Some important areas that should be addressed are:

- Detailed cardiac assessment and appropriate intervention prior to pregnancy (e.g. valvuloplasty for mitral stenosis, cardiac surgery for congenital cardiac lesions).
- Appropriate contraception for those with high maternal cardiovascular risk (NYHA III & IV, WHO Class IV) in whom pregnancy is contraindicated. (Table 1A, 1B & 2, pg. 18-21)
- Identification of patients at risk of genetic transmission to the fetus (e.g. CHD, Marfan syndrome). (section 3.2.1, pg. 48)
- Timing of pregnancy - For cardiac lesions with potential risk to deteriorate over-time, pregnancy should be encouraged early in the disease process (e.g. patients with systemic right ventricle, Fontan, certain valvular lesions).
- Appropriate advice and identification of the nearest health facility for antenatal booking as soon as pregnancy is confirmed.

## 3.2.1 Genetic counselling

Women with selected types of CHD have increased risk of cardiac disease in their offspring.

**I, c** Hence it is important for these women to undergo genetic counselling during their preconception counselling.

The risk of the fetus having CHD in a woman with CHD ranges from 4-7% versus a background risk of 1% in the normal population.<sup>25</sup> This risk varies depending on the type of lesion, presence of family history of CHD and gender of the affected parent.<sup>17,26</sup> (Table 10, pg. 49). In lesions with autosomal dominance inheritance [e.g. Marfan syndrome, DiGeorge syndrome (22q11 deletion)], the risk of recurrence can be as high as 50%.<sup>27</sup>

# General Principles in the Management of Cardiac Disease in Pregnancy

Genetic counselling and screening should be offered for the following conditions:

- Parents with CHD (Table 10, pg. 49)
- Autosomal dominant lesions e.g. Marfan syndrome, inherited cardiomyopathies and arrhythmias
- Channelopathies and cardiomyopathies e.g. long QT syndrome, cardiomyopathies
- Chromosomal 22q11.2 deletion syndrome (Di George syndrome) - features of this syndrome include Arch anomalies, truncus arteriosus, Tetralogy of Fallot with aortopulmonary collaterals, dysmorphic features, developmental delay and psychiatric illness.<sup>18</sup>
- Strong family history of genetic disorders and CHD
- Bicuspid aortic valve

**Table 10: Risk of Recurrent Congenital Heart Lesions in the Fetus of Parents with CHD\***

Lesion	Mother affected	Father affected	Siblings in unaffected parents	
	Risk of transmission (%)	Risk of transmission (%)	1 sibling (%)	≥ 2 siblings (%)
Atrioventricular septal defect	7-11.6	4.3-7	3-4	NA
Aortic stenosis	8.0	3.8	2	6
Coarctation	6.3	3.0	2	6
Atrial septal defect	6.1	3.5	2-3	8
Ventricular septal defect	6.0	3.6	3	10
Pulmonary stenosis	5.3	3.5	2	6
Persistent ductus arteriosus	4.1	2.0	NA	NA
Tetralogy of Fallot	2-5	1-6	2-3	8
All heart defects	5-7	2.2	NA	NA

NA: not available \*CHD: Congenital Heart Disease

If neither parent is affected, the risk of recurrence of CHD in a sibling of an affected individual is between 1-6% and if more than one sibling is affected the recurrence risk can be up to 10%.<sup>17,25,28</sup>

# General Principles in the Management of Cardiac Disease in Pregnancy

In addition to the standard Pregnancy Care Plan (Table 6, pg. 25-26 and pg. 29), it is advisable that these patients undergo:

- IIa, C nuchal translucency scan at 11 to < 14 weeks gestation.<sup>29</sup>
- IIa, C genetic karyotyping can be considered whenever necessary
- IIa, C a detailed anomaly scan should be offered at 18-22 weeks to screen for congenital heart lesions

## Key Message:

- Counselling should be initiated at puberty and re-emphasised at age 16-18.
- All women in the reproductive age with suspected or known cardiac disease should undergo preconception counselling.
- Preconception counselling should be initiated with the focus that every pregnancy is a planned pregnancy.

# General Principles in the Management of Cardiac Disease in Pregnancy

### 3.3 Medications in pregnancy and lactation

The background risk of major birth malformations (such as FGR, fetal death, anencephaly, mental retardation or a defect requiring surgery for correction etc.) in the general population, is usually cited as 1-3% of pregnancies.<sup>30</sup> If minor malformations (such as ear tags and extra digits) are also included, the rate may be as high as 7-10%.<sup>30</sup> These birth defects may be due to genetic, environmental or yet unknown causes. Drugs have been estimated to account for only 2-3% of these malformations.<sup>30,31</sup>

Many maternal medical diseases increase fetal risks. These include conditions such as hypertension, diabetes, epilepsy and cancer. During counselling, it is important that the pregnant patient and family understand the:

- background risk of congenital malformations in the general population
- baseline risk associated with the maternal medical condition
- risk, if any, of genetic transmission to the fetus
- risk, if any, associated with the drug

The United States Food and Drug Administration (FDA) had formulated a Pregnancy Risk Classification, classifying drugs according to the available evidence of safety in pregnancy (Appendix A, pg. 151). From 30<sup>th</sup> June 2015 however, FDA has proposed a new Pregnancy and Lactation Labelling Final Rule (PLLR) where the previous Risk Categories are replaced with Pregnancy Exposure Registries.<sup>32</sup> This new labelling includes:

- a summary of the risks of using the drug during pregnancy and lactation
- a discussion of the data supporting that summary, and
- relevant information to help health care providers make prescribing decisions and counsel women about the use of drugs during pregnancy and lactation

The information on drug safety in pregnancy is limited. About 91% of the medications approved by FDA for use in adults from 1980-2010, lacked sufficient data to determine the risk of birth defects if used during pregnancy.<sup>33</sup>

Some medications may be more detrimental in different stages of the pregnancy. First trimester exposure to Angiotensin Converting Enzyme Inhibitors (ACE-I) has not always been linked to adverse outcomes although fetotoxicity has been clearly documented during 2<sup>nd</sup> and 3<sup>rd</sup> trimester exposure.<sup>34-38</sup>

# General Principles in the Management of Cardiac Disease in Pregnancy

However, a small study of 209 infants with first trimester exposure to ACE-I, showed an increased risk of congenital malformations.<sup>39</sup>

**I, B** For this reason, as far as possible, women of child bearing potential should not be prescribed ACE-I/Angiotensin Receptor Blockers (ARB) for the treatment of hypertension. If they are on ACE-I/ARB then this should be discontinued or changed to an alternative afterload reducing agent if they are intending to become pregnant.

**I, C** Should there be inadvertent exposure to an ACE-I/ARB, the current recommendation is to change the medication to an anti-hypertensive that is considered safe in pregnancy and fetotoxic effects (congenital anomalies and renal abnormalities) excluded with appropriate scans.

It is not in itself an indication for termination of pregnancy.<sup>1,34</sup>

**I, C** Before drugs are prescribed to the pregnant patient, the risk versus the benefit should be carefully weighed and discussed with the patient.

Many drugs that are commonly prescribed are best avoided in pregnancy. This list includes statins, some anti-hypertensive medications (such as ACE-I/ARB, diuretics, β-blockers) and certain antibiotics (aminoglycosides, tetracycline). These medications are categorised C according to the previous FDA Pregnancy Risk Classification.

**IIa, C** Wherever possible, these medications should be stopped and substituted with safer alternatives. (Appendix B, C, D, pg. 152-155)

**IIa, C** Pregnant women should be discouraged from taking over the counter medications and should be taught methods other than drugs to cope with stress, aches and pains.

**I, C** Patients should be cautioned about any drug use in pregnancy since the long term effects of drugs in utero may not be known for many years.

## Key Message:

- Before drugs are prescribed to the pregnant patient, the risk versus the benefit should be carefully weighed and discussed with the patient.

# General Principles in the Management of Cardiac Disease in Pregnancy

## 3.4 Clinical findings of cardiac disease in pregnancy

### 3.4.1 Symptoms and signs

Women with pre-existing yet undiagnosed cardiac disease and those with new onset (whether or not pregnancy-related) disease, are likely to present for the first time when pregnant. To add to this, the symptoms and signs of a normal pregnancy may mimic that of cardiac disease. (Table 9, pg. 42)

I, C Thus a careful history and a thorough physical examination by the primary healthcare provider are important.

- **History:** In the history, the following should be elicited:
  - History of breathlessness, palpitations, near faints and chest pains. In patients with known cardiac disease, the WHO Risk Score and the NYHA Functional Class (Table 1A, 1B & 2, pg. 18-21) should be documented.
  - Past medical history of being told to have cardiac murmurs, having undergone cardiac surgery or procedures
  - Family history of cardiac disease, arrhythmias or sudden death.
- **Clinical examination:** Patients with normal pregnancy may have physiological flow murmurs. (Table 9, pg. 42) The following should be performed:
  - The heart rate and blood pressure (BP) should be measured manually.
    - Mercury sphygmomanometer remains the gold standard for recording BP in pregnancy.
    - Increasingly aneroid devices are being used and the accuracy of these devices are variable<sup>40,41</sup> The automated ones are commonly not reliable in pregnancy.
    - If only aneroid devices are available, care should be taken to use those that have been shown to be reliable in pregnancy and to have these calibrated periodically.
    - In pregnancy, Korotkoff V is taken as the diastolic BP. If the DBP according to this means is zero (up to 15%), then the Korotkoff sound IV (the quietening of the blood flow murmur) should be used. If phase IV is used, this should be carefully noted in the clinical records to avoid confusion in future.

# General Principles in the Management of Cardiac Disease in Pregnancy

- One should monitor for new onset or change in murmurs.
- In patients with heart disease in pregnancy, the oxygen saturation should be measured by pulse oximetry. (normal oxygen saturation  $\geq$  95% on room air)
- In patients with breathlessness and in those with known cardiac disease, one should examine for signs of heart failure. A slight increase in resting heart rate and a slightly raised jugular venous pulse may be “normal” findings in a pregnant patient.

## 3.4.2 Investigations in pregnancy

Essential investigations include:

I, C  
I, C

- ECG
- Echocardiogram:
  - is a useful tool in patients with known or suspected cardiac disease to confirm the clinical diagnosis and to obtain baseline hemodynamic and structural data.
  - should be considered in all patients with cardiac murmurs.

I, C

If radiological investigations or procedures are necessary, an abdominal lead shield should be used.

If the fetal dose is below a milliGray, the risks of childhood cancer are considered to be very low (below 1 in 10,000).<sup>42</sup> This is judged acceptable when compared with the natural risk of childhood cancers (1 in 500).<sup>42</sup>

I, C

The very low fetal risk from an inadvertent maternal exposure to a chest X-ray does not justify termination of pregnancy.<sup>42</sup> (Appendix E, pg. 156)

### Key Message:

- A careful history and a thorough physical examination by the primary healthcare provider are important in all patients with known or suspected to have cardiac disease.

# General Principles in the Management of Cardiac Disease in Pregnancy

## 3.5 Specialist referral and pregnancy care plan

Please refer to Table 3-5, pg. 22-24.

### 3.5.1 Specialist referral and level of care

When pregnancy is confirmed, the patient should be seen at the nearest health care facility. This patient should be referred as soon as possible for cardiac assessment and risk stratification.

Under the Ministry of Health Obstetrics Risk Stratification Charts, heart disease is coded red. (Colour coding Appendix F pg. 157)

The level of care will depend upon the maternal cardiovascular risk stratification.

- Women with WHO risk class I-II and NYHA I & II can be managed in their local hospital after at least one review by the physician/cardiac specialist. This review enables the primary team to anticipate any potential risk(s) to ensure good antepartum, intrapartum and postpartum care. (Table 3, pg. 22)
- Women with WHO risk class II-III, III & IV and NYHA III & IV should be followed up in a tertiary centre by a multidisciplinary team with expertise in managing high risk pregnancies. (Table 3, pg. 22)

Frequency of follow up at the specialist centre will depend on the maternal risk, baseline cardiovascular and functional status, progression of the pregnancy, onset of symptoms & potential complications. (Tables 3-5 pg. 22-24) Policies of the respective centres, patient socioeconomic & geographical factors and patient preferences should also be considered.

### 3.5.2 General pregnancy care plan

#### 3.5.2.1 Antepartum care

The aims of antepartum care are:

- to assess and risk stratify the maternal cardiovascular status
- to offer termination of pregnancy if indicated
- to review maternal medications for potential fetotoxicity
- wherever possible, to optimise maternal cardiovascular status
- to formulate an individualised pregnancy care plan which includes time, place and mode of delivery (pg. 29)
- fetal assessments and surveillance

# General Principles in the Management of Cardiac Disease in Pregnancy

Once pregnancy is confirmed:

- Early booking is advised.
- Detailed medical and surgical history should be taken.
- A medical report of the cardiac diagnosis and current status should be requested from the attending physicians.
- All pregnant women with cardiac disease should undergo risk stratification/ functional class assessment to determine the frequency and the level of antenatal care. (Tables 1-5, pg. 18-24)
- The core members of the multidisciplinary team should be family medicine specialist(s), obstetricians, maternal fetal medicine (MFM) specialists, cardiologists, and/or obstetric anaesthetists. Where appropriate, neonatologists, cardiac anaesthetists, cardiothoracic surgeons and/or intensivists should also be involved in the care.
- Patient information, education and advice about how cardiac disease will affect the pregnancy, birth and postpartum assessment are to be discussed. Wherever possible, the family should also be involved in the counselling.
- Appropriate care can be shared between district and tertiary hospitals to provide combined follow up by relevant specialists according to the maternal cardiovascular risk.
- An individualised pregnancy care plan should be formulated. (pg. 29)
- Termination of pregnancy should be considered in patients with WHO class IV.
- At every antenatal cardiac visit, the following parameters should be assessed and documented:
  - Symptoms – NYHA functional class
  - Vital signs – pulse rate and rhythm, BP (should be measured manually with a sphygmomanometer<sup>43,44</sup>), oxygen saturation
  - Cardiovascular signs – clubbing, polycythaemia, cyanosis, anaemia, murmurs etc.
  - Signs of heart failure e.g. gallop rhythm, lung crepitations
- Fetal assessment:
  - Nuchal translucency scan 11 to < 14 weeks
  - Genetic karyotyping, if indicated
  - Fetal anomaly scan at 18 – 22 weeks
  - Fetal echocardiogram is advisable in women with CHD<sup>43,44</sup>
- Iron and folic acid supplements should be prescribed to all patients.
- Correct anaemia if present.
- For anticoagulation in pregnancy, refer to section 4.9, pg. 114.
- Admission and rest may be required in patients with NYHA/ WHO Class II-III, III & IV.

# General Principles in the Management of Cardiac Disease in Pregnancy

- Correct factors that may contribute to cardiac decompensation e.g. infection, arrhythmias and hypertension.
  - Depending on the severity of the cardiac condition, the women may need to be seen at closer intervals. (Tables 3-5, pg. 22-24)
  - The pregnancy care plan (pg. 29) should be available to all caregivers. This should be filled up at the first specialist consultation and revised (if necessary) at each specialist review.
  - The pregnancy care plan addresses:
    - timing of delivery (spontaneous/ induced)
    - Mode of delivery
    - method of induction
    - anaesthetic considerations
  - Preferably, visits to the obstetrics and cardiologists (combined clinic) should coincide.
  - Timing of delivery should be individualised according the women's cardiac status, fetal wellbeing and Bishop score.
- I, C**
- In asymptomatic women, spontaneous labour is preferred.
  - Spontaneous labour is usually quicker than induced and carries a higher chance of successful vaginal delivery.
  - However, in women in NYHA/ WHO Risk **II-III, III & IV**, a planned delivery is advisable.
- I, B**
- Mechanical induction methods such as with Foley catheter is preferable to pharmacological agents in patients with cyanosis.<sup>45</sup>
- IIa, B**
- Vaginal administration of PGE2 may be used for induction of labour.<sup>46,47</sup>  
*Caution: there is a 1-5% risk of uterine hyperstimulation.*
- IIb, B**
- In patients with cyanosis, PGE2 should be used with caution due to the risk of hypotension.

## 3.5.2.2 Intrapartum care

**I, C** Management should be an obstetrician led care.

- Monitoring includes:
  - Haemodynamic cardiac monitor - ECG, pulse and non-invasive BP monitoring
  - Oxygen saturation – oxygen supplementation to be given if oxygen saturation is < 95%
  - Continuous fetal monitoring
  - Strict input output chart.

# General Principles in the Management of Cardiac Disease in Pregnancy

## General Principles:

- I, B** • In preterm labour, atosiban is the first line of therapy for tocolysis.<sup>48,49</sup>
- I, C** • If preterm delivery is warranted corticosteroids should be considered.
- I, C** • Due to the potential risk of pulmonary oedema with corticosteroids, the patient should be monitored for 24 – 48 hrs. This risk is however quite low.
- I, C** • Vaginal delivery is the preferred mode of delivery.
- I, C** • Caesarean section should be reserved for:
  - obstetric indications
  - women on oral anticoagulants who have not been switched to heparin at least 2 weeks before delivery
  - patients with Marfan syndrome and an aortic diameter > 45 mm
  - patients with acute or chronic aortic dissection
  - heart failure (NYHA III & IV)
  - LVEF < 30%
  - severe obstructive cardiac lesions
  - pulmonary hypertension and Eisenmenger syndrome

## During vaginal delivery:

- I, C** • Prolonged and difficult labour should be avoided. Lateral decubitus position to avoid aortocaval compression is preferred in labour<sup>43</sup>
- I, C** • Epidural is the analgesia of choice in labour and it should be instituted slowly with appropriate rehydration to prevent marked fluctuations in blood pressure. It should be initiated with low doses of local anaesthetic agents with increments given very slowly to avoid hypotension. Epidural analgesia should be administered more cautiously than in otherwise healthy women. (Section 3.7.2, pg. 65)
- I, C** • Oxytocin and artificial rupture of membranes are indicated when bishop score is favourable.
- Oxytocin is the drug of choice for:<sup>43</sup>
  - I, B** ➢ Active management during the 3<sup>rd</sup> stage of labour:
    - IM 5 IU oxytocin and control cord traction (CCT)
  - I, C** ➢ Prophylaxis against postpartum haemorrhage (PPH):
    - Low-dose infusion (12 mU/minute): use either 5 IU in 50 ml at 7 ml per hour or 10 IU in 500 ml at 36 ml per hour. Continue for 4 hours (longer if required).

# General Principles in the Management of Cardiac Disease in Pregnancy

- If postpartum haemorrhage (PPH) occurs:
  - **Avoid** prostaglandin 2α – carboprost (Hemabate)<sup>®1</sup>
  - **Avoid** high dose oxytocin<sup>1</sup>
  - **Avoid** carbetocin (Duratocin<sup>®</sup>)
  - **Avoid** ergometrine – it can cause hypertension and coronary artery spasm.
  - **Use** low dose oxytocin as in prophylaxis against PPH
- In the 2<sup>nd</sup> stage of labour, active pushing should be limited as this can cause haemodynamic instability in some women. The 2<sup>nd</sup> stage should be shortened by assisted delivery to avoid excessive maternal effort.<sup>50</sup>
- Syntometrine is contraindicated in women with cardiac disease.
- Consider central access or arterial monitoring in PPH.
- For antibiotic prophylaxis against infective endocarditis in high risk patients see section 4.10.3, pg. 120.

## 3.5.2.3 Postpartum care

- During the first few days of the puerperium, the patient needs to be monitored in the HDU/ICU/CCU managed by a team of obstetrician, anaesthetist and/or cardiologist/physician.
- Significant haemodynamic changes and fluid shifts occur in the first 24-72 hours and cardiac failure may occur.<sup>50</sup>
- The following should be monitored to detect signs of fluid overload:
  - respiratory rate
  - oxygen saturation
  - input-output charts
- The postpartum obstetric review should be individualised.
- Medication should be recommenced as indicated with breastfeeding safety profile considered.
- Patients at risk of thromboembolism should be identified and managed appropriately with:<sup>51</sup> (section 4.13, Pg. 131)
  - early ambulation
  - the use of anti-embolism stockings - these may be of limited use however, since pelvic veins are a more common site of deep vein thrombosis in pregnant patients.
  - the use of Low Molecular Weight Heparin for thromboprophylaxis where indicated.
- A minimum length of stay in hospital of 3-5 days is recommended. Suggest extending this to 7-14 days in women with pulmonary hypertension.<sup>52</sup>

III, C  
III, C  
III, C

I, C

III, C

I, C

I, C

I, C

# General Principles in the Management of Cardiac Disease in Pregnancy

I, C

I, C

- Contraception or contraceptive advice to be given prior to discharge.
- Following discharge, appropriate postpartum care and customised home visits should be provided.
- For some women cardiac assessment by a cardiologist and repeat echocardiography prior to discharge from hospital e.g. Marfan syndrome and dilated aortic root and women with peripartum cardiomyopathy.<sup>44</sup>
- A cardiac review/follow-up appointment should be given at 6 weeks postpartum. Following this, the patient can return to her usual cardiac follow-up. High Risk patients need to be seen earlier.
- Reiterate the need for preconception assessment and counselling.

## Key messages:

- Refer to flowcharts on antepartum, intrapartum and postpartum care on pg. 28-32.

# General Principles in the Management of Cardiac Disease in Pregnancy

## 3.6 Intervention and surgery in pregnancy

### 3.6.1 Percutaneous therapy

Wherever possible, cardiac intervention is preferably done after delivery. However, if an intervention is absolutely necessary, the best time to intervene is considered to be after the 4<sup>th</sup> month in the second trimester. By this time organogenesis is complete, the fetal thyroid gland is still inactive, and the volume of the uterus is still small, so there is a greater distance between the fetus and the chest than in later months. The disadvantage however, is that if there are any inadvertent maternal complications and the baby needs to be delivered, it will be very premature.

The effect of radiation on the fetus depends on the radiation dose and the gestational age at which exposure occurs. (Appendix E, pg. 156) If possible, procedures should be delayed until the completion of the period of major organogenesis (first trimester). There is no evidence of an increased fetal risk of congenital malformations, intellectual disability, FGR, or pregnancy loss at doses of radiation to the pregnant woman of < 50 mGy.<sup>53,54</sup>

**I, c** Fluoroscopy and cine-angiography should be as brief as possible and the gravid uterus should be shielded from direct radiation using abdominal lead shields.

**IIa, c** Heparin has to be given at 40–70 IU/kg, targeting an activated clotting time of 200–300 seconds.

The following are safe in pregnancy when indicated:

- IIa, c** • Percutaneous mitral commissurotomy (PTMC) in patients with symptomatic mitral stenosis refractory to medical therapy.
- I, c** • Pregnant women with ST Elevation Myocardial Infarction (STEMI) – Primary Percutaneous Coronary Intervention (PCI) is preferred over thrombolysis due to the lower risk of haemorrhage. Spontaneous coronary dissection is an important cause of MI in the pregnant population. These patients should be treated conservatively unless there is ongoing ischemia or hemodynamic changes.
- In general:
  - The safety of drug-eluting stents (DES) and dual antiplatelet therapy (DAPT) in pregnant patients is not known.
  - Bare-metal stents may be the preferred strategy because DES may mandate a longer period of DAPT.

# General Principles in the Management of Cardiac Disease in Pregnancy

IIa, C

- The use of an intra-aortic balloon pump in cardiogenic shock to improve left ventricular output and coronary perfusion is also considered safe.
- The patient should be positioned in the left lateral recumbent position to reduce compression of the inferior vena cava.

Invasive treatments during pregnancy (with the exception of primary PCI for STEMI) should only be used if the mother is symptomatic despite being on optimal medical therapy.

## 3.6.2 Cardiac surgery with cardiopulmonary bypass

Maternal mortality during cardiopulmonary bypass is now similar to that in non-pregnant women who undergo comparable cardiac procedures.<sup>55</sup> It is generally low but may be as high as 13.3% depending on the preoperative maternal cardiac status.<sup>56-59</sup>

However, fetal mortality rate is 14.3% to 38.5% and there is significant morbidity<sup>56-60</sup> For this reason cardiac surgery is recommended only when medical therapy or interventional procedures fail and the mother's life is threatened.

Determining the optimal timing for cardiac surgery is critical and needs to be individualised. Early surgery will decrease maternal risk but increase fetal loss. Delaying cardiac surgery after delivery may be detrimental to the mother.<sup>61,62</sup>

Important strategies are as listed below:

- Optimal timing of surgery – Gestational age has an impact on fetal outcome.<sup>60,62,63,64</sup>
  - The best period for surgery is in the second trimester.<sup>61</sup> Surgery during the first trimester carries a higher risk of fetal loss, and during the third trimester there is a higher incidence of pre-term delivery and maternal complications.
  - After 28 weeks gestation, if cardiac surgery is indicated, the decision to deliver the baby before or after the surgery should be made in consultation with the multidisciplinary team, patient and family.
- Patients should preferably be placed in the left lateral position to avoid aortocaval compression and impairment of uteroplacental blood flow.

# General Principles in the Management of Cardiac Disease in Pregnancy

IIa, C

Important technical considerations for better maternal and fetal outcomes include:<sup>57,65,66,67</sup>

- Fetal heart rate monitoring performed during cardio pulmonary bypass (CPB) and in the post-operative period.
- Pump flow rate should be maintained > 2.5 L/m<sup>2</sup>/min and higher mean arterial pressures, > 70 mmHg recommended.
- Using an alpha-stat as against a PH-stat management.<sup>68</sup>
- To use pulsatile normothermic or mild hypothermia CPB if possible.
- Uterine contractions monitored during CPB and cautious use of tocolytic drugs when indicated.
- CPB time should be minimised with meticulous management of haemostasis and blood loss. Maternal haematocrit maintained > 28%.
- Optimise maternal oxygen saturation, glycaemic and electrolyte control and fluid management.

## Key messages:

- Invasive treatments during pregnancy (with the exception of primary PCI for STEMI) should only be used if the mother is symptomatic despite being on optimal medical therapy.
- If cardiac surgery is indicated, determining the optimal timing is critical and needs to be individualized.

# General Principles in the Management of Cardiac Disease in Pregnancy

## 3.7 Anaesthetic management

### 3.7.1 General principles

I, c Pregnant women in WHO risk class II-III, III & IV and NYHA functional class III & IV should be referred to a multidisciplinary team as outlined in Tables 3-5, pg. 22-24 and Flowchart 2, pg. 28.

I, c The anaesthetist referral should be done early and the anaesthetist should be part of the multidisciplinary team.

Risk stratification (Table 1A, 1B & 2, pg. 18-21, section 3.1 pg. 45) constitutes an important element during anaesthetic assessment. This will determine the level of care needed for the patient. (Table 3-5, pg. 22-24)

I, c Important points to consider in risk stratifying these patients include:

- Complete history and physical examination to assess the severity of cardiac lesion
- Detailed assessment of functional status using NYHA classification (Table 2, pg. 21)
- Investigations include:<sup>69,70,71</sup>
  - full blood count
  - arterial blood gases
  - ECG
  - echocardiography
  - chest x-ray (if necessary)

I, c Important considerations include:<sup>69,70,71</sup>

- An early multidisciplinary forum is important to delineate a clear and detailed plan for the management and follow through of the patient.
- The anaesthetic management plan in labour and delivery must be established in advance, well documented, and distributed widely so that all parties are well informed of it. The plan must also include both elective and emergency scenarios.
- Communication between all parties involved is vital to make the appropriate decisions to ensure optimal care.
- A separate high risk file for the anaesthetic management should be created for these patients. The management plan should be communicated and passed over until the patient has delivered safely and is discharged from anaesthetic care.

# General Principles in the Management of Cardiac Disease in Pregnancy

The overall aim of anaesthetic management for the delivery is to reduce maternal cardiac stress whilst maintaining maternal-fetal circulation.

I, c This can be achieved by:

- Close monitoring – pulse oximetry, continuous ECG, intra-arterial line and/or central venous line
- Avoiding haemodynamic instability (e.g. hypotension), major fluid shift, hypoxia, acidosis, electrolyte imbalances
- Avoiding aortocaval compression at all times
- Adequate analgesia (section 3.7.2, pg. 65)
- Close attention to obstetric complications such as pre-eclampsia and haemorrhage
- Good communication by all members of the team

## 3.7.2 Intrapartum analgesia

Vaginal delivery is the preferred mode of delivery for most women with cardiac disease unless otherwise indicated. The process of labour is extremely challenging to the parturient with cardiac disease. The stress and the pain due to contractions might not be well tolerated. Good labour analgesia will help to minimise the sympathetic response during waves of contractions and calm the patient.

Labour analgesia can be achieved via the epidural or intravenous route.

I, c However, epidural analgesia is preferred.

- Epidural drugs consist of a mixture of low concentration of ropivacaine or bupivacaine (0.05%-0.06%) with 2 ug/ml fentanyl as continuous infusion or as PCEA (patient controlled epidural analgesia).<sup>72</sup>
- This low dose epidural analgesia reduces the pre-load and after-load without much hypotension.
- In patients with pre-eclampsia and uncontrolled hypertension, epidural analgesia allows better control of the blood pressure.
- Epidural analgesia can also be converted to epidural anaesthesia if the need for caesarean section arises.
- Where epidural analgesia is contraindicated/not possible, the alternative option is intravenous opioids example patient controlled analgesia (PCA) - morphine, fentanyl or remifentanil.

# General Principles in the Management of Cardiac Disease in Pregnancy

I, c Management during labour includes:

- Continuous maternal monitoring as mentioned
- Continuous cardiotocography (CTG) monitoring
- Oxygen supplementation as necessary - to maintain Oxygen saturation  $\geq$  95% with the exception of patients with congenital cyanotic heart disease

## 3.7.3 Anaesthesia during delivery

I, c The aim of anaesthesia is to maintain cardiovascular stability. This should involve:<sup>73</sup>

- Maintaining adequate preload
- Preservation of sinus rhythm
- Protection against tachycardia and extreme bradycardia
- Avoidance of systemic hypotension and myocardial depression.<sup>69,70,74</sup>

Efforts should be taken to reduce the risk of gastric acid aspiration.

I, c The following intraoperative monitoring would generally be required:

- Invasive intra-arterial monitoring (which allows beat-to-beat BP monitoring)
- ECG monitoring for detection of arrhythmias or ischaemia
- Pulse oximetry
- End tidal CO<sub>2</sub> using capnography
- Central monitoring depending on the risk of the patient.
- Non-invasive cardiac output monitoring if haemodynamic instability anticipated.

I, c Titratable neuraxial block is the preferred mode of anaesthesia. This includes continuous epidural anaesthesia, continuous spinal anaesthesia, combined spinal-epidural anaesthesia or combination of regional and general anaesthesia. Low dose combined-spinal epidural anaesthesia technique is increasingly advocated.<sup>75,76</sup>

I, c Single shot epidural or spinal must be avoided in fixed cardiac output cases (e.g. severe valvular stenosis or hypertrophic obstructive cardiomyopathy) and in those with low cardiac output states. (NYHA functional class III & IV and severe pulmonary hypertension)

I, c Regional anaesthesia is contraindicated in patients on anticoagulants and DAPT due to the increased risk of spinal haematoma.

# General Principles in the Management of Cardiac Disease in Pregnancy

**I, c** Hypotension should be avoided by positioning the patient in a left lateral tilt to avoid aortocaval compression.

In patients with Eisenmenger syndrome, vasoconstrictors (such as IV phenylephedrine) may be necessary to increase the systemic vascular resistance and reduce the right to left shunt. In these patients, cardiac based anaesthesia is the strategy of choice. For suggested regimes, see Appendix G, pg. 158.

**I, c** Post-operatively, patients should be closely monitored preferably in the intensive care unit for 24 to 72 hours as they are still at risk of decompensation.<sup>77,78,79</sup>

Pain relief is very important. Epidural opioid (e.g. 3 mg morphine at the end of surgery) or PCA (morphine or Fentanyl) can be offered. Multimodal analgesia ensures pain free surgery in the post-operative period. This will allow faster ambulation and reduces the risk of venous thromboembolism.

## Key message:

- The anaesthetist is part of the multidisciplinary team and should be involved early in the care of high risk patients.

## **4. MANAGEMENT OF PREGNANCY IN SPECIFIC CARDIAC DISEASE**



# Management of Pregnancy in Specific Cardiac Disease

## 4. Management of Pregnancy in Specific Cardiac Disease

### 4.1 Valvular heart disease

Improved survival of patients with congenital and acquired valvular heart disease has increased the number of women with these conditions reaching the age of childbearing potential.

**I, C** All patients with valvular heart disease should be counselled about their reproductive health prior to surgical correction of their condition or their plans to start a family.

This will help decide the timing of the operation, the type of surgery (valve repair or valve replacement) and the type of valve if valve replacement is carried out.

#### 4.1.1 Mitral stenosis

Mitral stenosis is a significant cause of maternal morbidity and mortality. It is often missed in pregnancy as clinical signs may be subtle.

Predictors of adverse outcome:

- Mitral valve area < 1.0 cm<sup>2</sup>
- NYHA functional class III & IV
- Pulmonary hypertension
- Development of atrial arrhythmias

Potential complications include acute pulmonary oedema, progressive heart failure and/or atrial fibrillation and death.<sup>80,81</sup>

**I, C** Patients with severe mitral stenosis should be counselled against pregnancy and appropriate contraception advised until corrective intervention is performed.

**IIa, B** In the event that pregnancy occurs, and the patient becomes refractory to medical therapy, percutaneous mitral commissurotomy (PTMC) in the second trimester may be feasible if the valve anatomy is favourable.<sup>74</sup>

In asymptomatic patients with moderate to severe mitral stenosis (MVA 1.0 – 1.5 cm<sup>2</sup>), close maternal surveillance is important as these patients may become symptomatic as the pregnancy progresses.

# Management of Pregnancy in Specific Cardiac Disease

**IIa, B** Heart rate control with β-blockers may be considered in patients who are in sinus rhythm and have:<sup>82,83,84</sup>

- a resting tachycardia but are otherwise asymptomatic
- symptoms associated with exercise

If atrial fibrillation develops, the following drugs are safe to use in pregnancy:

- |             |  |
|-------------|--|
| <b>I, C</b> | Selective β-blocker (e.g. bisoprolol)                    |
| <b>I, C</b> | Digoxin  |
| <b>I, C</b> | Anticoagulation is also indicated (section 4.9, pg. 114) |

**IIa, C** Should the patient develop a fast atrial tachyarrhythmia and decompensates, DC cardioversion should be considered.

**I, C** Cardioversion is safe in all stages of pregnancy.

If the left atrium is severely dilated however, cardioversion may likely fail to restore sinus rhythm.

## 4.1.2 Aortic stenosis

Patients with severe aortic stenosis may be asymptomatic until they become pregnant. Important points in the management of these patients include:

- The main aetiology is congenital aortic stenosis or bicuspid aortic valve.
- Symptoms of severe aortic stenosis include dyspnoea, chest pain and syncope.
- Features of severe aortic stenosis:<sup>74</sup>
  - aortic valve area of < 1.0 cm<sup>2</sup>
  - mean gradient of > 40 mmHg
  - peak velocity of > 4 m/s

**I, C** These patients with severe aortic stenosis should undergo corrective surgery pre-pregnancy.

- The potential complications include heart failure, arrhythmias, pre-term birth and/or FGR.
- Balloon aortic valvuloplasty may be considered should the pregnant patient become symptomatic and decompensates.<sup>85</sup>
- Vasodilators (such as nitrates) are contraindicated in severe aortic stenosis.

# Management of Pregnancy in Specific Cardiac Disease

## 4.1.3 Mitral or aortic regurgitation

Patients with regurgitant lesions are at lower risk compared to those with stenotic lesions as the decreased peripheral resistance will reduce the regurgitant volume. Patients with severe regurgitant lesions who are asymptomatic and have normal LV function usually tolerate pregnancy well.

Patient with regurgitant lesions may decompensate in the following situations:<sup>81</sup>

- Impaired LV function (LVEF < 50% for aortic regurgitation; LVEF < 60% for mitral regurgitation)
- Acute onset regurgitation
- Development of atrial tachyarrhythmias

**I, c** These patients should be managed as for heart failure with diuretics,  $\beta$ -blockers and nitrates.

**IIa, c** Patients who develop acute valve regurgitation often require surgical intervention. This carries a high maternal and fetal risk.  
(section 3.6.2, pg. 62)

**I, c** Patients with mixed stenotic and regurgitant valvular lesions (e.g. mitral stenosis/mitral regurgitation) require referral to a tertiary care centre.

## 4.1.4 Selection of prosthetic heart valves in women of child-bearing age

The counselling and decision regarding which type of prosthetic implant to be used in women of current or future childbearing potential should be made well in advance. The advantages and disadvantages of each surgical intervention is as in Table 11, pg. 74.

**I, B** In women of childbearing age, valve repair if possible and in centres with good surgical outcome, is the surgery of choice.<sup>86</sup>

Where prosthetic valves are indicated, a bioprosthetic valve is the valve of choice for good pregnancy outcomes.<sup>86</sup>

**I, c** The final decision however should be an informed choice by the patient and family.

# Management of Pregnancy in Specific Cardiac Disease

**Table 11: Selection of Prosthetic Heart Valves in Women of Child-bearing Age**

Surgical intervention	Advantages	Disadvantages
<b>Valve replacement</b>		
Mechanical valve	Durability	<ul style="list-style-type: none"><li>• Need for anticoagulation with warfarin</li><li>• Maternal risk - haemorrhage, valve thrombosis and thromboembolic events</li><li>• Fetal risk - warfarin embryopathy, fetal loss and miscarriage</li></ul>
Bioprostheses	Does not require anticoagulation with warfarin if in sinus rhythm	<ul style="list-style-type: none"><li>• Less durable necessitating repeat surgery at a later date</li><li>• High risk of structural degeneration occurring in 50% of women who are &lt; 30 years of age within 10 years of implantation</li><li>• Pregnancy may accelerate valve degeneration</li></ul>
<b>Valve repair</b>		
Valve repair	Does not require anticoagulation with warfarin if in sinus rhythm	Dependant on surgical expertise/ valve pathology

## Key messages:

- All patients with valvular heart disease should have pre-pregnancy counselling.
- Patients with severe obstructive lesions should have corrective intervention or surgery prior to pregnancy.
- When valve surgery is indicated, valve repair is superior to valve replacement if done in an experienced centre.

# Management of Pregnancy in Specific Cardiac Disease

## 4.2 Congenital heart disease (CHD)

Patients with CHD can be grouped into:

- Acyanotic heart disease – atrial septal defect (ASD), ventricular septal defect (VSD), patent ductus arteriosus (PDA), Coarctation of aorta (COA)
- Cyanotic heart disease – unrepaired Tetralogy of Fallot (TOF), complex cyanotic heart disease
- Surgically repaired/ palliative intervention – Fontan, post TOF repair, Rastelli, cyanotic heart disease with aortopulmonary shunt

The risk of an adverse cardiovascular event occurring will depend upon the underlying cardiac lesion and how the pregnant patient adapts to the haemodynamic and hormonal changes that occur.<sup>12,19</sup>

Pregnancy in acyanotic heart disease is generally well tolerated, except in the presence of:<sup>12,13</sup>

- pulmonary hypertension
- poor ventricular function
- obstructive valve lesions

Patients with good surgical repair and no haemodynamically significant residual lesion tolerate pregnancy well.<sup>12,19</sup>

Patients with cyanotic heart disease have higher maternal and fetal morbidity. In these patients pregnancy is high risk. (WHO cardiovascular risk II-III, III & IV)<sup>12,13,87</sup>

Predictors of adverse outcomes in patients with CHD include:<sup>13,14</sup>

- Cyanosis – oxygen saturation < 85%. In these patients, fetal loss and FGR are common.
- Pulmonary hypertension/ Eisenmenger syndrome – maternal mortality is high and pregnancy is contraindicated<sup>12,88</sup>
- Ventricular dysfunction – if LV (LVEF < 40%) and/or RV function<sup>19</sup> is impaired, maternal morbidity and mortality is increased
- History of arrhythmias – atrial tachyarrhythmias increase maternal and to a lesser extent fetal morbidity and mortality
- Left heart obstruction – peak LV outflow tract gradient > 30 mmHg<sup>13,14,19</sup>
- Prior cardiac event (heart failure, transient ischemic attack, or stroke before pregnancy)<sup>13</sup>

# Management of Pregnancy in Specific Cardiac Disease

Generally, obstetric complications are higher in pregnant women with CHD, up to 33%<sup>12,13,14,19,89</sup>. Common adverse obstetric events include:

- preterm labour
- premature rupture of membrane
- postpartum haemorrhage
- fetal loss
- pregnancy induced hypertension and preeclampsia.

Adverse fetal outcomes are greater in patients with CHD compared to other forms of cardiac disease.<sup>12,13,14,19,89,90</sup> These include:

- prematurity
- fetal growth restriction (FGR)
- stillbirth
- miscarriage
- fetal and perinatal mortality
- risk of having CHD in the fetus (section 3.2, pg. 47)

Fetal risk is also amplified in the presence of obstetric risk factors such as maternal smoking and multiple gestations.<sup>13,14,19</sup>

## 4.2.1 Pregnancy care plan

The importance of a planned pregnancy cannot be overemphasized. The level of maternal and fetal surveillance should be determined prior to the pregnancy.

**I, c** Pre-pregnancy cardiac assessment and counseling<sup>91</sup> should be stressed (section 3.1, pg. 45, Table 1A, 1B & 2, pg. 18-21).

Based on the maternal cardiovascular risk, an individualised pregnancy care plan should be instituted. (Table 3-5 pg. 22-24, 28)

It is important to note that this risk to mother and fetus is additive. It will increase if there are additional obstetric or non-cardiac risk factors such as nulliparity, smoking, NYHA functional class ≥ 2, and younger maternal age group.<sup>13,14,19,89</sup>

Some specific considerations:

**I, c**

- Preconception counselling: This is important for all patients with known or history of CHD (refer section 3.2, pg. 47).

# Management of Pregnancy in Specific Cardiac Disease

- For individual congenital heart defects, management is as documented in Table 12, pg. 78-81.
- Anticoagulation should be considered for low flow system e.g. Fontan circulation, cyanotic CHD and patients with atrial arrhythmias (section 4.9, pg. 114).
- Antibiotic prophylaxis in high risk patients - section 4.10.3 pg. 120
- Contraception – section 5, pg. 137, Appendix N & O, pg. 165-166
  - In patients with residual structural lesion(s), intrauterine devices may increase the risk of Infective Endocarditis.
  - Laparoscopic tubal ligation should be avoided in patients with Eisenmenger syndrome and Fontan.

## **Key messages:**

- All patients with known or suspected CHD should have preconception counselling.
- The management should be individualised based on the type and severity of the CHD.
- For management of individual congenital heart defects see Table 12, pg. 78-81.

# Management of Pregnancy in Specific Cardiac Disease

**Table 12: Specific Considerations and WHO Risk Stratification for Specific Congenital Heart Disease**

Congenital Heart Disease	WHO Risk Class	Specific Considerations	Pregnancy Management
<b>Left to Shunt Shunts</b>			
Small defects with insignificant shunt & no pulmonary hypertension (PH) (VSD, ASD, PDA) <sup>92</sup>	I	Nil	Low risk
Haemodynamic significant shunts without PH	II	Risk of heart failure Arrhythmias (ASD)	Low to moderate risk depending on the individual
Atrial septal defect	II	Low risk of paradoxical embolus	Caution with line management
Atrioventricular septal defect (partial/complete) Repaired lesions with no PH or significant residual lesions	I-II	Arrhythmia and heart failure if significant valve regurgitation, residual shunt	Low to moderate risk depending on the individual
Any shunts with pulmonary hypertension or Eisenmenger syndrome <sup>93,94</sup>	IV	Pregnancy contraindicated	High risk
<b>Cyanotic Heart Disease</b>			
Palliated cyanotic CHD Uncorrected cyanotic CHD <sup>97</sup>	III-IV	<ul style="list-style-type: none"> <li>Paradoxical emboli from right to left shunt</li> <li>Thromboembolic events/thrombosis</li> <li>Risk of FGR and fetal loss in severe cyanosis (Maternal SaO<sub>2</sub> &lt; 85% at rest +/- Hb: &gt; 20 g/dl - poorer fetal outcome)</li> </ul>	Moderate to high risk dependent on the: <ul style="list-style-type: none"> <li>severity of the lesion</li> <li>degree of cyanosis</li> <li>presence of other compounding risk</li> </ul>
Ebstein anomaly <sup>94</sup>	Uncomplicated	II-III	Absence of cyanosis and tachyarrhythmia Pregnancy well tolerated New onset arrhythmias and heart failure may develop with advancing pregnancy
	Complicated (Severe TR, RV dysfunction, cyanosis, arrhythmias)	III	<ul style="list-style-type: none"> <li>Risk of right heart failure</li> <li>Arrhythmias</li> <li>If cyanosed – paradoxical embolus</li> </ul> Moderate to high risk. Surgical repair pre-pregnancy preferable where indicated
Tetralogy of Fallot (TOF) <sup>95,96</sup>	Uncorrected/ palliated	III	As per cyanotic heart disease Risk of CHD in offspring
	Repaired TOF (No significant residual lesion)	II	Pregnancy well tolerated
	Free flow pulmonary regurgitation <sup>10</sup>	III	<ul style="list-style-type: none"> <li>Risk of right ventricular dysfunction &amp; failure</li> <li>Arrhythmias</li> </ul> Moderate risk Pre-pregnancy assessment to decide if pregnancy can be advocated or pulmonary valve replacement should be done first prior to pregnancy

# Management of Pregnancy in Specific Cardiac Disease

**Table 12: Specific Considerations and WHO Risk Stratification for Specific Congenital Heart Disease (cont')**

Congenital Heart Disease	WHO Risk Class	Specific Considerations		Pregnancy Management
Obstructive lesion				
Congenital Aortic stenosis (AS) <sup>97,98</sup> (Bicuspid Aortic valve)	Mild to moderate	I-II	Usually well tolerated	Low risk
	Severe AS (asymptomatic)	III	If asymptomatic, Pre-pregnancy assessment of: • Functional capacity and blood pressure response to exercise • Symptoms • Ventricular function • Risk of arrhythmias Need to decide if intervention necessary before conception. Risk of: • Maternal hypertension, HF • Fetal: preterm labour, FGR, low birth weight	Moderate risk • If stable, may proceed with pregnancy but risk of heart failure and arrhythmias with advancing pregnancy • Bed rest, diuretics and β-blockers as necessary • If symptomatic despite optimal medical treatment, percutaneous balloon valvuloplasty considered where indicated • Cardiac surgery is high risk
	Severe AS (symptomatic)	IV	If symptomatic, poor ventricular function and decrease exercise capacity	Pregnancy contraindicated Consider surgery to correct lesion prior to conception
	Bicuspid aortic valve with aortopathy	III-IV	Assess the aortic root pre-pregnancy Potential risk of dissection if aortic root dimensions > 5.0 cm	Moderate risk if Aortic root < 4.5 cm High risk if aortic root > 5.0 cm; Patients should be advised aortic root replacement prior to pregnancy
	Supravalvular aortic stenosis	Risk dependant on the severity of the obstruction	Usually seen in William syndrome (Supravalvular AS), Coronaries arteries may be abnormal	If symptomatic with severe obstruction/ ventricular dysfunction: manage as high risk pregnancy Consider surgery before conception
	Sub aortic stenosis (subaortic ridge)		As per aortic stenosis management	
Pulmonary stenosis <sup>99</sup> (PS) (can be subvalvular, valvular and supravalvular)	Risk dependant on the severity of the obstruction	Usually well tolerated even if moderate to severe. • If right ventricular dysfunction present, risk of right heart failure and arrhythmias • If severe right ventricular obstruction, cyanosis may be present and may have right to left shunting via patent foramen ovale with risk of FGR/ paradoxical embolus	Moderate risk Consider β blockers, bed rest if symptomatic Percutaneous balloon valvuloplasty can be performed for valvular PS during pregnancy if symptomatic despite medical treatment. For severe right ventricular outflow tract obstruction, consider surgical intervention pre-pregnancy.	

# Management of Pregnancy in Specific Cardiac Disease

**Table 12: Specific Considerations and WHO Risk Stratification for Specific Congenital Heart Disease (cont')**

Congenital Heart Disease	WHO Risk Class	Specific Considerations	Pregnancy Management
Coarctation of aorta (COA) <sup>100,101</sup>	Uncorrected COA	Risk dependant on the severity of the obstruction & residual lesion	Risk of hypertensive complications • Stroke (Rupture intracerebral berry aneurysm) • Hypertension • Antihypertensive drugs may affect fetal growth Preconception check for: • aortic root dilatation • blood pressure • severity of COA • associated lesions
	Repaired COA <sup>100,101</sup>		Moderate risk If severe COA: high risk
Congenitally Corrected Transposition of the Great Arteries (can be associated with VSD/PS) <sup>102,103</sup>	III-IV	If good systemic RV function and no associated lesions. Assess for: • Systemic right ventricular dysfunction & heart failure • Arrhythmias • Tricuspid regurgitation (systemic atrioventricular valve)	Moderate risk High risk if poor ventricular function
D-transposition of the Great Arteries (Repaired) Can be associated with other lesions (VSD/COA)	Arterial switch (no residual lesion)	II	Pregnancy usually well tolerated
	Residual lesions (neo AR/ RVOT obstruction/ ventricular dysfunction)	III	Pre-pregnancy assessment to decide if can proceed with pregnancy or needs surgical intervention first
	Atrial switch (post Mustard/ Senning operation) <sup>104-106</sup>	III	To assess for: • Systemic right ventricle dysfunction • Pulmonary/systemic venous baffle obstruction • Tricuspid regurgitation • Arrhythmias
			Moderate to high risk depending on clinical status

# Management of Pregnancy in Specific Cardiac Disease

**Table 12: Specific Considerations and WHO Risk Stratification for Specific Congenital Heart Disease (cont')**

Congenital Heart Disease	WHO Risk Class	Specific Considerations	Pregnancy Management
Post FONTAN surgery (performed in patients with single ventricle physiology) <sup>107,108</sup>	III	<p>Pre-pregnancy assessment to decide if can proceed with pregnancy</p> <p>Subfertility</p> <p>Complication risk include</p> <ul style="list-style-type: none"><li>• Heart failure</li><li>• Atrial Arrhythmias</li><li>• Cyanosis</li><li>• Thrombosis/thromboembolic event</li><li>• Fetal: preterm labour/FGR</li></ul>	<p>Moderate to high risk depending on clinical status</p> <p>Complications and preconception cardiac status should be determine before considering pregnancy</p> <p>Anticoagulation may be indicated</p> <p>If high risk: appropriate contraception prescribed</p>

Table 12 classifies the maternal risk of pregnancy based on specific cardiac lesions.<sup>12,19</sup> It is important to note that this risk is additive and will increase if there are additional obstetric or non-cardiac risk factors.<sup>13,14,19,89</sup>

# Management of Pregnancy in Specific Cardiac Disease

## 4.3 Pulmonary hypertension and Eisenmenger syndrome

Pulmonary hypertension (PH) is defined as mean pulmonary artery pressure of  $> 25$  mmHg at rest, measured by cardiac catheterization.<sup>109</sup> PH is classified into 5 different groups based on the aetiology, mechanism of vasculopathy and response to treatment.<sup>110</sup> (Table 13, pg. 82)

**Table 13: Clinical Classification of Pulmonary Hypertension<sup>111,112</sup>**

Group	Definition	Selected aetiologies
Group 1	Pulmonary arterial hypertension (PAH)	Idiopathic PAH, connective tissue disease – associated PAH, congenital heart disease – associated PAH, heritable PAH, schistosomiasis-associated PAH, persistent PH of the new-born
Group 2	PH due to left heart disease	Left ventricular systolic dysfunction, left ventricular diastolic dysfunction, aortic or mitral valvular heart disease
Group 3	PH due to lung diseases and/or hypoxia	Chronic obstructive pulmonary disease, interstitial lung disease, sleep-disordered breathing, developmental lung disease
Group 4	Chronic thromboembolic PH	
Group 5	PH with unclear multifactorial mechanisms	Sarcoidosis, chronic haemolytic anaemia

Adapted from Simonneau et al.<sup>110</sup>

In group 1, 3, 4 and 5, pulmonary arterial hypertension (PAH) reflects pre capillary PH (Table 12) where the pulmonary capillary wedge pressure (PCWP) is  $\leq 15$  mmHg and pulmonary vascular resistance is  $> 3$  Wood units (WU).<sup>109</sup>

Groups 2 and some of group 5 are post capillary and the pulmonary capillary wedge pressure (PCWP) is  $\geq 15$  mmHg.

Congenital heart disease (CHD) is a heterogeneous group with most lesions classified in Group 1 and some lesions classified in Group 2 (e.g. congenital mitral stenosis, anomalous pulmonary venous drainage).

# Management of Pregnancy in Specific Cardiac Disease

Eisenmenger syndrome is defined as the reversal of shunt (pulmonary to systemic) in the presence of severe pulmonary vascular resistance causing cyanosis at rest in patients with large intra and extra-cardiac shunts.

Pulmonary hypertension may be diagnosed for the first time during pregnancy as the haemodynamic effects of pregnancy may worsen the pulmonary vascular disease and precipitate symptoms of right heart failure.

## 4.3.1 Haemodynamic considerations in PH

Pregnancy has the following adverse effects in patients with PH.

- The increase in cardiac output during late second trimester and delivery worsens the pulmonary hypertension and may cause right ventricular failure and syncope.
- The decrease in systemic vascular resistance increases the right to left shunt in patients with Eisenmenger syndrome.
- The resulting hypoxia causes pulmonary vasoconstriction and increases the pulmonary hypertension further.
- Hypoxia also increases the risk of fetal loss and FGR.
- The right to left shunt may cause paradoxical embolism and cerebrovascular accidents.
- The hypercoagulable state puts these patients at risk of in situ pulmonary thrombosis and pulmonary embolism.
- Women with cyanosis also have abnormal coagulopathy and bleeding tendencies.
- Hypovolemia, anaemia and acidosis during delivery further aggravates the pulmonary hypertension.

## 4.3.2 Maternal and fetal outcomes

With improvement in care and the availability of PAH targeted therapy, maternal mortality has decreased.<sup>88,112,113</sup> (Table 14, pg. 84)

Most morbidity and mortality occurs in the late second, third trimester and in the postpartum period.<sup>88,113,114</sup> Most deaths occurred within the first month post-delivery and were due to right heart failure.<sup>88,113</sup> Deaths however may occur up to 2 years post-delivery.<sup>113</sup> Thus regular cardiac follow up and review of these patients are important.

# Management of Pregnancy in Specific Cardiac Disease

Most of the women who died had severe PH. However even women with mild or moderate PH have been reported to deteriorate during pregnancy. A safe cut-off value of pulmonary artery pressures is not known.<sup>88,113,115</sup>

Fetal and neonatal mortality was also high ranging from 7-13%. Risk for FGR and prematurity were also more common compared to the normal population.<sup>88,113,114</sup>

**Table 14: Comparison of Maternal Mortality in Women with Pulmonary Hypertension**

	Weiss et al <sup>114</sup> (1978-1996)	Bedard et al <sup>113</sup> (1997-2007)	Pieper et al <sup>88</sup> (1998-2013)
Total mortality	38% (n=125)	25% (n=73)	16% (n=77)
Mortality from iPAH	30%	17%	9%
Mortality from CHD & PAH	36%	28%	23%
Mortality from oPAH	56%	33%	13%

iPAH: idiopathic pulmonary arterial hypertension, CHD-PAH: pulmonary arterial hypertension associated with congenital heart disease, oPAH: PAH associated with other causes.

## 4.3.3 Preconception counselling

**I, c** In patients suspected of having PH by echocardiography, the diagnosis should be confirmed by cardiac catheterization prior to pregnancy.

**III, c** Pregnancy in the presence of severe PH, irrespective of cause, is high risk (WHO risk IV). Women with severe PH should be advised of the high mortality rates associated with pregnancy. As such, pregnancy is contraindicated.

**I, c** All patients with severe PH, should be counselled prior to pregnancy and contraception encouraged.

However pregnancy remains the choice of the woman and her partner, and if she decides to go ahead with pregnancy after detailed counselling, this decision should be respected.

For those patients with mild PH, pregnancy may be considered. These patients should be well informed about the potential worsening of symptoms as pregnancy advances.<sup>115,116</sup>

# Management of Pregnancy in Specific Cardiac Disease

## 4.3.4 Antenatal Care

For those patients with known PH who present pregnant, early referral to a tertiary centre is crucial for assessment of the severity of the PH and whether pregnancy can be continued.

**III, C** Termination of pregnancy is recommended for those with severe PH and appropriate contraception should be encouraged.

Women with severe pulmonary hypertension and an unplanned pregnancy should be informed of their high risk status and termination of pregnancy should be offered.

Patients with severe PH who chose to continue pregnancy, should be referred to a tertiary centre as early as possible after presentation for further management of the pregnancy.

Antenatal care would include:

### A. Assessing the severity of the PH

#### A.1 Clinical assessment:

- History of right heart failure, syncope/ presyncope
- Fatigue and shortness of breath are common presentations and should not be mistaken for normal pregnancy symptoms.
- Cyanosis: need to assess oxygen saturation at rest and on exertion
- Monitor for signs and symptoms of right heart failure
- Determine the functional class based on the WHO Functional Classification

#### A.2 Investigations

- Haemoglobin: > 15 g/dL – review if patient has cyanotic heart disease
- Iron studies in patients with cyanosis/ Eisenmenger syndrome
- Baseline and serial echocardiogram – to assess:
  - Worsening pulmonary artery pressure
  - Decreasing right ventricular function
  - Presence of pericardial effusion
- Serial B natriuretic peptides – BNP/ NT proBNP measurement (if available)
- Serial 6-minute walk test – This may however be difficult to interpret in pregnant women

# Management of Pregnancy in Specific Cardiac Disease

- CT pulmonary angiography if pulmonary thrombosis suspected
- In patients with newly diagnosed PH, secondary causes should be excluded. (e.g. connective tissues disease, liver disease, respiratory disease, cardiac and thromboembolic causes)

## B. Medications:

### B.1 General Principles

- Review current medications
- Stop potentially fetotoxic medication(s) where possible and replace with safer options.
- I, C** • Correct iron deficiency anaemia in patients with Eisenmenger syndrome
- Avoid excessive exertional activity
- Low salt diet & fluid restriction in those with heart failure
- Judicious use of diuretics in patients with fluid overload. Avoid hypovolemia.
- III, C** • Routine venesection should be avoided.

### B.2: PAH targeted therapy

- Should be instituted by physicians with expertise in treatment of PH
- Start PAH targeted therapy where indicated:
  - in symptomatic patients
  - syncope/ presyncope
  - RV failure
  - decreasing functional class
- IIa, C** • PDE5 inhibitors (e.g. sildenafil) and Prostaglandin Agonists (e.g. iloprost) can be used in pregnancy.<sup>112,117,118</sup>
- IIa, C** • Calcium channel blockers may also be used if appropriate.<sup>112,119</sup>
- III, C** • Endothelin receptor antagonist (e.g. Bosentan) is contraindicated in pregnancy.<sup>120,121</sup>
- I, C** • If the patient is on these medications pre-pregnancy, they should be stopped and switched to safer alternatives.
- PAH therapy should be optimised.
- IIa, C** • In certain situations, the teratogenic effect of the drugs needs to be weighed against the maternal benefit and adverse outcome. This has to be discussed with the patient preferably during the pre-pregnancy counselling.

# Management of Pregnancy in Specific Cardiac Disease

## B.3 Anticoagulation<sup>113</sup>

Pulmonary hypertension carries a significant risk of pulmonary thrombosis and paradoxical embolism.

Patients who are on oral anticoagulation pre-pregnancy should be converted to low molecular weight heparin (LMWH) or unfractionated heparin (UFH). However the type of anticoagulation and regime should be individualised based on the indication (section 4.9, pg. 114).

- I, C • Low molecular weight heparin is generally recommended in most patients especially those at increased risk of venous thromboembolism, cyanosis and Eisenmenger syndrome.
- I, C • Patients with atrial fibrillation and those with a past history of thromboembolic events may require higher levels and longer duration of anticoagulation.
- I, C • Aspirin may be adequate for low risk patients.
- Thromboprophylaxis using LMWH is indicated in the postpartum period for most patients with PH. However it should be used judiciously in those at risk of bleeding (Eisenmenger syndrome).<sup>93</sup>

## C. General care

The patient and family should be advised about the potential maternal and fetal risk.

A pregnancy care plan should be developed and disseminated to all personnel caring for the patient.

The patients should be referred to a combined clinic with multidisciplinary team.

## D. Monitoring and follow up

### D.1: Maternal

- This will depend on the patient's clinical status, functional class and symptoms as pregnancy progresses.
- IIb, C • If there is worsening of symptoms and functional class in the first or early second trimester, termination of pregnancy should be considered.
- If patient deteriorates in the late second or third trimester, she should be admitted, care optimised and planned for early delivery.

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- Echocardiogram, 6 min walk test and biomarkers (BNP/ NTproBNP) can be used to monitor for deterioration. The changes in serial 6 min walk tests however, may sometimes be difficult to interpret in pregnancy.

## D.2: Fetal

Close fetal surveillance is recommended as there is increased fetal morbidity and mortality.<sup>12,88,113</sup>

### 4.3.5 Labour and delivery

The intra and postpartum care plan should be decided by the multidisciplinary team consisting of cardiologist, obstetrician, cardiac and obstetric anaesthetist, intensivist and neonatologist.

This is done between 30 to 32 weeks gestation or earlier if indicated.

The mode, timing and place of delivery are based on:

- The safest option for the patient taking into consideration the clinical status, functional class and fetal status.
- The expertise and facilities available in the chosen hospital.

#### 4.3.5.1 Mode of delivery

##### 4.3.5.1.1 Elective lower segment caesarean section (LSCS)

IIa, C

This is the preferred mode of delivery in our local setting for the following reasons:

- This procedure can be planned in advance with the advantage that it can be done:
  - when the patient is still haemodynamically stable
  - the haemodynamic complications associated with labour and autotransfusion associated with vaginal delivery are avoided
  - during working hours when care is optimal
- It is useful for those patients that need early delivery when the cervix is unfavourable.

However care should be taken to manage the acute fluid shifts that occur with LSCS as this may cause haemodynamic decompensation.

Blood loss should be minimal with meticulous attention to haemostasis and postpartum haemorrhage.

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**I, c** Oxytocin should be given at the smallest effective infusion rate.

## 4.3.5.1.2 Vaginal delivery

If the patient presents in labour, the following precautions should be taken:

- good analgesia for pain control (low dose epidural anaesthesia)
- low threshold for assisted second stage of labour (forceps/ vacuum)
- left lateral decubitus position is preferred in labour to avoid IVC compression

**IIa, c** Vaginal delivery can be considered in mild to moderate PH who are haemodynamically stable.

**I, c** The mode of delivery should however be individualised and efforts should be taken to avoid an unplanned delivery.

## 4.3.5.2 Type of anaesthesia

The type of anaesthesia for LSCS is to be determined during the multidisciplinary meeting.

**IIb, c** General anaesthesia carries a higher risk and is not routinely recommended.<sup>122</sup>

**IIa, c** It is currently recommended that a careful combination of epidural and low dose spinal anaesthesia be used in these patients.<sup>112,122-125</sup>

It should be administered by an experienced anaesthetist.

The choice of anaesthesia will need to take into consideration the following:

- The clinical and functional status of the patient
- The expertise and experience of the respective centres

## 4.3.5.3 Monitoring during labour and delivery

Close monitoring of the mother and fetus is crucial during labour, delivery and in the postpartum.

- I, c**
- Continuous intra-arterial pressure, central venous pressure, pulse oximetry and electrocardiogram monitoring during delivery is indicated
  - Pulmonary pressure catheters are not advised as the risk may outweigh the benefit.<sup>126</sup>

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- IIa, C** • Non-invasive cardiac output monitoring should be considered if haemodynamic instability is anticipated.
- IIa, C** • Nitric oxide should be available and is useful for patients with severe PH, at risk of PH crisis or in RV failure.<sup>122</sup>
- IIa, C** • Inhaled pulmonary vasodilators such as iloprost (Pregnancy Risk Factor Category C) should also be available.<sup>122,127</sup>
- I, C** • Inotropes (e.g. vasopressors such as vasopressin, catecholamines),<sup>112,125,128</sup> are also useful in stabilising patients.
- Careful handling of intravenous lines by using filters to prevent paradoxical embolus/ air embolization in patients with Eisenmenger syndrome and other forms of right to left shunting.
- Patients with Eisenmenger syndrome are also at higher risk for bleeding.
- Close monitoring of coagulation profile and early correction with blood products to prevent excessive bleeding.
- All patients should be monitored in the HDU/ICU/CCU for 3-5 days post-delivery.

## 4.3.5.4 Anticoagulation

**I, C** In patients with Eisenmenger syndrome, elastic stockings, early mobilisation and antithrombotic prophylaxis with low molecular weight heparin is recommended to prevent deep vein thrombosis and potential pulmonary and paradoxical embolism.

**I, C** For those with idiopathic PH and others who are at risk for thromboembolic events (e.g. past history of thromboembolic event, atrial fibrillation) oral anticoagulation should be instituted after 24 hours if there are no bleeding complications.

## 4.3.5.5 Extracorporeal membrane support (ECMO)

**IIa, C** ECMO has been used in pregnant patients with respiratory or haemodynamic compromise.<sup>129,130</sup> There may be a role in patients with PH who have severe haemodynamic decompensation.

## 4.3.6 Postpartum

The morbidity and mortality is highest in the postpartum period especially in the first 2 weeks to 1 month post-delivery.<sup>88,113,114,122</sup>

**IIa, C** All patients should remain in hospital for at least 2 weeks post-delivery.

# Management of Pregnancy in Specific Cardiac Disease

In the event of acute PH crisis or haemodynamic decompensation, nitric oxide or prostacyclins (intravenous epoprostenol or inhaled iloprost if epoprostenol is not available) can be administered to stabilise the patient.

Patients should be monitored closely up to 6 months postpartum as late deaths and decompensation can still occur. These patients should be seen at least once more in the combined clinic to:

- review the patient's clinical status
- decide on the further management plan
- ensure appropriate contraception

Patients who were newly diagnosed with PH during delivery, should be referred to a PH expert for further investigation and management.

## 4.3.7 Contraception

**I, c** Appropriate contraception is important as pregnancy is contraindicated in patients with PH (section 5, pg. 137) Appendix N & O pg. 165-166.

**I, c** The contraception of choice in these patients are implants (Nexplanon® previously known as Implanon®).

The Endothelin receptor antagonist Bosentan, may have an effect on the efficacy of progesterone only contraceptives. In these patients, one should consider combining an implant (Nexplanon®, previously known as Implanon®) with progesterone only pill.<sup>9</sup>

Depo medroxyprogesterone however has no interaction with Bosentan and can be used. It however has to be used with caution because it causes significant water retention.

**III, c** Intra-uterine systems/devices (e.g. Mirena®) must be used with great caution because there is a risk of vasovagal reactions during insertion and in patients with PH and Eisenmenger syndrome, this may result in fatal cardiovascular collapse.<sup>9</sup> Hence this should never be done by inexperienced staff or in an outpatient situation. It should only be considered if Nexplanon® (previously known as Implanon®) fails.

**III, c** Laparoscopic sterilisation is discouraged as the pneumoperitoneum created may cause these patients to decompensate.

# Management of Pregnancy in Specific Cardiac Disease

As subsequent pregnancies increases the maternal mortality risk, it is important to ensure that this is avoided by appropriate contraception.

## Key messages:

- Pre-pregnancy counselling and appropriate contraception is important.
- Should pregnancy occur, termination should be considered as these patients are high risk.
- Should pregnancy continue, these patients should be managed by a multidisciplinary team with expertise in the management of patients with pulmonary hypertension.
- Morbidity and mortality is highest in the postpartum period especially in the first 2 weeks to 1 month post-delivery and up to 6 months.
- Permanent sterilisation (including male sterilisation) should be considered.

# Management of Pregnancy in Specific Cardiac Disease

## 4.4 Marfan syndrome and other thoracic aortic aneurysmal syndromes

Patients with Marfan syndrome are almost always asymptomatic pre-pregnancy and may be diagnosed for the first time after complications occur. They have an increased risk of aortic dissection during pregnancy.

In a report of unselected pregnancies, it was suggested that the expected rate of aortic dissection of ≈ 3% - an estimated 1% in women with aortic diameter < 40 mm and 10% in high-risk patients.<sup>131,132,133</sup> High risk patients for aortic dissection are those with:

- aortic root diameter:
  - > 40 mm and/or an increase in aortic root diameter during pregnancy<sup>134,135</sup>
  - > 45 mm<sup>1</sup>
  - 40–45 mm, and family history of dissection<sup>1</sup>
- rapid dilatation
- previous dissection of the ascending aorta

In these High Risk patients, aortic root replacement should be encouraged pre-pregnancy, following which the risk of pregnancy is much lower.

Even in women with normal sized aorta, (< 40 mm – generally considered safe) dissections may still occur.<sup>133,134,136</sup>

Aortic dissections occur most often in the last trimester or the early postpartum period.<sup>132,133,137</sup>

In the measurement of aortic root diameter, consideration of body surface area is important, especially in women of small stature. The z-score for aortic root diameter adjusted for body surface area is available at the website <[www.marfan.org/dx/zscore#formtop](http://www.marfan.org/dx/zscore#formtop)>.

There is a small but significant increase in aortic root diameter in patients with Marfan syndrome during pregnancy.<sup>135,138</sup>

It has been speculated that there is an association between the hyperdynamic and hypervolemic state of pregnancy and aortic dissections.<sup>139</sup> The hormones of pregnancy may also effect the aortic wall integrity.

Hypertension and any cause of tachycardia (such as anaemia, infection or thyrotoxicosis) have to be avoided and treated appropriately as these may increase the risk of dissection.

I, C

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The commonest symptoms were severe chest and back pain, epigastric and abdominal and leg pain often described as sharp, tearing, or ripping.

Other complications include worsening mitral regurgitation leading to supraventricular arrhythmias and/or heart failure.

Following elective aortic root replacement, patients remain at risk for dissection in the residual aorta.<sup>140</sup>

## 4.4.1 Preconception counselling

I, c Pregnancy is contraindicated (WHO Class IV) in the following:

- Marfan syndrome with aorta dilated > 45 mm<sup>1</sup>
- Bicuspid aortic valve with aorta dilated > 50 mm<sup>1</sup>
- Previous history of aortic dissection

I, c These high risk patients should be advised aortic root replacement prior to pregnancy. Following surgery, the risk of pregnancy is much lower.

The risk of Marfan syndrome in the offspring is 50%.<sup>141</sup>

## 4.4.2 Antenatal care

IIa, c Patients with aortic pathology should be monitored by serial echocardiography. The initial echocardiogram should be done at antenatal booking and repeated at 4–6 week intervals from the 24<sup>th</sup> week of pregnancy.

IIa, c Treatment with β-blocking agents may reduce the rate of aortic dilatation and may improve survival.<sup>137,142</sup>

Higher doses of β-blockers may be required to achieve adequate heart rate control because of the increased sympathetic activity seen in pregnancy. Fetal growth needs to be monitored more frequently in patients on β-blockers.

## 4.4.3 Labour and delivery

The aim of intrapartum management in patients with ascending aorta enlargement is to reduce the cardiovascular stress of labour and delivery.

- I, c
- If the woman is taking β-blockers during pregnancy, they should be continued in the peripartum period.

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I, C

- Caesarean delivery should be considered:<sup>137</sup>
  - if aortic diameter is progressively increasing
  - in Marfan syndrome when the aortic diameter exceeds 45 mm
  - in bicuspid aortic valve when the aortic diameter exceeds 50 mm
- In all other patients, the mode of delivery should be individualised.
- Regional anaesthesia techniques can be difficult in patients with Marfan syndrome depending on the presence and severity of scoliosis and the presence of dural ectasia.<sup>143,144</sup>

## 4.4.4 Postpartum care

Patients should be monitored haemodynamically for 24 hours postpartum. They should have a cardiac review at 6 weeks. Echocardiography should be performed 3-6 months post-delivery.

### Key message:

- Pregnancy in the following patients are High Risk (WHO Class IV):
  - Marfan syndrome with aorta dilated > 45 mm<sup>1</sup>
  - Bicuspid aortic valve with aorta dilated > 50 mm<sup>1</sup>
  - Previous history of aortic dissection
- They should be advised aortic root replacement prior to pregnancy.
- Even in women with normal sized aorta dissections may still occur.

# Management of Pregnancy in Specific Cardiac Disease

## 4.5 Ischaemic heart disease and acute coronary syndromes

Ischaemic heart disease (IHD) is uncommon during pregnancy. Pregnancy however, increases the risk of an acute myocardial infarction (MI) by 3-4 fold.<sup>145</sup> However with the changing lifestyle that includes cigarette smoking, diabetes and stress, the prevalence of IHD in women is increasing. With more women delaying childbearing until older age, the incidence of acute coronary syndrome (ACS) during pregnancy may occur more frequently.

Although rare, ACS during pregnancy may have devastating consequences. The incidence of acute MI is estimated at 6 to 10 per 100,000 pregnancies with maternal mortality being 5.1% to 37%.<sup>145,146</sup> Fetal death occurs in 12% to 34% of cases.<sup>147</sup> Pregnant women with pre-existing CAD or ACS/MI before pregnancy are at increased risk of adverse events during pregnancy.

Most maternal deaths occur:

- at index MI
- within two weeks of MI
- usually in association with labour and delivery

Acute MI may occur at any stage of the pregnancy. It is more common in:

- women older than 30 years of age
- multigravida
- smokers
- women with multiple traditional risk factors such as diabetes, hypertension and hypercholesterolaemia.<sup>145,147</sup>

Most MI's were located in the anterior wall.<sup>145</sup>

ACS in pregnancy also constitutes an important problem for the patient and the treating physician, as the selection of diagnostic and therapeutic approaches is influenced not only by maternal, but also by fetal safety.

With the application of PCI, maternal mortality rate has dropped from 20% to 5%.<sup>145,146</sup>

### 4.5.1 Pathophysiology, symptoms and diagnosis

Atherosclerosis appears to be the most common cause, although coronary spasm, coronary dissection and thrombus have also been reported. Coronary atherosclerosis was the primary cause of MI in the antepartum group, while in the postpartum period, coronary dissection was the primary cause of ACS.<sup>146</sup>

# Management of Pregnancy in Specific Cardiac Disease

Symptoms of ACS include:

- severe or progressive dyspnoea
- syncope with exertion
- chest pain related to effort or emotion

These can mimic common symptoms of pregnancy and hence the diagnosis of ACS is often missed. Chest discomfort is rarely attributed to heart problems in, otherwise healthy, pregnant women.

The diagnostic tests for ACS in the pregnant women can be challenging. Investigations include:

- ECG
  - In normal pregnant patients, the ECG may show non-specific changes such as left- or right-axis deviation, small Q wave in lead III, T wave inversion, or an increased R/S ratio in leads V1 and V2. This may cause confusion in the diagnosis of MI.<sup>147</sup>
- Cardiac biomarkers
  - CK and CKMB, may be falsely elevated in labour and delivery. Cardiac troponins are the biomarkers of choice in the diagnosis of MI although these may sometimes be elevated in gestational hypertension and pre-eclampsia.<sup>148,149</sup>
- Coronary angiography
  - Where indicated, coronary angiography should be performed ensuring that radiation is kept to a minimum. (see section 3.6, pg. 61 and Appendix E, pg. 156)

## 4.5.2 Management of ACS in pregnancy

Treatment of ACS is not based on randomised trials, but on limited data from case reports, observational studies and clinical individual experience.

Treatment of STEMI involves:

- IIa, C**
- Primary percutaneous coronary intervention (PCI) –
    - Treatment of choice if facilities are available and it can be performed in a timely manner.
    - Main concerns are radiation and the need for dual antiplatelet agents (DAPT). The latter may predispose to bleeding complications and preclude the use of epidural analgesia/anaesthesia during labour. For these reasons, bare metal stents are generally preferred in pregnancy.<sup>150</sup>

# Management of Pregnancy in Specific Cardiac Disease

- Fibrinolysis –
  - To date, pregnant patients have been excluded from the clinical trials and pregnancy is considered to be a relative contraindication for fibrinolysis.
  - The risk of haemorrhage in a pregnant patient should be weighed against the benefits of treatment.
  - Limited data is available on the agents of choice (streptokinase or rTPA)
- Fibrinolysis is contraindicated in MI's due to coronary dissections. It may cause propagation of the dissection and expansion of the intramural hematoma.

If the STEMI is due to coronary dissection:

- Fibrinolytic therapy is contraindicated.
- A conservative approach is the treatment of choice if the patient is stable, without chest pains and the coronary vessel is open with TIMI 3 flow.
- Primary Percutaneous Coronary Intervention (PCI) should be considered if the patient has ongoing pain, hemodynamic instability and/or flow limitation in a large epicardial vessel with a large area of myocardium at risk. The technical success of PCI and the long term results in these patients are much lower than in patients with atherosclerotic disease.

Following acute MI, several drugs have been proven beneficial in secondary prevention. There is however, limited data in pregnancy of the safety of many of the drugs used for treatment of ACS. The following drugs are safe:

- IIa, B
  - Low dose aspirin < 150 mg/day<sup>147,151</sup>
  - Low molecular weight heparins<sup>152</sup>
  - β-blockers
  - Calcium channel blockers – nifedipine
  - Long acting nitrates – at high dose nitrates may cause hypotension

The following drugs must be used with caution or not at all:

- IIb, C
  - Clopidogrel – Based on limited animal data this is categorised B by FDA. (Appendix B-D, pg. 152-155) Should stop this 7 days prior to planned delivery.<sup>153</sup>
  - Statins are contraindicated.

## 4.5.3 Intrapartum

IIa, C Delivery should be postponed, if possible, for at least 2–3 weeks after MI as it may cause aggravation of heart failure and a theoretical risk of myocardial rupture.<sup>154</sup>

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The mode of delivery should be individualised and determined by obstetric reasons and the clinical status of the mother.

## 4.5.4 Postpartum

In the puerperium, patients with ACS are still at risk for new events – reinfarction, heart failure and arrhythmias.<sup>154</sup> Therefore, clinical observation for at least 3 days after delivery is recommended.

Patients should be followed-up by the cardiologist for risk assessment 6 weeks post-delivery.

## 4.5.5 Prognosis

This would depend upon:

- LV function – Impairment of left ventricular function is one of the main determinants of poor maternal and fetal outcome. If the LVEF is below 40%, patients should be counselled appropriately.<sup>13</sup>
- Arrhythmias
- Presence of residual ischaemia

The above indicators would determine the risk of future pregnancies in these patients. Wherever possible, residual coronary lesions should be treated appropriately. In patients who are already taking cardiovascular medications, the discontinuation or the switch to a 'safer' drug should be discussed before the next pregnancy.

### Key messages:

- Ischaemic heart disease in pregnancy is uncommon but is increasing in prevalence due to the older age of mothers and higher prevalence of traditional risk factors (such as hypertension, diabetes mellitus, dyslipidaemia and obesity).
- Management needs to be individualised and the risk : benefit ratio of therapeutic options (cardiac interventions e.g. PCI) and medications need to be considered.
- Often, cardiac medications have to be continued despite the potential fetal risks.

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## 4.6 Peripartum cardiomyopathies and other cardiomyopathies

The cardiomyopathies constitute a group of disorders in which the dominant feature is direct involvement of the heart muscle itself. According to the European Society of Cardiology Working Group definition, cardiomyopathy is “a myocardial disorder in which heart muscle is structurally and functionally abnormal in the absence of coronary artery disease, hypertension, valvular disease, and congenital heart diseases”.<sup>155</sup>

Cardiomyopathies may be classified on the basis of their predominant morphofunctional phenotype into:

- dilated cardiomyopathy (DCM)
- hypertrophic cardiomyopathy
- restrictive cardiomyopathy
- arrhythmogenic RV dysplasia
- unclassified cardiomyopathy

They can be further subclassified into familial/genetic and non-familial/non-genetic.<sup>155</sup>

### 4.6.1 Peripartum cardiomyopathy

Peripartum cardiomyopathy (PPCM) is the development of heart failure (HF) in the last month of pregnancy or within 5 months of delivery in the absence of an identifiable cause and recognisable heart disease prior to the last month of pregnancy.<sup>156</sup>

A more recent definition of PPCM is an Idiopathic cardiomyopathy presenting with HF secondary to LV systolic dysfunction from one month antepartum, up to 5 months after delivery, when no other causes of HF is evident.<sup>155</sup>

The prevalence of PPCM in Malaysia is at 34 per 100,000 live births<sup>157</sup> whereas in other parts of the world it varies from 0.88 per 100,000 live births in USA<sup>158</sup> to 250 per 100,000 live births in Haiti.<sup>159</sup>

Plausible etiologic mechanisms are myocarditis, apoptosis and inflammation, abnormal immune response to pregnancy (Chimerism), maladaptive response to haemodynamic stresses of pregnancy, excessive prolactin secretion and prolonged tocolysis.<sup>160</sup>

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Predisposing factors are:

- maternal age greater than 30 years
- multiparous
- eclampsia
- twin pregnancy
- hypertension
- nutritional deficiencies
- racial origin (black)

In the majority of cases there is no family history.

Patients often present with symptoms and signs of new onset HF. These symptoms are often confused with that of a normal pregnancy.

The ECG may show non-specific ST/ T wave changes, atrial or ventricular arrhythmias and conduction defects. The diagnosis is confirmed by echocardiography. This may show enlargement of all four chambers with marked reduction in left ventricular systolic function, small to moderate pericardial effusion, mitral, tricuspid and pulmonary regurgitation, ventricular wall motion abnormalities and a reduced ejection fraction and cardiac output.

Other tests to be considered are Brain Natriuretic Peptide (BNP)/ NT proBNP and cardiac magnetic resonance imaging (c-MRI). In patients with inflammatory cardiomyopathies, c-MRI may show late gadolinium enhancement.

Important considerations in management are:

- Time of presentation – the patient may present antepartum, intrapartum or postpartum
- Mode of presentation – acute HF or chronic HF

## 4.6.1.1 Preconception counselling

In patients with a past history of PPCM, the risk of recurrence in a subsequent pregnancy would depend upon the recovery of the LV function.<sup>161</sup>

- I, B  
• If LV function has recovered fully, subsequent pregnancies are not contraindicated but the patient should be warned of a possibility of recurrence.

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- I, B** • If the LV function has not recovered, subsequent pregnancy is contraindicated and appropriate contraceptive measures should be advised.<sup>161,162</sup>
- IIb, C** • A small study of 6 patients found dobutamine stress echocardiography useful in predicting contractile reserve and subsequent recovery of LV function.<sup>163</sup> This however, needs to be evaluated in larger studies.<sup>161</sup>

## 4.6.1.2 Antenatal care

Women who present with PPCM during pregnancy should be referred to tertiary centres and managed by a multidisciplinary team. Maternal cardiovascular risks will depend upon the following factor at presentation:

- Acute vs chronic HF
- LV function
- NYHA functional class
- Gestational age

The more severe the clinical presentation (NYHA Functional Class) and the lower the LVEF (< 30%), the worse the maternal and fetal prognosis.

### General Principles:

- I, C** • Heart failure in PPCM can develop very rapidly, and the guidelines for the management of Acute HF apply (see Malaysian CPG on HF 2014).<sup>164</sup>
- I, C** • In patients with stable HF, management is as outlined in the Malaysian CPG on HF 2014<sup>164</sup> with some exceptions (section 4.8, pg. 112).
- I, C** • When prescribing drugs, the maternal benefits need to be weighed against possible adverse effects on the fetus (Appendix D, pg. 155).
- IIa, C** • Anticoagulant therapy is recommended in all patients with PPCM because of the high incidence of thromboembolic events.
- Patients on warfarin need to be changed to UFH/ LMWH prior to delivery. After delivery warfarin may be recommenced (section 4.9, pg. 114).
- I, C** • Urgent delivery, irrespective of gestation, may need to be considered in patients with severe HF refractory to medical therapy and with haemodynamic instability.
- As soon as the baby is delivered, standard therapy for HF can be applied (section 4.8, pg. 112)<sup>165</sup>

# Management of Pregnancy in Specific Cardiac Disease

It is important to note that the prognosis of PPCM is different from that of DCM, with a significant proportion improving or normalising their LV function over the first 6 months after diagnosis.<sup>166</sup> There is a relatively high rate (50%) of spontaneous recovery.<sup>165,167</sup>

## 4.6.1.3 Labour and delivery

- Timing and mode of delivery in patients with PPCM should be determined by the clinical status of the mother and the fetus.
- I, C** • Vaginal delivery is preferred if the patient is haemodynamically stable and there are no obstetric indications for caesarean section.
- IIa, B** • PGE2 is the drug of choice in those requiring induction of labour.<sup>46</sup>
- IIa, C** • If the patient presents in labour, artificial rupture of membrane (ARM) is to be done followed by augmentation with oxytocin.
- I, C** • Slow oxytocin infusion is preferred to avoid sudden vasodilatation and hypotension. It also helps to decrease the after load and maintain haemodynamic stability.
- I, C** • Close haemodynamic monitoring and fetal monitoring is required
- I, C** • Lumbar epidural analgesia is preferred.
- I, C** • Left lateral recumbent position during labour and to avoid “push”, second stage of labour assisted by forceps delivery.

## 4.6.1.4 Postpartum care

**I, C** These patients should be monitored in a critical care unit - HDU/CCU/ICU for 24 to 72 hours since the condition may deteriorate postpartum.

**IIa, C** These patients should be followed-up by the cardiologist until the LV function normalises.

The risk of a subsequent pregnancy will depend on the recovery of LV function.

## 4.6.1.5 Specific treatment for peripartum cardiomyopathy (PPCM)

**IIa, C** The following treatment options may be considered:<sup>168</sup>

- Bromocriptine – A recent small prospective randomised pilot study supports the hypothesis that the addition of bromocriptine to standard heart failure therapy has beneficial effects on ventricular ejection fraction (EF) and clinical outcome in women with acute severe PPCM.<sup>169</sup>
- IIb, B** • IV immunoglobulin – Improves LVEF and reduces levels of inflammatory

# Management of Pregnancy in Specific Cardiac Disease

IIb, C

- Immunosuppressive therapy (e.g. azathioprine, cyclophosphamide) – No proven role but can be tried in inflammatory myocarditis.
- Others – Monoclonal antibodies, interferon, therapeutic plasmapheresis, pentoxifylline, cardiomyoplasty – may be considered.

IIa, C

For patients with refractory HF, cardiac support options that can be considered are intra-aortic balloon pump, LV assist device and cardiac transplantation.

## 4.6.1.6 Prognosis

About 28-50% of patients recover baseline LV function within 6 months.<sup>165,170</sup> Prognosis is positively related to recovery of LV function.<sup>165</sup>

- LVEF is the strongest predictor of outcome
- Failure of LV size to return to normal is associated with increased morbidity and mortality<sup>171,172</sup> The 5 year survival rate is 94%<sup>173,174</sup> and mortality varies from 0.9% -15%.<sup>165,170</sup>
- A subsequent pregnancy carries a recurrence risk for PPCM of 30–50%<sup>162,174,175</sup>

## 4.6.2 Dilated cardiomyopathy

Dilated cardiomyopathy (DCM) is a syndrome characterised by cardiac enlargement and impaired systolic function of one or both ventricles. The incidence of DCM is reported to be 2-5 cases per 100,000 population per year and the prevalence 1 in 2500. The true figure is probably higher as a consequence of under-reporting and under-diagnosis of mild or asymptomatic cases.<sup>176</sup>

The cause is often not known. This condition also represents a final common pathway of myocardial damage produced by a variety of cytotoxic, metabolic, immunological, familial and infectious mechanisms.

It is defined by the presence of typical symptoms of HF, LV dilatation, and LV systolic dysfunction of unknown origin. Differentiation from PPCM is supported by the time of manifestation. If not known before conception, the condition is most often unmasked during the first or second trimester when the haemodynamic load is increasing. A family history of DCM favours the diagnosis of DCM.<sup>177</sup>

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## 4.6.2.1 Preconception counselling

Women with DCM should be informed about the risk of deterioration of the condition during gestation and peripartum.<sup>174</sup> Furthermore the late effects of pregnancy on long term left ventricular function and prognosis are still not known.<sup>178</sup> They should be counselled based on individual risk stratification.

## 4.6.2.2 Antenatal care

**IIa, c** If pregnancy occurs, LVEF < 40% is a predictor of high risk, and close monitoring in a tertiary centre is advised.

**I, c** If LVEF is < 20%, maternal mortality is very high and termination should be considered.<sup>178</sup>

**I, c** DCM is treated in accordance with the current heart failure guidelines described above for PPCM.

## 4.6.3 Hypertrophic cardiomyopathy

Patients with Hypertrophic Cardiomyopathy (HCM) have:

- diastolic dysfunction due to the hypertrophied non-compliant myocardium, and/or
- severe LV Outflow Tract Obstruction (LVOTO) and/or
- arrhythmias

They can present with symptoms of HF with pulmonary congestion or syncope during physical activity as a response to outflow tract obstruction. Supraventricular and ventricular arrhythmias are common.

Echocardiography is the diagnostic tool of choice. Valsalva manoeuvre should be performed routinely during the diagnostic echocardiogram in patients with HCM. If a peak LVOTO gradient of  $\geq 50$  mmHg is demonstrated at rest or on provocation, the patient is considered high risk.

## 4.6.3.1 Preconception counselling

Women with HCM usually tolerate pregnancy well.<sup>179</sup> Risk is increased in women who are symptomatic before pregnancy and in those with a high LV outflow tract gradient. Patients with a high risk clinical profile before pregnancy are at higher risk and need specialists' care.<sup>179</sup>

# Management of Pregnancy in Specific Cardiac Disease

## 4.6.3.2 Antenatal care

General principles of management:

- IIa, C** • β-blockers in patients with LVOTO<sup>180</sup>
- IIa, C** • β-blockers for rate control in AF and to suppress ventricular arrhythmias.
- IIa, C** • Verapamil as an alternative when β-blockers are not tolerated.
- I, C** • AF is poorly tolerated in these patients and cardioversion should be considered early.
- I, C** • For those with AF, anticoagulation with LMWH or warfarin according to the stage of pregnancy is recommended.
- I, C** • Patients with a family history of sudden death need close surveillance with prompt investigation if symptoms of palpitations or pre-syncope are reported.

## 4.6.3.3 Labour and delivery

Important considerations are:

- I, C** • Low risk cases may have a spontaneous labour and vaginal delivery.
- I, C** • Patients with significant LVOTO should have a planned delivery.
- I, C** • Epidural anaesthesia causes systemic vasodilation and hypotension, and therefore must be used with caution in patients with severe LVOTO.
- I, C** • Intravenous (IV) fluids must be titrated carefully and volume overload must be avoided as it is poorly tolerated in the presence of diastolic dysfunction.
- I, C** • Avoid the use of drugs that cause vasodilatation and excessive blood loss.
- I, C** • Oxytocin may cause hypotension, arrhythmias, and tachycardia, and should only be given as a slow infusion.

## 4.6.3.4 Postpartum care

- I, C** These patients should be monitored in a critical care unit/HDU for haemodynamic stabilisation.

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## Key messages:

- Women presenting with heart failure during pregnancy or postpartum have a high morbidity and mortality.
- The more severe the clinical presentation (NYHA Functional Class) and the lower the LVEF (< 30%), the worse the maternal and fetal prognosis.
- Most of these women have peripartum cardiomyopathy (PPCM).
- A significant proportion of women presenting with PPCM will have improvement in LV systolic function. Prognosis for PPCM is generally better than dilated cardiomyopathy of other aetiologies.
- Treatment for heart failure is as in Malaysian CPG on HF 2014.

# Management of Pregnancy in Specific Cardiac Disease

## 4.7 Arrhythmias in pregnancy

Arrhythmias are the most common cardiac complication encountered during pregnancy. This increased arrhythmic risk is due to a combination of hormonal, autonomic and haemodynamic factors such as atrial and ventricular myocardial stretch resulting from the rise in plasma volume and cardiac output.<sup>181,182</sup> These arrhythmias include:

- sinus tachycardia, sinus bradycardia and sinus arrhythmia<sup>183</sup>
- ectopic beats and non-sustained arrhythmias - encountered in more than 50% of pregnant women.<sup>182,184</sup>
- sustained tachycardias – less common at around 2–3/1000<sup>183</sup>  
Exacerbations of paroxysmal Supraventricular Tachycardia (SVT) occur in about 20-44% of pregnancies.<sup>183,185</sup>

The majority of these arrhythmias are benign. In patients with structural heart disease however, the presence of arrhythmias is one of the five independent predictors of having an adverse cardiac event during the pregnancy.<sup>14</sup>

Supraventricular and ventricular arrhythmias requiring treatment develop in up to 15% of patients with CHD during pregnancy.<sup>12</sup> Women with SVT (ARVRT and AVRT) may have a recurrence during pregnancy and Right Ventricular Outflow Tract (RVOT) VT can present for the first time in pregnancy.

Ventricular Tachycardia (VT) in patients with structural heart disease is associated with an increased risk of maternal Sudden Cardiac Death (SCD).<sup>1</sup> Peripartum cardiomyopathy should always be excluded in women presenting with new-onset VT during the last 6 weeks of pregnancy or in the early postpartum period.<sup>1</sup>

### 4.7.1 Management

Management of arrhythmias in pregnancy is similar to that in the non-pregnant patient.<sup>186-189</sup> (Appendix H, pg. 159)

I, C

These include:

- Reassurance alone in the majority of cases who do not have significant arrhythmias.
- β-blockers are often first line therapy during pregnancy in most conditions.

# Management of Pregnancy in Specific Cardiac Disease

- I, C • Anti-arrhythmic drugs due to their potential fetotoxicity, are reserved for the treatment of clinically significant symptoms and/or haemodynamic compromise. (see Appendix E, pg. 156)
- I, C • In patients already on anti-antiarrhythmic drugs, the risk of continuing these during pregnancy must be weighed against the risk of stopping the medications.
- The decision needs to be individualised based on the nature of the arrhythmia and the underlying cardiac disease.
- I, C • Wherever possible, catheter ablation should be advised before the patient becomes pregnant.
- IIb, C • Should refractory tachyarrhythmias develop during pregnancy, catheter ablation is preferably performed during the 2<sup>nd</sup> trimester.<sup>190</sup>
- Specific arrhythmias:
  - Paroxysmal Supraventricular Tachycardia (PSVT) can be managed similar to the non-pregnant state.<sup>186-188</sup>
  - Sustained tachycardias, particularly atrial flutter and VT, are not well tolerated and may cause fetal hypoperfusion. In these patients, Direct Current Cardioversion (DCCV) can be safely performed to restore sinus rhythm.<sup>186-188</sup>
  - Atrial fibrillation and flutter are rare during pregnancy and are usually associated with underlying metabolic disturbances such as thyrotoxicosis or CHD. They should be investigated and managed in a similar manner to the non-pregnant state. This should include assessment of stroke risk and anticoagulation.<sup>189</sup>
  - Life-threatening ventricular arrhythmias during pregnancy are rare.
    - Idiopathic right ventricular outflow tract (RVOT) tachycardia is the most frequent type occurring in structurally normal hearts.<sup>186,187</sup> It can be treated using either verapamil or β-blockers. If symptoms are intolerable or haemodynamic compromise occurs, then catheter ablation should be considered.<sup>186</sup>
    - In women with the congenital long QT syndrome, the risk of cardiac arrest is greater during the postpartum period compared with before or during pregnancy. β-blocking agents should be administered during pregnancy and postpartum.<sup>186</sup>

# Management of Pregnancy in Specific Cardiac Disease

- Bradyarrhythmias and conduction disturbances due to sinus node dysfunction and atrioventricular blocks are rare during pregnancy.<sup>181,183</sup> Asymptomatic brady-arrhythmias however, may become symptomatic due to the demands of a higher heart rate and cardiac output in patients with cardiac disease.

IIa, B

- Bradyarrhythmias usually have a favourable outcome.
- Most women with stable asymptomatic complete heart block who do not require a permanent pacemaker before delivery, can be safely managed during labour without temporary pacing.<sup>191</sup>
- If indicated, the risks of permanent pacemaker implantation are generally low. These are preferably implanted in the 2<sup>nd</sup> trimester with abdominal lead shielding.

## • Usage of anti-arrhythmic drug therapy:

- Digoxin can be used to control ventricular rate but has no prophylactic antiarrhythmic effect.
- I, C
- β-blocking agents, class I antiarrhythmic drugs and sotalol should be used with caution if the LV or RV function is impaired.
  - Atenolol should be avoided.<sup>192,193</sup>
- III, C
- AV nodal blocking agents should not be used in patients with manifest pre-excitation on resting ECG. (Wolff-Parkinson White Syndrome)
- III, C
- Amiodarone should be used only when other therapies have failed and then at the lowest effective dose. Amiodarone's adverse effects on the fetus include hypothyroidism, FGR and premature delivery. Newborns of mothers who had received amiodarone should be admitted for paediatric review.
- IIb, C

## 4.7.2 Preconception counselling

The risk related to arrhythmias is highest in mothers with:

- known cardiac disease especially CHD
- established arrhythmias including some of the inherited arrhythmias such as long QT

These women who are in the childbearing age should be screened for risk of arrhythmias and conduction defects. The counselling should include the risk of antiarrhythmic drugs on the fetus and mother.

The presence of cardiac pacemakers and implantable cardioverter defibrillator do not itself contraindicate future pregnancy.

# Management of Pregnancy in Specific Cardiac Disease

## 4.7.3 Antenatal care

All pregnant women with complaints of palpitations or dizziness should undergo a detailed clinical assessment to identify the nature of the arrhythmia. Investigations should include:

- Blood tests – full blood count, renal function, electrolytes and thyroid function test
- ECG
- Telemetry or Holter monitoring and
- Echocardiogram

## 4.7.4 Labour and delivery

I, C All sustained arrhythmias with haemodynamic compromise should be electrically cardioverted.

I, C Temporary pacing (preferably transvenous) during delivery is recommended in the presence of symptomatic complete heart block.

## 4.7.5 Postpartum care

Patients with symptoms due to recurrent arrhythmias should be referred for catheter ablation.

### Key Messages:

- Cardiac arrhythmias are common in pregnancy.
- Most of them are benign and self-limiting and do not require treatment.

# Management of Pregnancy in Specific Cardiac Disease

## 4.8 Heart failure in pregnancy

The treatment of heart failure (HF) in pregnant women is more difficult than in non-pregnant women, and should always involve a multidisciplinary team approach.<sup>194</sup> The HF may develop for the first time in pregnancy or pregnancy may occur in a patient who had HF previously and still has a depressed myocardial function. (LVEF < 40%).

Common causes for the development of new onset HF in pregnancy are:

- Decompensation in a patient with known cardiac disease due to the stress of the pregnancy
- Peripartum cardiomyopathy or other cardiomyopathies (section 4.6, pg. 100)

### 4.8.1 Preconception counselling

Patients with LVEF < 30% and those in NYHA Class III and IV should be strongly advised not to get pregnant.<sup>13</sup> If pregnant, termination should be considered. (Table 1A, 1B & 2, pg. 18-21)

### 4.8.2 Antenatal care

The principles of management of HF in pregnancy are similar to that in the non-pregnant state and as outlined in the 3<sup>rd</sup> Ed Malaysian CPG on Management of Heart Failure.<sup>164</sup> There are however a few exceptions:

- Diuretics are the first line therapy in patients who are fluid overloaded
- Nitrates and/or Hydralazine are used for preload and afterload reduction
- β-blockers can be used cautiously
- Digoxin is safe in pregnancy
- Angiotensin Converting Enzyme Inhibitors (ACE-I) and Angiotensin Receptor Blockers (ARB) are contraindicated in pregnancy. ACE-I (enalapril and captopril) can be used in the postpartum period.
- Ivabradine should not be used in pregnancy
- Spironolactone is best avoided (FDA Category C) in pregnancy and during breast feeding

I, B
IIa, B
I, B
I, C
III, C

III, C
III, C

### 4.8.3 Labour and delivery

Timing and mode of delivery should be carefully planned by the multidisciplinary team. In the majority of patients, vaginal delivery with epidural anaesthesia is the preferred mode of delivery.

# Management of Pregnancy in Specific Cardiac Disease

## 4.8.4 Postpartum care

After delivery, careful monitoring of haemodynamic status should be done for at least 24 h, or longer in high risk patients. In patients with severe cardiac lesions, haemodynamics may be abnormal up to 10 days after delivery.

**I, C** These patients should be evaluated postpartum to assess the need for corrective surgery.

**I, C** The risk of recurrence of HF in subsequent pregnancies should also be made known to the patient (section 4.6.1.1, pg. 101).

Follow-up visit at 6 weeks postpartum should be attended by the multidisciplinary team, a full cardiac assessment should be done, and appropriate contraception should be advised.

### Key message:

- Patients with LVEF < 30% and those in NYHA Class III and IV should be strongly advised not to get pregnant.
- Heart failure that develops during pregnancy can be managed with the judicious use of diuretics, digoxin, nitrates,  $\beta$ -blockers and/or hydralazine.

# Management of Pregnancy in Specific Cardiac Disease

## 4.9 Anticoagulation in pregnancy

### 4.9.1 Indications for anticoagulation

The general indications are:

- Mechanical heart valves
- Atrial fibrillation
- Eisenmenger syndrome – (use with caution-may have bleeding diathesis)
- Pulmonary arterial hypertension
- Congenital heart disease – cyanotic heart disease, Fontan circuit
- Previous history/current history of thromboembolic disease
- Hypercoagulable states – e.g. antiphospholipid syndrome

Management of these patients will vary depending upon the indication.

#### 4.9.1.1 Mechanical heart valves

Prosthetic valve thrombosis is a rare complication with an estimated incidence of 0.1-5.7% per patient year.<sup>195</sup> During pregnancy, this risk is much higher (as high as 10%) due to the prothrombotic state.<sup>196,197</sup> Changes in drug metabolism may also affect control of INR compared to the non-pregnant state.

There is no optimal anticoagulation regimen during pregnancy for patients with mechanical heart valves because every therapeutic option has its drawbacks. Anticoagulant regimens in pregnant patients with prosthetic heart valves are associated with similar risks of maternal bleeding but with different embolic risks.

The goal of anticoagulation in a patient with mechanical heart valve(s) is to prevent valve thrombosis which is a lethal event for both the mother and the fetus. The risk of prosthetic valve thrombosis is lowest (< 4%)<sup>198</sup> in patients receiving oral anticoagulants (OAC) and greatest in those receiving subcutaneous unfractionated heparin (UFH) throughout the pregnancy (up to 33%).<sup>199</sup> It is about 5-10% in those patients receiving unfractionated heparin (UFH) in the first trimester and OAC in the 2<sup>nd</sup> and 3<sup>rd</sup> trimesters.<sup>199</sup>

All anticoagulation regimens also carry an increased risk of fetal teratogenicity, fetal wastage, miscarriage and haemorrhagic complications.<sup>196,198,200-207</sup> Bleeding complications include:

- Retroplacental bleeding leading to premature birth or fetal death.
- Intracranial bleeding in the fetus during vaginal delivery if the mother is on OAC as warfarin can cross the placenta.

# Management of Pregnancy in Specific Cardiac Disease

The fetal risks are higher with OAC than with the use of heparin based therapies.

In a contemporary study of 212 women with mechanical heart valves, the maternal mortality was 1.4% and pregnancy loss was 18.4%. Valve thrombosis occurred in 4.7% and haemorrhagic complications in 23.1% of the pregnancies. Overall, serious complications occurred in 42% of pregnancies in women with mechanical heart valves compared to 21% with tissue valves.<sup>208</sup>

In patients with mechanical heart valves, management is as follows:

- Preconception counselling is mandatory. The following issues should be addressed:
  - Risk of warfarin embryopathy during the 1<sup>st</sup> trimester.<sup>200,207</sup>
  - Risk of valve thrombosis with heparin based therapy-both UFH and low molecular weight heparin (LMWH).<sup>196,198,203-206</sup> Valve thrombosis is a potentially lethal event for the mother.
  - If UFH is chosen for bridging in the 1<sup>st</sup> trimester, this should be given intravenously. The patient would thus have to stay in hospital till week 12 of gestation. The patient and family should prepare themselves for this.
  - Subcutaneous UFH is not advisable in our local setting due to the difficulty in monitoring and adjustment of dose. Subcutaneous UFH heparin is associated with high thrombotic risk.<sup>198,209</sup>
  - If subcutaneous UFH heparin is used, large doses (12,500-15,000 units bid) are necessary. It should be given 12 hourly and the dose adjusted to achieve a mid- interval (6 hours after last dose) aPTT of 2 x control or anti-Xa heparin level of 0.35-0.7 unit/ml.<sup>210</sup>
  - LMWH is a potential option only if factor anti-Xa levels can be monitored and the patient is managed in centres with experience. If monitoring of anti-Xa levels cannot be done, LMWH should not be used.
  - If LMWH is chosen, the timely monitoring of anti-factor Xa levels should be easily available.<sup>196,202,206</sup> Despite therapeutic anti-Xa levels valve thrombosis may still occur.<sup>206</sup> Unresolved questions still exist regarding the optimal anti-Xa levels, the importance of peak vs. pre-dose levels, and the best time intervals for anti-Xa monitoring.<sup>1</sup> During the initial up-titration phase, the patient needs to be admitted until an appropriate dose has been determined.

IIb, C

IIb, C

# Management of Pregnancy in Specific Cardiac Disease

III, C

- LMWH should not be dosed according to weight.
  - The identification and availability of services in the patient's locality for monitoring therapeutic levels of UFH/ LMWH should be confirmed prior to conception.
  - Ideally a haematologist should be involved in the management.
  - Risks and benefits of continuing warfarin throughout pregnancy as against heparin bridging in the first trimester.<sup>198,208</sup>
  - The patients' and family's preferences should be clearly documented.
- Once pregnancy is confirmed, the patient should be seen and followed-up as per pregnancy care plan on pg. 29.

Studies consistently show that if warfarin is used in the 1<sup>st</sup> trimester there is a lower rate of valve thrombosis but higher fetal losses.<sup>198,208</sup> With heparin based therapy in the 1<sup>st</sup> trimester, the reverse occurs.<sup>198,208</sup> In a contemporary study, half of the valve thrombosis occurred in the 1<sup>st</sup> trimester and almost all were in patients who were on heparin based therapy.<sup>208</sup>

I, C

Anticoagulation regimes in these patients with **mechanical heart valves** should be individualised based on the patients' preferences, maternal and fetal risk.

Suggested regimes:

- Warfarin throughout pregnancy up till 36 weeks
- Warfarin in the 2<sup>nd</sup> and 3<sup>rd</sup> trimester up to 36 weeks with heparin bridging in the first trimester
- Low dose aspirin (75-100 mg) daily can be added to warfarin or heparin throughout pregnancy especially in patients with first generation heart valves.<sup>82,203,210</sup>

## Anticoagulation Regimes in the 1<sup>st</sup> Trimester:

### Regime A:

IIa, C

Warfarin throughout pregnancy:

- If dose of warfarin is > 5 mg/day, there may be potential fetal adverse events.<sup>201</sup> A daily dosage > 5 mg was a significant predictor of poor pregnancy outcomes.<sup>201,211</sup>
- If the warfarin dose ≤ 5 mg - the risk of embryopathy is low.<sup>211</sup>

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## Regime B:

**IIb, C** Bridging heparin therapy in the 1<sup>st</sup> trimester:

- Intravenous dose adjusted UFH with regular aPTT monitoring which should be kept at > 2x control<sup>209</sup> **OR**
- Self-injected adjusted-dose LMWH with monitoring at regular intervals at the discretion of the attending physician/cardiologist/haematologist:
  - The target anti-Xa levels 4-6 hours post dose is 0.8–1.2 U/mL.<sup>1,202,206</sup>
  - The target trough levels should be  $\geq$  0.7 U/mL.<sup>212</sup>
  - The dose should be closely monitored and adjusted weekly as the weight of the patient increases during pregnancy.<sup>205,213-215</sup>
  - The timely monitoring of anti-factor Xa levels should be easily available.<sup>196,202,206</sup> Despite therapeutic anti-Xa levels valve thrombosis may still occur.<sup>206</sup> Unresolved questions still exist regarding the optimal anti-Xa levels, the importance of peak vs. pre-dose levels, and the best time intervals for anti-Xa monitoring.<sup>1</sup>
  - During the initial up-titration phase, the patient needs to be admitted to hospital until an appropriate dose has been determined.

Patients at higher risk of valve thrombosis include:

- First generation mechanical heart valves (Starr Edwards, Bjork-Shiley)<sup>204</sup>
- Double mechanical valve replacement
- Mechanical valve in the mitral position with AF
- History of valve thrombosis despite anticoagulation

**IIa, B** Warfarin throughout pregnancy up to 36 weeks (Regime A) is advocated in all high-risk patients with mechanical valves, considering the risk : benefit ratio.

- IIa, C** At 36 weeks, the patient and warfarin should be switched to LMWH or IV UFH
- IIa, C** • Women on LMWH should be switched to IV UFH at least 36 hours before induction of labour or caesarean section.
- IIa, C** • IV UFH should be discontinued 4-6 hrs before planned delivery and restarted 4-6 hours after vaginal delivery and 6-12 hours after LSCS if there are no bleeding complications.<sup>153,209,216</sup>
- I, C** • Oral anticoagulation can be resumed after 24 hours if there are no bleeding concerns.<sup>209,216</sup>

# Management of Pregnancy in Specific Cardiac Disease

If labour begins while the patient is still on warfarin, then LSCS should be performed after appropriate correction of anticoagulation with blood products. This is because of the risk of intracranial bleeding during vaginal delivery.

Bilateral tubal ligation should be offered with proper counselling if these patients are going for LSCS.

## 4.9.1.2 Anticoagulation for other indications

The choice of therapeutic anticoagulation for other indications would depend upon the risk of thrombosis, patients' preference and the consensus of the multidisciplinary team. Either:

- IIb, C Regime A – warfarin throughout pregnancy till 36 weeks
- IIa, C Regime B – UFH/LMWH therapy in the first trimester

IIb, C Depending on the indication(s) (e.g. Venous thrombosis embolism, non valvular AF) and the risk of thrombosis, LMWH may be given as a weight based regime without anti-Xa monitoring.<sup>51,189,216,217</sup>

IIa, C In patients where the risk of thrombosis is high (e.g. PH due to thromboembolic disease, recent pulmonary embolism, valvular AF) Regime A (warfarin throughout pregnancy till 36 weeks) is advocated.

IIa, C If Regime B – bridging therapy with LMWH in the 1<sup>st</sup> trimester is chosen – then efforts should be taken to monitor anti-Xa levels.

If AF should occur for the first time in patients with valvular heart disease, immediate anticoagulation with UFH is advised.

Both warfarin and heparin based therapy are safe during breast feeding.<sup>210</sup>

## 4.9.2 Management of valve thrombosis in pregnancy

Any pregnant patient with a mechanical heart valve presenting with dyspnoea or an embolic event requires an urgent echocardiogram and/or transoesophageal echocardiography or fluoroscopy (with lead shielding of the abdomen) if needed, to make the diagnosis.

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Management includes:<sup>74</sup>

- Stable patients
  - Fibrinolysis (streptokinase without heparin or TPA followed with heparin)
  - Anticoagulation needs to be optimised with intravenous heparin infusion and aPTT monitoring and resumption of OAC.
- Unstable patients
  - Surgery is indicated
  - If surgery is not available, fibrinolysis may be considered as an option

## Key Messages:

- In pregnant patients, the choice of anticoagulation regime has to be individualised depending upon the maternal and fetal risk and patient preferences.
- In patients with **mechanical heart valves**, we advocate:
  - Warfarin throughout pregnancy till 36 weeks.
  - At 36 weeks, patients should be switched to IV UFH or LMWH.
  - If patient is on LMWH, anti-Xa levels should be monitored regularly.
  - If patient is on IV UFH, aPPT levels should be maintained at 2x normal.
  - Subcutaneous UFH is not recommended.
  - Patients who are on LMWH should be switched to IV UFH at least 36 hours before planned delivery.
- In patients who are being **anticoagulated for other indications**, the choice of anticoagulation would depend upon the risk of thrombosis, patients' preference and the consensus of the multidisciplinary team. The options include:
  - Regime A: warfarin throughout pregnancy till 36 weeks and then switched to IV UFH or LMWH.
  - Regime B: Heparin based therapy in the 1<sup>st</sup> trimester and then warfarin in the 2<sup>nd</sup> and 3<sup>rd</sup> trimester till 36 weeks.
  - At 36 weeks, patients should be switched to IV UFH or LMWH.
  - Patients who are on LMWH should be switched to IV UFH at least 36 hours before planned delivery.
- IV UFH should be discontinued 4-6 hours before planned delivery and restarted 4-6 hours after vaginal delivery and 6-12 hours after LSCS if there are no bleeding complications.
- Oral anticoagulation can be resumed after 24 hours if there are no bleeding concerns.

# Management of Pregnancy in Specific Cardiac Disease

## 4.10 Infective endocarditis in pregnancy

Infective endocarditis (IE) during pregnancy is rare,<sup>219,220</sup> but the maternal mortality rate has been reported to be as high as 33%, with a fetal mortality of 29%.<sup>220</sup> However, the prognosis has been improving over time. Currently, the maternal mortality ranges about 10.5-11.5%, but the fetal mortality still persists at 14.3%.<sup>221</sup>

### 4.10.1 Aetiology

Worldwide, there has been a decrease in rheumatic heart disease as an underlying cardiac risk factor. Survivors of CHD and intravenous drug users are now an increasing risk factor associated with endocarditis.<sup>221</sup> In Malaysia, as data is sparse, we can only postulate that rheumatic heart disease is still a significant underlying condition for the occurrence of IE. The most commonly identified pathogens are still streptococci and staphylococci. The mitral valve is still the commonest valve involved in IE. Most cases (about 75%) occur during the second and third trimester.<sup>222</sup>

### 4.10.2 Management

**I, C** Treatment for IE in pregnancy is similar to the non-pregnant state with multidrug regimes. Please refer to the National Antibiotic Guidelines (2014) of the Ministry of Health, Malaysia for current antibiotic recommendations.<sup>223</sup> Surgical intervention has been reported in about 50% of cases, mostly occurring after delivery.<sup>221,222</sup> The timing of surgery is usually delayed until the infection has been eradicated.<sup>224</sup> Most common indications for surgery are:

- congestive heart failure,
- refractory sepsis,
- embolic complications and vegetation size, or
- a combination of the above factors.

Wherever possible, cardiac operations should be deferred until after 28 weeks due to possible risks of fetal death related to immaturity.<sup>225</sup>

### 4.10.3 Prophylaxis

**IIa, C** International guidelines do not advocate the use of routine antibiotic prophylaxis for normal vaginal delivery. They advocate that antibiotic prophylaxis be restricted to high risk patients such as:<sup>226</sup>

- Prosthetic cardiac valves/ material
- Previous history of bacterial endocarditis
- Complex cyanotic congenital heart disease (operated or un-operated)

# Management of Pregnancy in Specific Cardiac Disease

**I, c** In all other women with structural cardiac disease, the risk and benefits of antibiotic prophylaxis against IE should be discussed with the patient (serious nature of IE and the low risk of anaphylaxis).

The antibiotic prophylaxis regimes against IE are as follows:

- Ampicillin 2 g IV and gentamycin 1.5 mg/kg IV<sup>209</sup>
- Vancomycin 1 g IV over 1-2 hrs along with Gentamycin IV (if penicillin allergy)

The first dose of antibiotic should be given at:

- rupture of membranes for vaginal delivery or
- 15 to 60 minutes prior to skin incision for caesarean section<sup>227</sup>

The second dose of antibiotics should be given 6 hours after the first dose<sup>209</sup>.

## Key message:

- Antibiotic prophylaxis is advocated to high risk patients such as:
  - Prosthetic cardiac valves/ material
  - Previous history of bacterial endocarditis
  - Complex cyanotic congenital heart disease (operated or un-operated)

# Management of Pregnancy in Specific Cardiac Disease

## 4.11 Hypertension in pregnancy

### 4.11.1 Definition

Definition of Hypertension:

Hypertension in pregnancy is defined as:

- BP of  $\geq 140/\geq 90$  mmHg taken after a period of rest on two occasions.<sup>228-230</sup>

A rise of systolic blood pressure (SBP) of 30 mmHg and/or a rise in diastolic blood pressure (DBP) of 15 mmHg compared to pre-pregnancy levels should raise concerns for careful follow-up.<sup>231,232</sup>

**I, C** The Korotkov phase V (disappearance of the blood flow murmur) is the correct means of measuring DBP in pregnancy. If the DBP according to this means is zero (up to 15%), then the Korotkov sound IV (the quietening of the blood flow murmur) should be used.<sup>228</sup> If phase IV is used, this should be carefully noted in the clinical records to avoid confusion in future.

Classification of HDP:<sup>228-230</sup>

- Pregnancy Induced Hypertension (PIH) - Hypertension after the 20<sup>th</sup> week of pregnancy in a previously normotensive woman in the absence of multiple pregnancy or molar pregnancy. It may be associated with proteinuria. The condition is expected to return to normal after the puerperium.
  - Gestational Hypertension (GH) – PIH without proteinuria
  - Pre-eclampsia (PE) – PIH with proteinuria
  - Eclampsia – PIH with convulsions
  - HELLP syndrome – severe PE with haemolysis, elevated liver enzymes and low platelet count.
- Chronic Hypertension – This includes essential and secondary hypertension. There is pre-existing hypertension prior to conception, or it is diagnosed before week 20 of gestation or late in the gestational stage with the increase in blood pressure persisting postpartum.
- Chronic Hypertension with superimposed pre-eclampsia.

Proteinuria is defined as:

- > 300 mg of protein in a 24-hour period
- 1 gm/L or more in two randomly collected urine samples 6 hours apart or
- a spot urine protein/ creatinine ratio of > 30 mg/mmol<sup>228</sup>

# Management of Pregnancy in Specific Cardiac Disease

Semiquantitative assessment of proteinuria using dipstix is convenient and has collaborated well with maternal outcome. If a result of 1+ or more is obtained, use a spot urinary protein: creatinine ratio or 24-hour urine collection to quantify proteinuria.<sup>228</sup>

Recently the International Society for Study of Hypertension in Pregnancy (ISSHP) have come up with a revised classification for hypertensive disorders in pregnancy as follows:<sup>40</sup>

1. Chronic hypertension.
2. Gestational hypertension (GH)
  - This can progress to pre-eclampsia in about 25% of cases, especially when the hypertension presents before 32 weeks.
3. Pre-eclampsia – de novo or superimposed on chronic hypertension.
4. White coat hypertension.
  - The prevalence is estimated to be about 1 in 3 to 4 patients.<sup>233,234</sup>
  - The diagnosis is confirmed by demonstrating normal BP using 24 hour ambulatory BP monitoring (ABPM) in the first half of pregnancy.
  - It is reasonable to withhold antihypertensive therapy in this group.
  - Up to half of these patients will develop true gestational hypertension or pre-eclampsia.<sup>233</sup>
  - Thus increased surveillance using home BP measurements or BP checked by a healthcare personnel other than the doctor.

The revised definition of preeclampsia is as follows:<sup>40</sup>

Hypertension developing after 20 weeks gestation and the coexistence of one or more of the following new onset conditions:

1. Proteinuria
2. Other maternal organ dysfunction:
  - renal insufficiency (creatinine > 90 umol/L)
  - liver involvement (elevated transaminases and/or severe right upper quadrant or epigastric pain)
  - neurological complications (examples include eclampsia, altered mental status, blindness, stroke, or more commonly hyperreflexia when accompanied by clonus, severe headaches when accompanied by hyperreflexia, persistent visual scotomata)
  - haematological complications (thrombocytopenia, DIC, haemolysis)
3. Uteroplacental dysfunction fetal growth restriction

# Management of Pregnancy in Specific Cardiac Disease

## 4.11.2 Antepartum care

For a detailed account please refer to the Training Manual on Hypertensive Disorders in Pregnancy, 2014 produced by the Family Health Division, Ministry of Health, Malaysia.<sup>229</sup>

**I, A** Pregnant women who are at increased risk of pre-eclampsia should be offered aspirin 75 mg daily from 12 weeks gestation till delivery. Women are at increased risk of pre-eclampsia if they have 1 high risk factor or  $\geq 1$  moderate risk factor.<sup>235</sup>

**High Risk Factors** include:

- Hypertensive disease in a previous pregnancy
- Chronic kidney disease
- Auto-immune disease such as systemic lupus syndrome or anti-phospholipid syndrome
- Type 1 or 2 diabetes mellitus
- Chronic hypertension

**Moderate Risk Factors** include:

- First pregnancy
- Age  $\geq 40$  years
- Pregnancy interval of  $> 10$  years
- Body mass index  $\geq 35 \text{ kg/m}^2$  at first visit
- Family history of pre-eclampsia
- Multiple pregnancy

**IIa, B** The benefit of calcium supplementation appears mixed. An earlier review showed that calcium supplementation significantly reduced pre-eclampsia especially in women with low calcium diets and at high risk of pre-eclampsia.<sup>236,237</sup> A more recent review suggested no clear additional benefits in the prevention of preterm birth or low infant birthweight.<sup>238</sup>

**I, B** In the treatment of hypertension in pregnancy, the aim is to keep the Systolic BP  $< 150 \text{ mmHg}$  and the diastolic BP 80-100 mmHg.<sup>228,229</sup> It is important not to lower BP below the stated lower limits as this may be associated with poor placental perfusion.<sup>40</sup>

Commonly used oral and parenteral anti-hypertensive drugs in pregnancy are as listed in Tables 15 & 16, pg. 127-128.

# Management of Pregnancy in Specific Cardiac Disease

**I, B** In patients already on anti-hypertensive medications pre-pregnancy, the following drugs need to be changed to the recommended drugs listed in Tables 15 & 16, pg. 127-128:

- atenolol
- angiotensin converting enzyme inhibitors (ACE-I)
- angiotensin receptor blockers (ARB)
- thiazide diuretics

These drugs have been associated with impaired fetal growth and fetal anomaly and therefore contraindicated in pregnancy.<sup>228</sup> The data on diltiazem, verapamil and amlodipine are inadequate to provide reliable information on their efficacy and safety in the treatment of hypertension in pregnancy.<sup>239</sup>

Acute onset severe hypertension (systolic BP  $\geq$  160 mmHg and diastolic BP  $\geq$  110 mmHg) that persists for longer than 15 mins is called a hypertensive crisis.<sup>226</sup>

**I, B** First line acute treatment includes:<sup>228</sup> (Table 16, pg. 128)

- IV labetolol
- IV hydralazine<sup>240</sup>
- Oral nifedipine - 10 mg orally without biting to a maximum of 30 mg. (Should not be given sublingually due to rapid onset of action)<sup>241</sup>

In these patients, the goal is not to normalise the BP, but to achieve a range of 140–150/90–100 mmHg.<sup>242</sup>

## 4.11.3 Labour and delivery

**I, B** Women with chronic hypertension, gestational hypertension or white-coat hypertension should be delivered no later than 40 weeks and earlier if there is inability to control maternal blood pressure or if pre-eclampsia develops.<sup>40</sup>

**I, B** Women with pre-eclampsia  $>$  37 weeks gestation should be delivered.<sup>40,243</sup>

## 4.11.4 Postpartum care

Following delivery:<sup>228</sup>

- Continue the same antenatal anti-hypertensive medications.
- Methyldopa should be stopped within 2 days following delivery to avoid the risk of depression.
- Consider reducing the dose of medications if BP  $<$  140/ $<$  90 mmHg.
- Reduce anti-hypertensive medications if BP falls below 130/80 mmHg.

# Management of Pregnancy in Specific Cardiac Disease

- Consider starting anti-hypertensive medications if the patient did not have GH and the BP > 149/ > 99 mmHg.
- I, c • If the patient still requires anti-hypertensive medications at the end of 2 weeks, she should be referred to a Physician/FMS for review.
- Women with GH or pre-eclampsia should:
  - discuss future pregnancy/fertility during their post-natal visit.
  - have their BP monitored regularly as there is an increased risk of developing hypertension in the future.

I, B The following drugs are safe during breast feeding:<sup>239</sup>

- Labetolol
- ACE-I: enalapril, captopril
- β-blockers: atenolol, metoprolol
- Nifedipine

The safety of the following drugs has not as yet been established during breast feeding:<sup>228</sup>

- ACE-I other than enalapril and captopril
- ARBs
- Amlodipine

IIa, c Diuretic therapy for the treatment of hypertension should be avoided during breast feeding and milk expression.

## Key messages:

- Hypertension in pregnancy is defined as BP of  $\geq 140/\geq 90$  mmHg taken after a period of rest on two occasions.
- The aim is to keep the Systolic BP  $< 150$  mmHg and the diastolic BP 80-100 mmHg.
- The definition of preeclampsia has been revised in the latest International Society for Study of Hypertension in Pregnancy (ISSHP) 2014.
- Women with pre-eclampsia  $> 37$  weeks gestation should be delivered.

# Management of Pregnancy in Specific Cardiac Disease

**Table 15: Oral Anti-hypertensive Drugs Commonly Used in Pregnancy\***

Drug	Mode of Action	Daily Dosage (mg/day)	Max. Dosage (mg/day)	Half-life T <sub>1/2</sub> (hours)	Adverse Effects
Methyldopa	Centrally-acting (false transmitter precursor)	250-1000 mg in 2-3 divided doses	3000	1.8	Depression, drowsiness, lupus-like syndrome, blood dyscrasias, liver dysfunction
Labetolol	α & β-blocker	200-800 mg in 2-3 divided doses	2400	4	Complete heart block, pulmonary oedema, bronchoconstriction
Nifedipine** (extended release)	Ca-channel blocker	30-60 mg daily	120		Headaches, flushing

\*Adapted from:

- Training Manual on Hypertensives Disorders in Pregnancy, 2014, Division of Family Health Division, Ministry of Health, Malaysia.
- Hypertensive Disorders in Pregnancy. Guideline Summary. New York State Department of Health, May 2013.

\*\* Short acting nifedipine is not recommended for maintenance therapy due to the risk of hypotension.

# Management of Pregnancy in Specific Cardiac Disease

**Table 16: Parenteral Anti-hypertensive Drugs Commonly Used in Pregnancy\***

Drug	Dosages
Labetolol	For rapid control <ul style="list-style-type: none"><li>• IV Labetolol 10 mg over 1 minute and repeat at 5 minute intervals (Maximum dose: 200 mg (40 mls))</li><li>• Effective dose: 20-150 mg/hr (4-30 mls/hr)</li><li>• Infusion syringe pump<ul style="list-style-type: none"><li>➢ Put 200 mg Labetolol in 50 mls syringe and start at 20 mg/hr i.e. 20 mg or 4 mls/hr and increase at 30 minutes.</li><li>➢ Stop infusion if rate exceeds 150 mg/hr (30 mls/hr) and inform specialist.</li></ul></li></ul>
Hydralazine	For rapid control: <ul style="list-style-type: none"><li>• IV bolus 6.25 mg over 20 minutes and repeat every 20 minutes only if DBP &gt; 90 mmHg (1-10 mg/hr infusion is preferred)</li></ul> Maintenance Dose <ul style="list-style-type: none"><li>• Effective dose: 1-10 mg/hr</li><li>• Infusion Pump<ul style="list-style-type: none"><li>➢ Dilute 50 mg Hydralazine in 50 mls Normal saline i.e. 1 mg/ml and start at 5 mls/hr.</li><li>➢ Increase every 20 minutes by 1 ml/hr until maximum dose of 10 mls/hr or 10 mg/hr.</li></ul></li><li>• Infusion Drip Set<ul style="list-style-type: none"><li>➢ Dilute 20 mg Hydralazine in 500 mls Normal Saline and start at 10 dpm.</li><li>➢ Increase every 20 minutes at 10 dpm to titrate against blood pressure so as to maintain at 140/90 mmHg.</li></ul></li></ul>
Nitroglycerine**	For rapid control and maintenance dose: <ul style="list-style-type: none"><li>• Infusion rate: 5-100 ug/min<ul style="list-style-type: none"><li>➢ Put 50 mg in 50 mg syringe and start at 5 ug/min (0.3 mls/hour) and titrate at 15 minute intervals until the desired Systolic BP is achieved.</li><li>➢ Maximum dose: 100 ug/min (6 mls/hour)</li></ul></li></ul>
Nicardipine	For rapid control: <ul style="list-style-type: none"><li>• IV bolus 10–30 mcg/kg over 1 minute</li></ul> For maintenance: <ul style="list-style-type: none"><li>• IV Infusion: 2–10 µg/kg/min</li></ul>
Sodium Nitroprusside	This is not advisable in pregnancy due to the risk of thiocyanate and cyanide toxicity.

\*Adapted from:

- *Training Manual on Hypertensives Disorders in Pregnancy, 2014, Division of Family Health Division, Ministry of Health, Malaysia*
- *4<sup>th</sup> Ed Malaysian CPG on Hypertension*.

\*\*Limited data on the use of IV nitroglycerin in pregnancy

# Management of Pregnancy in Specific Cardiac Disease

## 4.12 Diabetes mellitus in pregnancy

Pregnant patient with diabetes may have:

- diabetes prior to conception
- gestational diabetes (GDM) – defined as any degree of glucose intolerance which is first recognised during pregnancy, whether or not the condition persisted after pregnancy.

This topic is covered in depth in the Malaysian CPG Management of Diabetes Mellitus 2015, 5<sup>th</sup> Ed.<sup>244</sup>

### 4.12.1 Preconception counselling

I, C

- Women with diabetes who receive preconception counselling have better preconception glycaemic control and are more likely to have favourable pregnancy outcomes.
- Pregnancy has to be planned and to occur only when the woman has a good glycaemic control, has had appropriate assessment and management of comorbidities and diabetic complications (such as retinopathy and nephropathy).

I, B

- Keep the A1c as normal as possible – preferably < 6.5%<sup>245</sup>.
- Weight reduction in those obese and overweight.
- The BP control should be < 130/80 mmHg.
- Medications that are unsafe in pregnancy - statins, ACE-I, ARB - should be withdrawn. Anti-hypertensives that are safe in pregnancy (section 4.11, pg. 122) should be substituted.
- Insulin therapy should be considered if the blood glucose targets are not met 1-2 weeks after introducing changes to diet and initiating exercise.
- Women on oral hypoglycaemic can be switched to insulin for a better glycaemic control before planning pregnancy.
- Insulin treated women should be on multiple daily doses (basal-bolus) of insulin.

I, B

### 4.12.2 Antepartum

- Women who are at risk, should be screened for GDM at booking (Table 17, pg. 130).
- "Universal screening" for GDM is being advocated for all other pregnant women at 24-28 weeks.
- Screening is done using the 75-g OGTT.
- A repeat OGTT, 4–6 weeks later, should be performed in those whose initial OGTT results are normal.

# Management of Pregnancy in Specific Cardiac Disease

- The blood glucose targets in pregnancy are in Table 18, pg. 130. The treatment targets are lower than those used for diagnosis of GDM.<sup>244,245,246</sup>

**Table 17: Diagnostic Criteria for Overt Diabetes and GDM by OGTT at 24 to 28 Weeks Gestation\***

Diagnosis	FBG (mmol/L)	2 Hour Value (mmol/L)
GDM	≥ 5.1	≥ 7.8

\*From the International Federation of Gynecology and Obstetrics (FIGO) Initiative on gestational diabetes mellitus: A pragmatic guide for diagnosis, management, and care. *Int J Gynaecol and Obstet* 2015; 131 (Suppl 3): S173-211

**Table 18: Blood Glucose Targets in Pregnancy**<sup>245,246</sup>

	Target Value (mmol/L)
Pre-prandial blood glucose	≤ 5.3
1 hour after the start of a meal	≤ 7.8
2 hours after the start of a meal	≤ 6.7

## 4.12.3 Postpartum

- Insulin requirement drops immediately after delivery by 60-75%.
- If glycaemic control is inadequate with diet therapy alone, consider appropriate therapy.
- Those whose blood sugar normalised immediately after delivery should have a modified OGTT performed 6 weeks later.
- Women with a history of GDM should have annual screening for diabetes.

I, C

### Key messages:

- Women at risk should be screened for GDM.
- Women with a history of GDM should have annual screening for diabetes.

# Management of Pregnancy in Specific Cardiac Disease

## 4.13 Venous Thromboembolism in Pregnancy

Venous thromboembolism (VTE) occurs in 1 in 500 to 1 in 2000 pregnancies.<sup>51</sup> This is about 4-5 times higher than in the non-pregnant state.<sup>247,248</sup> In women with previous VTE, the recurrence rate per 100 patient-years could be as high as 11%.<sup>249</sup> It was one of the leading direct causes of maternal deaths in Malaysia for the year 2008.<sup>51</sup>

The 2 manifestations of VTE are deep venous thrombosis (DVT) and pulmonary embolism (PE). The sequelae of VTE are pulmonary hypertension, post-thrombotic syndrome and venous insufficiency.

This topic of VTE in pregnancy is covered in depth in the Malaysian CPG Prevention and Treatment of Venous Thromboembolism, 2013, 1<sup>st</sup> Ed.

VTE in pregnancy is more common:

- In the postpartum period than antepartum – In one study, the risk of VTE and PE was 5-fold and 15-fold, respectively, in the postpartum period compared to during pregnancy.<sup>247</sup>
- After LSCS than with vaginal delivery - It is twice as common after LSCS.<sup>250</sup>
- In the left than in the right leg - It is postulated that this is due to the May-Thurner syndrome, in which the left iliac vein is compressed by the right iliac artery.<sup>251</sup>
- In the pelvic veins than in the calf veins - 12% of DVTs in pregnancy are in the pelvic veins as compared to only 1% of DVTs in the general population.<sup>252</sup>

The risk factors for VTE in pregnancy and the puerperium are as listed in Appendix I, pg. 160. The more common risk factors are:<sup>253</sup>

- Normal physiological changes of pregnancy such as the hypercoaguable state, venous stasis and vascular endothelial damage during delivery<sup>254</sup>
- Previous history or family history of VTE
- Thrombophilias
- Older age > 35 years of age
- Obesity  $BMI \geq 30 \text{ kg/m}^2$
- Gross varicose veins

# Management of Pregnancy in Specific Cardiac Disease

- Smoking
- Parity  $\geq 3$
- Maternal cardiac disease

Cardiac patients who are at higher risk of VTE include those with:

- Eisenmenger Syndrome and other forms of cyanotic heart disease
- Heart failure who are sedentary and lying in bed most of the time

## 4.13.1 Diagnosis

The clinical diagnosis of VTE and PE is sometimes difficult in pregnancy because the symptoms and signs may be vague and non-specific. The diagnostic algorithms for VTE and PE in pregnancy are in Appendix J and K, pg. 161 and 162.

## 4.13.2 Treatment of VTE

**I, c** Where the diagnosis is strongly suspected, (especially in the case of PE) empiric anticoagulation is recommended (unless contraindicated for other reasons) prior to the diagnostic evaluation. In patients with low or intermediate suspicion for PE or DVT, anticoagulation may be delayed till the diagnosis is confirmed.

In the treatment of DVT:

- I, A** LMWH is the therapy of choice and superior to UFH. When used for VTE:
  - It should be dosed according to the patient's weight (Table 19, pg. 134).
- IIb, C**
  - Routine monitoring of anti-Xa activity is not necessary.<sup>255</sup>
  - It should be continued throughout pregnancy and for at least 6 weeks postpartum until a total of at least 3 months of treatment have been given.
- I, C**
  - Following delivery, the patient should be offered the choice of continuing LMWH or warfarin postnatally. Both are safe during breast feeding.
- IIb, C** • Fondaparinux is not recommended because it crosses the placental barrier.

# Management of Pregnancy in Specific Cardiac Disease

- UFH
  - Initial treatment may be commenced with IV UFH and after achieving a stable aPTT in the therapeutic range, it may be converted to LMWH.
  - Subcutaneous UFH is less predictable in its efficacy and is not advisable.
  - If SC UFH is used, large doses (15,000 to 17,500 iu every 12 hours) are required and the aPTT checked periodically to ensure anticoagulation is within the therapeutic range.

IIb, C

Prior to delivery, there are several management options:

- Discontinue LMWH or SC UFH 24-36 hours before planned delivery
- Conversion from LMWH to IV UFH at 36 weeks or earlier if delivery is expected earlier. IV UFH can be discontinued 4-6 hours prior to delivery

IIa, C

Following delivery LMWH or UFH can be restarted 4-6 hours after vaginal delivery and 6-12 hours after LSCS if there are no bleeding complications. Oral anticoagulation can be resumed after 24 hours if there are no bleeding concerns.

## 4.13.3 Treatment of Pulmonary Embolism

Patients presenting with massive PE require urgent cardiorespiratory resuscitation. They may be treated by:

- Initial thrombolysis
- Percutaneous catheter directed embolectomy devices

This is then followed up with LMWH and then warfarin post-delivery for a total duration of treatment of about 6 months.

## 4.13.4 Prevention of VTE

I, C All women should undergo an assessment of risk factors for VTE in:

- Early pregnancy or before pregnancy and
- Intrapartum or immediately postpartum

I, C

This assessment should be repeated if the woman is admitted to the hospital for any reason or develops other intercurrent problems during the antenatal and postpartum period. (Appendix L & M, pg. 163 and 164) They should be offered thromboprophylaxis with LMWH where appropriate.

# Management of Pregnancy in Specific Cardiac Disease

**Table 19: Dosing\* of Subcutaneous LMWH for the Treatment and Thromboprophylaxis of VTE in Pregnancy**

Agent		Pregnancy Weight (kg)			
		< 50 kg	50-69 kg	70-90 kg	> 90 kg
Thromboprophylactic Dose**	Enoxaparin	20 mg daily	40 mg daily		
	Tinzaparin 20,000 IU/ml	3500 IU daily	4500 IU daily		
Therapeutic anticoagulation dose***	Enoxaparin	40 mg bid	60 mg bid	80 mg bid	100 mg bid
	Tinzaparin 20,000 IU/ml	175 units/kg once daily Volume of tinzaparin in mL required = $(\text{weight in Kg} - 10) \div 100$			

\*Doses should be reduced in renal impairment

\*\* RCOG. Reducing the Risk of Venous Thromboembolism during Pregnancy and the Puerperium. Green-top Guideline No. 37a April 2015

\*\*\* Ministry of Health Malaysia. Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism. 2013

## **5. CONTRACEPTION**

# Contraception

When considering contraception in patients with heart disease, the following factors are important:

- Efficacy of the method
- Potential complications of the contraceptive method which include:
  - Risk of thrombosis
  - Risk of infective endocarditis
  - Risk of increased menstrual blood loss with anticoagulation
- Complication of the surgery or procedure of insertion/implant
- Drug interaction
- Individual preference
- Cost

There are many types of contraceptive methods such as: (Table 20, pg. 139-140, Appendix N & O, pg. 165-166)

- Combined hormonal contraception
- Progestogen only contraception
- Depo provera
- Implants
- Intrauterine system (IUS)
- Intrauterine contraceptive device (IUD)
- Sterilisation
- Barrier methods

In advising contraception to cardiac patients, the following should be considered:

- Efficacy-preferable those with pearl Index > 1
- Interaction with medications:
  - Bosentan may antagonise the efficacy of the hormonal contraceptives. Thus a second method of contraception may be necessary.
  - Concomitant use of rifampicin, proton pump inhibitors, antiepileptics.
- Safety profile and risk of:
  - Thrombogenicity - estrogen based contraceptives and injectable progestins are associated with increased thrombotic risk.<sup>256</sup> They should be avoided in patients with Fontan, cyanotic heart disease, atrial arrhythmias, PH, Eisenmenger syndrome, those with mechanical valves, stents and right to left shunts.
  - Infection - in patients with IUS and IUDs there is a potential risk of infective endocarditis.

# Contraception

- Water retention - with the injectable progestin preparations. This may be a problem in patients with severe obstructive lesions and/or poor cardiac reserve.
- Heavy menstrual bleeding in patients on oral anticoagulants and IUDs.
- Surgical methods
  - Mini laparotomy is preferable.
  - Laparoscopic sterilisation in patients with PH and Eisenmenger syndrome is contraindicated as these patients do not tolerate the pneumoperitoneum.
  - Hysteroscopic sterilisation and insertion of intrauterine devices may give rise to vasovagal reaction due to manipulation of the cervix. This is poorly tolerated in patients with PAH and Eisenmenger syndrome.<sup>107</sup>

III, c

III, c

For emergency contraception, the following are available:

- the emergency contraceptive pill (Ella®, Escapelle®) – the preparation containing high dose Levonogestrel may interact with warfarin
- copper IUD

I, c

All women should be given information on contraception before they need them and know where to get expert advice when needed.

I, c

The contraceptive method of choice will depend on the patient's underlying cardiac condition.

In patients with PH and Eisenmenger syndrome who are not on Bosentan, progestin only implants (Nexplanon® previously known as Implanon®) are recommended. This is an effective contraceptive method that is easy and safe to implant.<sup>107</sup>

## Key messages:

- Contraception plays a key role in stabilising the maternal heart condition by the prevention of an unwanted pregnancy.
- A planned pregnancy brings the best outcomes.
- If pregnancy is contraindicated, then appropriate contraceptive advice is paramount for the safety of the patient.

# Contraception

**Table 20: Contraceptive Methods**

Contraceptive Method	Route of Use/ Administration	Pearl Index*		General Considerations
		Typical Use**	Perfect Use	
Combined hormonal contraception	Oral (combined oral contraceptives - COC)	5	0.1	<ul style="list-style-type: none"> <li>Contain oestrogen and progestogen</li> <li>Have high efficacy (PI 0.05)</li> <li>Increased risk of thrombosis</li> <li>Have non contraceptive benefits</li> <li>Refer Appendix J, pg. 161 for the WHOMECA risk classification for the use of these agents</li> </ul>
	Vaginal	5	0.1	
	Patch – worn for three weeks, off for one week – allowing menstrual cycle – then start with a new patch	5	0.1	
Progestogen only contraception (e.g. Noriday®, Cerazette®)	Oral	5	0.1-0.5	<ul style="list-style-type: none"> <li>Has low risk for thrombosis</li> <li>Mode of action is by secondary mechanisms</li> <li>Less efficacious than combined hormonal contraception</li> <li>Must take at the same time each day (within 3 hours – Noriday®, within 12 hours – Cerazette®)</li> <li>May be used during lactation</li> <li>Refer Appendix I, pg. 160 for safety of the different progesterone only contraceptions in cardiac disease</li> </ul>
Depo provera	Intramuscular (can be given monthly or 3 monthly depending on preparation)	0.3	0.3	<ul style="list-style-type: none"> <li>Has high efficacy similar to combined oral contraceptive pill</li> <li>Contains medroxyprogesterone</li> <li>Increases risk of water retention</li> <li>Increases risk of osteoporosis with long term use (&gt; 2 yrs)</li> </ul>
Implant	Inserted subcutaneously	0.05	0.05	<ul style="list-style-type: none"> <li>Contains desogestrel</li> <li>Has very high efficacy</li> <li>Lasts for 3 years</li> <li>Has low risk for thrombosis</li> <li>Can be inserted 48 hours after delivery</li> </ul>

# Contraception

**Table 20: Contraceptive Methods (cont'd)**

Contraceptive Method	Route of Use/ Administration	Pearl Index*		General Considerations
		Typical Use**	Perfect Use	
Intrauterine system (IUS) (Mirena®)	Inserted into uterus	0.8	0.5	<ul style="list-style-type: none"> <li>• Contains levonorgestrel</li> <li>• Has high efficacy</li> <li>• Lasts for 5 years</li> <li>• Has low risk for thrombosis</li> <li>• Reduced risk of anaemia</li> </ul>
Intrauterine contraceptive device (IUD)	Inserted into uterus May be: • Hormonal (progesterone) or • Copper	0.1	0.1	<ul style="list-style-type: none"> <li>• Has high efficacy</li> <li>• Risk of infection is highest during the first 3 weeks after insertion</li> <li>• Increases risk of pelvic inflammatory diseases</li> <li>• Can be kept for 3-5 years</li> <li>• Increases risk of heavy menstrual blood loss</li> <li>• Not recommended in patients on anticoagulants</li> </ul>
Sterilisation	Tubal ligation • Done surgically (minilaparotomy or hysteroscopically)	0.5	0.5	<ul style="list-style-type: none"> <li>• This is a permanent surgical option which should be considered when pregnancy is contraindicated.</li> <li>• Careful counselling to the patient and spouse is important.</li> <li>• Has high efficacy</li> <li>• Can be considered</li> </ul>
	Vasectomy • Surgical	0.15	0.1	
Barrier method		29	18	<ul style="list-style-type: none"> <li>• Condom with or without spermicide</li> <li>• Diaphragms/caps/sponge</li> </ul> <p>These methods are not very effective and are <b>not recommended</b> as the only form of contraception</p>
		32	20-26	

\*Pearl index: is the most common technique used in clinical trials for reporting the effectiveness of a birth control method. < 1 = good, < 0.5 = very good, < 0.1 = excellent;

\*\*Typical use refers to the fact that most women may only occasionally use the method incorrectly

## **6. TERMINATION OF PREGNANCY**

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# Termination of Pregnancy

The request for termination of pregnancy (TOP) may be made by;

- The patient herself
- The family
- The attending cardiologist/physician
- The obstetrician

Each of these requests must be based on the merits of the individual case within the provision of the law. It will depend upon:

- Patient's current cardiac status
- The risk to the patient as the pregnancy advances
- Existing contraindications for pregnancy

The safest time for elective TOP is early in the 1<sup>st</sup> trimester. This procedure must be performed within a facility equipped to manage the patient's cardiac disease as well as possible complications that may arise.

Whenever TOP is being considered a detailed counselling session is a prerequisite. It should involve:

- The patient
- Partner
- Other family members (deemed necessary)
- Physician/cardiologist
- Obstetrician
- Anaesthetist

The session has to address issues such as:

- Timing
- Methods
- Place
- Attending Doctors
- Anaesthesia
- Complications
- Average length of stay
- Costs
- Post TOP contraception

For every patient the method and the need for anaesthesia should be individualised.

- I, c
- High risk patients should be managed in a centre equipped to handle complications including cardiac surgery.

# Termination of Pregnancy

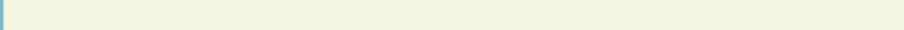
- I, C** • Prophylaxis against IE is advised in high risk patients. (section 4.10, pg. 120)
- I, C** • Dilatation and evacuation is the safest procedure in both the first and second trimesters.
- IIa, C** • When surgical evacuation is not feasible in the second trimester, prostaglandins E1 or E2, can be administered to evacuate the uterus.<sup>257</sup> These drugs are absorbed into the systemic circulation and can lower systemic vascular resistance and BP, and increase heart rate, effects that are greater with E2 than with E1.<sup>258</sup>
- With prostaglandin E compounds, systemic arterial oxygen saturation should be monitored with a transcutaneous pulse oximeter and norepinephrine infused at a rate that supports the DBP.
- III, C** • Prostaglandin F compounds should be avoided because they can significantly increase pulmonary artery pressure (PAP) and may decrease coronary perfusion.<sup>258</sup>
- III, C** • Saline abortion should be avoided because saline absorption can cause expansion of the intravascular volume, heart failure, and clotting abnormalities.
- It must be borne in mind that despite the TOP the maternal cardiac risks may persist until haemodynamic changes normalise.

For more details, please refer to Ministry of Health, TOP guidelines 2012.<sup>259</sup>

## Key messages:

- Whenever TOP is being considered a detailed counselling session is a prerequisite.
- Despite the TOP, maternal cardiac risks may persist until haemodynamic changes normalise.

## **7. IMPLEMENTING THE GUIDELINES, RESOURCE IMPLICATION AND PERFORMANCE MEASURES**



# Implementing the Guidelines, Resource Implication and Performance Measures

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The objective of this CPG is to improve the care of pregnant women with cardiac disease. It works within the existing framework of perinatal care, emphasising:

- Clinical signs that should raise suspicion of the presence of cardiac disease and the early signs of cardiac decompensation.
- Clear guidelines on the flow pattern of perinatal care and referral of these patients starting from preconception counselling till postpartum.

There are no additional cost implications. Drugs, if any, are easily available at all the government health clinics.

For the success of any CPG, it should be successfully implemented. This involves:

- Continuous medical education via regular seminars, lectures and roadshows particularly at the district hospital and family medicine clinics. Education and training is the most important aspect of the implementation of this CPG.
- Coordinated linkages between primary healthcare personnel and tertiary centres to allow easy and appropriate referrals. Guidelines for referral are in Table 6, pg. 25-26.
- Widespread availability of this CPG to healthcare providers via printed copies, electronic websites, etc.

The performance measures for this CPG will be the confidential report of maternal mortality. Cardiac disease accounts for almost 50% of indirect maternal deaths. Most of these cardiac deaths are preventable.

The aim of the CPG is to reduce maternal cardiac deaths by 50% by 2020.

# Implementing the Guidelines, Resource Implication and Performance Measures

Other Performance measures are:

Percentage of pregnant cardiac patients who have documentation in their medical record of all of the following:

Performance Measure	Yes	No	Target to Achieve in 3-5 Years
Preconception counselling given			> 70%
Contraceptive advice			> 70%
Planned pregnancy			> 50%
WHO/NYHA risk classification assigned			> 90%
Referred to specialist at first detection of underlying cardiac disease			> 90%
Written pregnancy care plan detailing issues			> 95%
Anaesthetic assessment for patients in WHO class III & IV			> 95%
Labour and delivery in appropriate setting with availability of HDU/CCU/ICU bed if necessary			> 95%
Discharge summary provided to all caregivers and patient			> 95%

## APPENDIX

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# Appendix A

## Appendix A: US FDA Pregnancy Risk Classification and Suggested Management Strategies

CATEGORY	DEFINITION	MANAGEMENT STRATEGY	EXAMPLE DRUGS
A (controlled studies show no risk)	Adequate and well-controlled studies in pregnant women have failed to demonstrate a risk to the fetus in the first trimester of pregnancy (there is no evidence of risk in later trimesters).	Because studies are not able to rule out the possibility of harm, the drug should be used during pregnancy only if clearly indicated.	levothyroxine, folic acid, magnesium sulfate, liothyronine
B (no evidence of risk in humans) <i>Or</i> Animal studies demonstrate a risk, and adequate and well-controlled studies in pregnant women have not been done during the first trimester.	Animal reproduction studies have failed to demonstrate a risk to the fetus, but there are no adequate and well-controlled studies of pregnant women. <i>Or</i> Animal studies demonstrate a risk, and adequate and well-controlled studies in pregnant women have not been done during the first trimester.	Because the studies of humans cannot rule out the possibility of harm, the drug should be used during pregnancy only if clearly needed.	metformin, hydrochlorothiazide, cyclobenzaprine, amoxicillin, pantoprazole
C (risk cannot be ruled out)	Animal reproduction studies have failed to demonstrate a risk to the fetus, but there are no adequate and well-controlled studies of pregnant women. <i>Or</i> Animal studies demonstrate a risk, and adequate and well-controlled studies in pregnant women have not been done during the first trimester.	The drug should be given to pregnant women only if clearly needed.	tramadol, gabapentin, amlodipine, trazodone, prednisone
D (positive evidence of risk)	There is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience or studies of humans, but the potential benefits from the use of the drug in pregnant women might be acceptable despite its potential risks.	If this drug is used during pregnancy, or if the patient becomes pregnant while taking this drug, the patient should be apprised of the potential hazard to the fetus.	lisinopril, alprazolam, losartan, clonazepam, lorazepam
X (contraindicated in pregnancy)	Studies in animals or humans have demonstrated fetal abnormalities or there is positive evidence of fetal risk based on adverse reaction reports from investigational or marketing experience, or both. The risk involved in the use of the drug in pregnant women clearly outweighs any possible benefits.	This drug is contraindicated in women who are or might become pregnant. If this drug is used during pregnancy, or if the patient becomes pregnant while taking this drug, the patient should be advised of the potential hazard to the fetus.	atorvastatin, simvastatin, warfarin, methotrexate, finasteride

Adapted from:

- PDR Staff. *Drug Information for the Health Care Professional USDPI* vol. 1 (23<sup>rd</sup> Edition). Micromedex, NY, USA (2003).
- Boothby LA, Doering PL. FDA labeling system for drugs in pregnancy. *Ann Pharmacother*. 2001; 35(11):1485-9

## Appendix B

### Appendix B: Recommendations for Cardiovascular Drug Use during Pregnancy

Drug	FDA category	Placenta permeable	Transferable to breast milk	Adverse Effects
Aspirin (low dose)	B	Yes	Well tolerated	No teratogenic effects known (large data sets)
Adenosine	C	No	No	No fetal adverse effects reported (limited human data)
Amiodarone	D	Yes	Yes	Thyroid insufficiency (9%), hyperthyroidism, goitre, bradycardia, growth retardation, premature birth
Atenolol	D	Yes	Yes	Hypospadias (first trimester); birth defects, low birth weight, bradycardia and hypoglycaemia in fetus (second and third trimester)
ACE-Inhibitors	D	Yes	Yes	Renal or tubular dysplasia, oligohydramnion, growth retardation, ossification disorders of skull, lung hypoplasia, contractures, large joints, anaemia, intrauterine fetal death
Angiotensin Receptors Blockers	D	Unknown	Unknown (not recommended)	Renal or tubular dysplasia, oligohydramnion, growth retardation, ossification disorders of skull, lung hypoplasia, contractures, large joints, anaemia, intrauterine fetal death
B-Blockers (bisoprolol, metoprolol, propranolol)	C	Yes	Yes	Bradycardia and hypoglycaemia in fetus
Clopidogrel	C	Unknown	Unknown	No information during pregnancy available
Digoxin	C	Yes	Yes	Serum levels unreliable, safe
Diltiazem	C	No	Yes	Possible teratogenic effects
Diuretics (frusemide/hydrochlorothiazide)	C	Yes	Yes, Well tolerated; milk production can be reduced	Oligohydramnion
Fibrates (fenofibrate <sup>a</sup> , gemfibrozil <sup>b</sup> )	C	Yes	Yes <sup>a</sup> /Unknown <sup>b</sup>	No adequate human data
Fondaparinux		Yes	No	New drug, (limited experience)
Heparin (low molecular weight)	B	No	No	Long-term application: seldom osteoporosis and markedly less thrombocytopenia than UF heparin
Heparin (unfractionated)	B/C*	No	No	Long-term application: osteoporosis and thrombocytopenia
Labetolol	C	Yes	Yes	Fetal growth restriction (second and third trimester), neonatal bradycardia and hypotension (used near term)
Lidocaine	C	Yes	Yes	Fetal bradycardia, acidosis, central nervous system toxicity
Methyldopa	B	Yes	Yes	Mild neonatal hypotension

## Appendix B

<b>Drug</b>	<b>FDA category</b>	<b>Placenta permeable</b>	<b>Transferable to breast milk</b>	<b>Adverse Effects</b>
Nifedipine	C	Yes	Yes	Tocolytic; s.I. application and potential synergism with magnesium sulfate may induce hypotension (mother) and fetal hypoxia
Nitrites (GTN, Isosorbide dinitrate)	B	Unknown	Unknown	Bradycardia, tocolytic
Propafenone	C	Yes	Unknown	Unknown (limited experience)
Sotalol	B	Yes	Yes	Bradycardia and hypoglycaemia in fetus (limited experience)
Spironolactone	D	Yes	Yes, milk production can be reduced	Antiandrogenic effects, oral clefts (first trimester)
Statins	X	Yes	Unknown	Congenital anomalies
Ticlopidine	C	Unknown	Unknown	Unknown (limited experience)
Verapamil (oral)	C	Yes	Yes	Well tolerated (limited experience during pregnancy)
Verapamil (IV)	C	Yes	Yes	Intravenously use is may be associated with a greater risk of hypotension and subsequent fetal hypoperfusion
Warfarin	D/X*	Yes	Yes, well tolerated as inactive metabolite	Coumarin-embryopathy, bleeding

\*MERCK manual grading

<http://www.msdmanuals.com/professional/gynecology-and-obstetrics/drugs-in-pregnancy/drugs-in-pregnancy>

# Appendix C

## Appendix C: Recommendations for Antibiotic Use during Pregnancy

Drug	FDA category	Placenta permeable	Transferable to breast milk	Adverse Effects
Ampicillin, amoxicillin, cephalosporins, erythromycin, mezlocillin, penicillin	B	Yes	Yes	No fetal adverse effects reported
Imipenem, rifampicin, teicoplanin, vancomycin	C	Unknown	Unknown	Risk cannot be excluded (limited human data)
Chloramphenical	C			Gray Baby syndrome, in women or fetuses with G6PD deficiency - haemolysis
Aminoglycosides	D			Ototoxicity (e.g. damage to fetal labyrinth), resulting in deafness
Fluoroquinolones	D/C*			Possibly arthralgia; theoretically, musculoskeletal defects (e.g. impaired bone growth), but no proof of this effect
Nitrofurantoin	B			In women or fetuses with G6PD deficiency - haemolysis
Primaquine	C			In women or fetuses with G6PD deficiency - haemolysis
Sulfonamides (except sulfasalazine, which has minimal fetal risk)	C			When the drugs are given after about 34 weeks gestation, neonatal jaundice and, without treatment, kernicterus In women or fetuses with G6PD deficiency - haemolysis
Tetracycline	D			Slowed bone growth, enamel hypoplasia, permanent yellowing of the teeth, and increased susceptibility to cavities in offspring Occasionally, liver failure in pregnant women
Trimethoprim	C			Increased risk of neural tube defects due to folate antagonism

\*MERCK manual grading

<http://www.msdmanuals.com/professional/gynecology-and-obstetrics/drugs-in-pregnancy/drugs-in-pregnancy>

# Appendix D

## Appendix D: Recommendations for Drug Use during Pregnancy

Drug	FDA Category	Adverse Effects
<b>ORAL HYPOGLYCAEMICS</b>		
Chlorpropamide	C	Neonatal hypoglycaemia
Glyburide	C	Neonatal hypoglycaemia
Metformin	B	Neonatal hypoglycaemia
<b>ANTI INFLAMMATORY AGENTS</b>		
Aspirin and other salicylates	D	Fetal kernicterus With high doses, possibly 1 <sup>st</sup> - trimester spontaneous abortions, delayed onset of labour, premature closing of the fetal ductus arteriosus, jaundice, occasionally maternal (intrapartum and postpartum) and/or neonatal haemorrhage, necrotising enterocolitis, and oligohydramnios With low doses (81 mg) of aspirin, no significant teratogenic risk
NSAIDs	C D - for some drugs if given after 30 weeks	Same as those for salicylate Contraindicated in the 3 <sup>rd</sup> trimester
<b>ANTI THYROID MEDICATIONS</b>		
Methimazole	D	Fetal goitre and neonatal scalp defects (aplasia cutis)
Propylthiouracil	D	Fetal goitre and maternal hepatotoxicity and agranulocytosis
Radioactive iodine ( <sup>131</sup> I)	D	Destruction of the fetal thyroid gland or, when the drug is given near the end of the 1 <sup>st</sup> trimester, severe fetal hyperthyroidism
Saturated solution of K iodide		Large fetal goitre, which may obstruct breathing in neonates
Triiodothyronine	D	Fetal goitre
<b>VACCINES</b>		
Live-virus vaccines such as those for measles, mumps, rubella, polio, chickenpox, and yellow fever		With rubella and varicella vaccines, potential infection of the placenta and developing fetus With other vaccines, potential but unknown risks
<b>OTHERS</b>		
Corticosteroids	B	When these drugs are used during the 1 <sup>st</sup> trimester, possibly orofacial clefts
Loratadine	B	Possible hypospadias
Ondansetron	B	No significant teratogenic risk
Pseudoephedrine	C	Placental vasoconstriction and possible risk of gastroschisis
Vitamin K	C	In women or fetuses with G6PD deficiency-haemolysis

## Appendix E

### Appendix E: Estimated Fetal and Maternal Radiation Doses from Common Radiological and Cardiac Diagnostic and Interventional Procedures

Conventional X-Ray examinations	Fetal dose		Maternal Exposure*
	Mean (mGy)	Maximum (mGy)	mGy
Skull	<0.01	<0.01	0.1
Chest	<0.01	<0.01	
Thoracic Spine	<0.01	<0.01	
Abdomen	1.4	4.2	
Lumbar spine	1.7	10	
Pelvis	1.1	4	
Intravenous Urogram	1.7	10	
Computed Tomography	Fetal dose		Maternal Exposure*
	Mean (mGy)	Maximum (mGy)	mGy
Head	<0.005	<0.005	
Chest	0.06	0.96	7
Abdomen	8.0	49	
Lumbar spine	2.4	8.6	
Pelvis	25	79	
Fluoroscopic Examinations	Fetal dose		Maternal Exposure*
	Mean (mGy)	Maximum (mGy)	mGy
Barium meal (Upper GI)	1.1	5.8	
Barium meal (lower GI)	6.8	24	
Cardiac procedures* (depends on number of exposures)	Fetal exposure*		Maternal exposure*
	1.5		7
Coronary angiogram	1.5		
Percutaneous Coronary intervention or Radiofrequency Catheter Ablation	3		15

Adapted from:

- Sharp C, Shrimpton JA, Bury RF. Diagnostic medical exposures: Advice on exposure to ionising radiation during pregnancy. National Radiological Protection Board, Chilton, Didcot, Oxon, UK; 1998.
- Regitz-Zagrosek V, Lundqvist CB, Borghi C, Cifkova R, Ferreira R et al. The Task Force on the Management of Cardiovascular Diseases during Pregnancy of the European Society of Cardiology (ESC). Endorsed by the European Society of Gynecology, the Association for European Paediatric Cardiology, and the German Society for Gender Medicine. ESC Guidelines on the management of cardiovascular diseases during pregnancy. European Heart Journal (2011) 32, 3147–3197.

When considering fetal risk from radiation exposure and termination of pregnancy:<sup>260</sup>

- at fetal doses of less than 100 mGy (10,000 mrad) termination is NOT justified based upon radiation risk
- at fetal doses between 100 and 500 mGy, decisions should be based upon individual circumstances
- at fetal doses in excess of 500 mGy, there can be significant fetal damage, the magnitude and type of which is a function of dose and stage of pregnancy

## Appendix F

### Appendix F: Sistem Kod Warna dan Senarai Semak Penjagaan Antenatal\*

KOD WARNA	TAHAP PENJAGAAN
MERAH	Rujukan segera ke Hospital dan pengendalian selanjutnya adalah bersama (shared care) Pakar O&G dan Pakar Perubatan Keluarga
KUNING	Rujukan untuk pengendalian oleh Pakar O&G Hospital/Pakar Perubatan Keluarga, dan penjagaan selanjutnya boleh dilakukan bersama (shared care) Pegawai Perubatan dan Jururawat Kesihatan
HIJAU	Pengendalian di Klinik Kesihatan oleh Pegawai Perubatan dan Kesihatan dan pengendalian selanjutnya boleh dilakukan bersama Jururawat Kesihatan/Jururawat Masyarakat di bawah pengawasan Pegawai Perubatan
PUTIH	Penjagaan oleh Jururawat Kesihatan/Jururawat Masyarakat di Klinik Kesihatan dan Klinik Desa (sekiranya tiada terdapat faktor risiko yang disenaraikan dalam kod merah, kuning dan hijau, ibu diberi kod warna putih)

\*Adapted from: *Garis panduan senarai semak bagi penjagaan kesihatan ibu dan bayi mengikut sistem kod warna. Bahagian Pembangunan Kesihatan Keluarga Kementerian Kesihatan Malaysia Edisi Keempat, 2013*

## Appendix G: Suggested Anaesthetic Techniques/ Regimes for Pregnant Patients with Heart Disease\*

### **Anaesthetic preparation**

Preparation for anaesthesia should be the same like any other case but extra monitoring and more cardio stable drugs should be chosen.

### **Haemodynamic goals for both GA and regional anaesthesia:**

- To maintain sinus rhythm (Phenylephrine infusion can help maintaining heart rate)
- To maintain good cardiac output (might need Dopamine or Dobutamine infusion)
- To prevent hypotension (MAP to keep at baseline of above 70 mmHg)

### **GA technique for heart case**

1. Invasive line i.e. arterial line and CVP monitoring (via Internal jugular preferably under ultrasound guidance) should be done whilst patient still widely awake.  
**\*Some centres consider central line monitoring as an optional especially in mild to moderate risk case.**
2. Induction agent of choice-Etomidate 0.2 mg/kg, Titration midazolam up to 5 mg
3. IV fentanyl (2-3 mcg/kg) during induction.  
(Need to warn paediatrician on the risk of fetal apnoea).
4. Muscle relaxant-Suxamethonium can induce bradycardias. Rocuronium can be used instead (0.6-1 mg/kg of lean body weight). Normally 50 mg is enough for average weight.  
**\*Please ensure the availability of Sugammadex before using high dose Rocuronium for intubation.**
5. To maintain MAP as recorded during baseline monitoring or (above 70 mmHg) especially in Pulmonary HPT, any congenital heart defect and hypertensive patient.
6. IV Morphine 10 mg (titration of 5.5 mg), after fetus is delivered.
7. IV Oxytocin to be given as slow bolus, 2 unit in 5 cc N/S over 10 mins then followed by either 5 IU in 50 ml at 7 ml per hour or 10 IU in 500 ml at 36 ml per hour. Continue for 4 hours.
8. Reversal is by IV Sugammadex 0.2 mg/kg or mixture of IV Glycopyrrolate 400 mcg and IV Neostigmine 2.5 mg.
9. Pain relief is by multimodal analgesia if no contraindication. PCA morphine is optional.
- 1.10 Post-operative monitoring should be in HDW/ICU.

### **Regional technique for heart case**

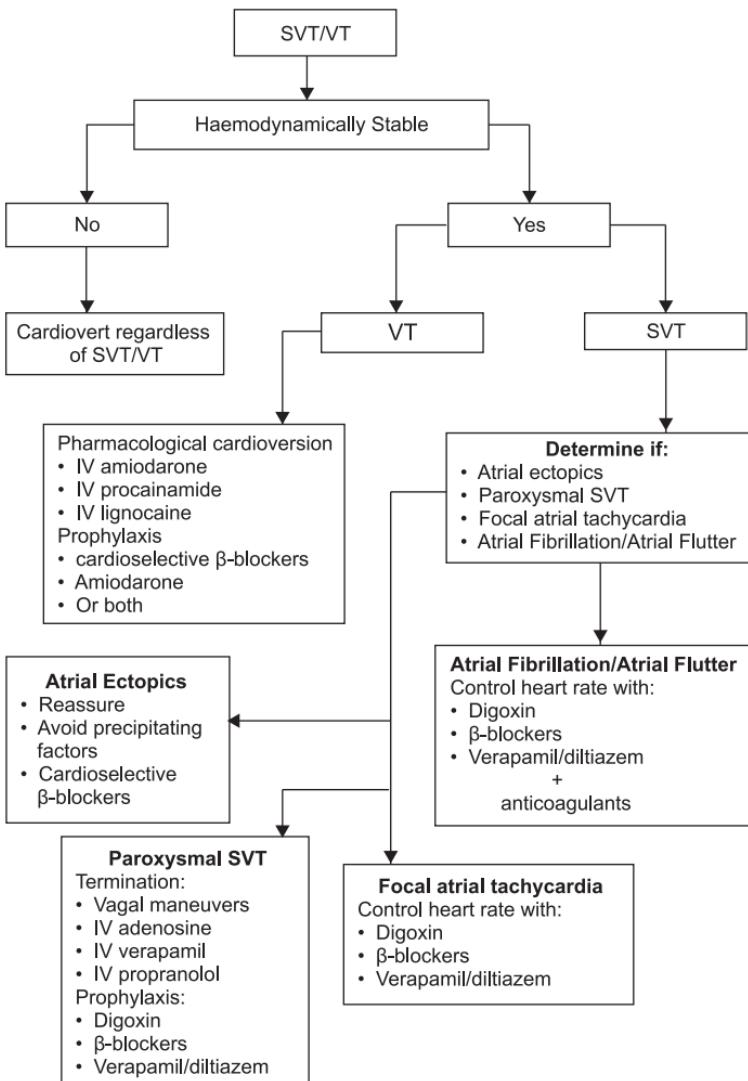
**Low dose sequential Combined Spinal Epidural (CSE)** is recommended whenever regional is considered as a better choice compared to GA.

#### **2.1 Dosage of (CSE) in Heart Case**

- **Spinal dose**  
(0.5-1 ml of heavy 0.5% bupivacaine) + 25 mcg fentanyl.  
To check the level of sensory loss to pin prick after 5 minutes. If still below T5-T6 level, to slowly increase the level with titration of epidural.
- **Epidural drug**  
(2% of lignocaine in 1:200 000 Adrenaline), 3-5 mls every 5 minutes until T5-T6 is reached.

\*From: Obstetric Anaesthesia & Analgesia Service, Policies and Guidelines, HKL/OAS 2014.

## Appendix H: Management of Tachyarrhythmias During Pregnancy\*



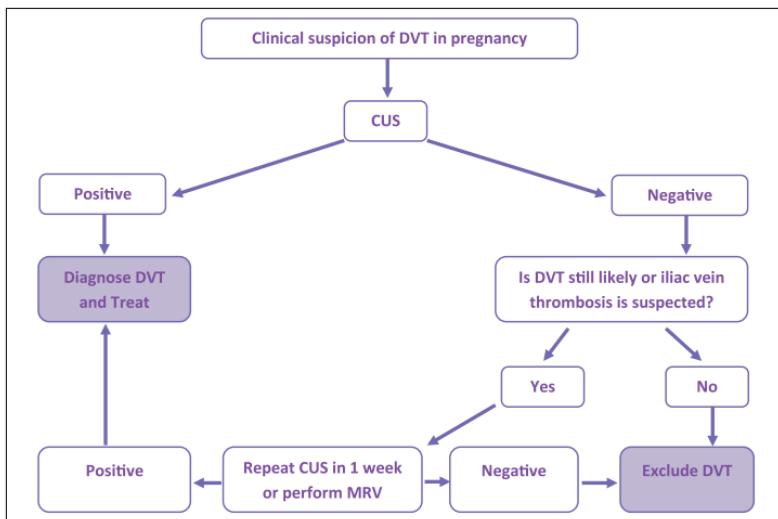
\*Adapted from: Baig M. Arrhythmia-centered treatment review of tachyarrhythmia during pregnancy. An article from the e-journal of the ESC Council for Cardiology Practice 2014; 12: N° 13

## Appendix I: Risk Factors for VTE in Pregnancy

Pre-existing	Previous VTE	
	Thrombophilia	<p><i>Heritable</i></p> <ul style="list-style-type: none"> <li>Antithrombin deficiency</li> <li>Protein C deficiency</li> <li>Protein S deficiency</li> <li>Factor V Leiden</li> <li>Prothrombin gene mutation</li> </ul>
		<p><i>Acquired</i></p> <ul style="list-style-type: none"> <li>Antiphospholipid antibodies</li> <li>Persistent lupus anticoagulant and/or persistent moderate/high titre anticardiolipin antibodies and/or <math>\beta_2</math> glycoprotein 1 antibodies</li> </ul>
		Medical comorbidities e.g. cancer, heart failure, active SLE, inflammatory polyarthropathy or IBD, nephrotic syndrome, type 1 diabetes mellitus with nephropathy, sickle cell disease, current intravenous drug user
		Age > 35 years
		Obesity ( $BMI \geq 30 \text{ kg/m}^2$ ) either pre-pregnancy or in early pregnancy
		Parity $\geq 3$ (a woman becomes para 3 after her third delivery)
		Smoking
		Gross varicose veins (symptomatic or above knee or with associated phlebitis, oedema/ skin changes)
		Paraplegia
Obstetric risk factor	<ul style="list-style-type: none"> <li>Multiple pregnancy</li> <li>Current pre-eclampsia</li> </ul>	
	<ul style="list-style-type: none"> <li>Caesarian section</li> <li>Prolong labour (&gt; 24 hours)</li> <li>Mid-cavity or rational operative delivery</li> <li>Stillbirth</li> <li>Preterm birth</li> <li>Postpartum haemorrhage (&gt; 1 litre/requiring transfusion)</li> </ul>	
New onset/transient  <i>These risk factors are potentially reversible and may develop at later stages in gestation than the initial risk assessment or may resolve and therefore what is important is an ongoing individual risk assessment</i>	<ul style="list-style-type: none"> <li>Any surgical procedure in pregnancy or puerperium except immediate repair of the perineum, e.g. appendicectomy, postpartum sterilisation</li> <li>Bone fracture</li> <li>Hyperemesis, dehydration</li> <li>Ovarian hyperstimulation syndrome (first trimester only)</li> <li>Admission or immobility (<math>\geq 3</math> days bed rest)</li> <li>Current systemic infection (requiring intravenous antibiotics or admission to hospital)</li> <li>Long-distance travel (&gt; 4 hours)</li> </ul>	
	<ul style="list-style-type: none"> <li>Assisted reproductive technology (ART), in vitro fertilisation (IVF)</li> <li>e.g. pelvic girdle pain restricting mobility</li> <li>e.g. pneumonia, pyelonephritis, postpartum wound infection</li> </ul>	

From: RCOG. Reducing the Risk of Venous Thromboembolism during Pregnancy and the Puerperium. Green-top Guideline No. 37a April 2015

## Appendix J: Diagnostic Algorithm for Suspected DVT in Pregnancy\*

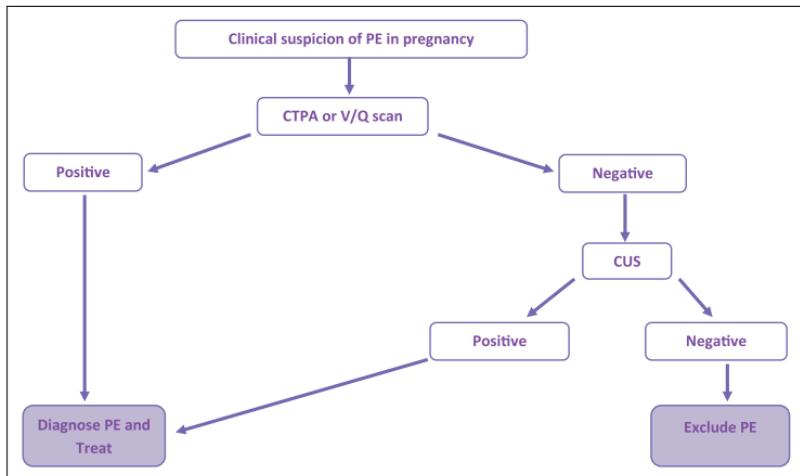


CUS: Compression Ultrasonography; DVT: Deep Vein Thrombosis MRV: Magnetic Resonance Venography

\* Ministry of Health Malaysia. Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism. 2013

# Appendix K

## Appendix K: Diagnostic Algorithm for Suspected PE in Pregnancy\*



CUS: Compression Ultrasonography; CTPA: Computed Tomography Pulmonary Angiography; V/Q Scan: Ventilation/Perfusion Scan

\* Ministry of Health Malaysia. *Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism*. 2013

## **Appendix L: Antenatal Risk Assessment and Indications for Antenatal Thromboprophylaxis\***

Risk Factors	Requirements	Management	When to Initiate Treatment
<b>High Risk</b>			
<ul style="list-style-type: none"> <li>Single previous VTE with:           <ul style="list-style-type: none"> <li>➤ Family history or</li> <li>➤ Unprovoked/ estrogen related</li> </ul> </li> <li>Previous recurrent VTE &gt; 1</li> </ul>	Any 1 Risk Factor	<b>Requires antenatal prophylaxis with</b> <ul style="list-style-type: none"> <li>• LMWH</li> <li>➤ Enoxaparin 1 mg/kg daily or</li> <li>➤ Tinzaparin 4500 units daily (if BW &gt; 90 kg, to dose at 75 units/kg daily)</li> </ul>	Recommend from as early as possible in pregnancy
<b>Intermediate Risk</b>			
<ul style="list-style-type: none"> <li>Single previous VTE with no family history</li> <li>Medical comorbidities e.g.           <ul style="list-style-type: none"> <li>➤ Heart/lung disease</li> <li>➤ SLE</li> <li>➤ Cancer</li> <li>➤ Inflammatory conditions</li> <li>➤ Nephrotic syndrome</li> <li>➤ Sickle cell disease</li> <li>➤ Thalassaemia</li> <li>➤ Intravenous drug user</li> </ul> </li> <li>Surgical procedures e.g.           <ul style="list-style-type: none"> <li>➤ Appendectomy</li> </ul> </li> </ul>	Any 1 Risk Factor (if admitted into hospital)	<b>Consider (not routinely recommended) antenatal prophylaxis with</b> <ul style="list-style-type: none"> <li>• LMWH</li> <li>➤ Enoxaparin 1 mg/kg daily or</li> <li>➤ Tinzaparin 4500 units daily (if BW &gt; 90 kg, to dose at 75 units/kg daily)</li> </ul>	Timing of initiation has to be individualised. Consider: <ul style="list-style-type: none"> <li>➤ from early in pregnancy (not routinely recommended) or</li> <li>➤ from 28 weeks (recommended)</li> <li>➤ when admitted to hospital (recommended)</li> </ul>
<ul style="list-style-type: none"> <li>Age &gt; 35 years</li> <li>Obesity BMI &gt; 30 kg/m<sup>2</sup></li> <li>Parity ≥ 3</li> <li>Smoker</li> <li>Gross varicose veins</li> <li>Current systemic infection</li> <li>Immobility e.g. paraplegia, long haul travel &gt; 4 hours</li> <li>Preeclampsia</li> <li>Dehydration/ hypermesis/ Ovarian hyperstimulation syndrome</li> <li>Multiple pregnancy</li> <li>Assisted reproductive treatment</li> </ul>	Any ≥ 3 Risk Factors or Any ≥ 2 Risk Factors (if admitted into hospital)	<b>Consider antenatal prophylaxis with</b> <ul style="list-style-type: none"> <li>• LMWH</li> <li>➤ Enoxaparin 1 mg/kg daily or</li> <li>➤ Tinzaparin 4500 units daily (if BW &gt; 90 kg, to dose at 75 units/kg daily)</li> </ul>	Consider: <ul style="list-style-type: none"> <li>➤ from 28 weeks</li> <li>➤ when admitted to hospital</li> </ul>
	Any ≤ 2 Risk Factors or less (not admitted into hospital)	<ul style="list-style-type: none"> <li>• Mobilisation</li> <li>• Avoid dehydration</li> </ul>	

- Patients to be assessed at booking and with every admission into hospital. This table does not replace clinical judgement.
- It does not include very high risk individuals who require anticoagulation when not pregnant (ie those on long term warfarin). This includes:
  - Previous VTE on warfarin
  - Anti-phospholipid syndrome with previous VTE
- These very high risk patients require therapeutic dose of LMWH antenatally and at least 6 weeks postnatal LMWH or until switched back to oral anticoagulant therapy

\*Adapted from:

- Ministry of Health Malaysia. Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism. 2013
- RCOG. Reducing the Risk of Venous Thromboembolism during Pregnancy and the Puerperium. Green-top Guideline No. 37a April 2015

# Appendix M

## Appendix M: Postnatal Risk Assessment and Indications for Postnatal Thromboprophylaxis\*

Risk Factors	Requirements	Management
<b>High Risk</b>		
• Any previous VTE • Anyone requiring antenatal prophylactic LMWH	Any 1 Risk Factor	At least 6 weeks postnatal prophylactic LMWH
<b>Intermediate Risk</b>		
• Caesarean section in labour • BMI > 40 kg/m <sup>2</sup> • Prolonged hospital admission • Medical comorbidities e.g. ➢ Heart/ lung disease ➢ SLE ➢ Cancer ➢ Inflammatory conditions ➢ Nephrotic syndrome ➢ Sickle cell disease ➢ Thalassaemia • Intravenous drug abuser	Any 1 Risk Factor	• At least 7 days postnatal prophylactic LMWH • If persisting or > 3 risk factors, consider extending thromboprophylaxis with LMWH
• Age > 35 years • Obesity BMI > 30 kg/m <sup>2</sup> • Parity ≥ 3 • Smoker • Elective caesarean section • Any surgical procedure in the puerperium • Gross varicose veins • Current systemic infection • Immobility e.g. paraplegia, long haul travel > 4 hours • Preecclampsia • Midcavity rotational operative delivery • Prolonged labour > 24 hours • Assisted reproductive treatment • Postpartum hemorrhage > 1 litre or blood transfusion	Any ≥ 2 Risk Factors	• At least 7 days postnatal prophylactic LMWH • If persisting or > 3 risk factors, consider extending thromboprophylaxis with LMWH
	Any ≤ 2 Risk Factors or less (not admitted into hospital)	• Mobilisation • Avoid dehydration

\*Adapted from Ministry of Health Malaysia. Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism. 2013

# Appendix N

## Appendix N: Safety of Progesterone Only Contraceptive Methods in Women with Cardiac Disease

Progesterone only contraceptive method	Cardiac condition	WHOME# Class
Progesterone only pill <sup>a</sup> • Noriday® • Cerazette <sup>®b</sup>	All cardiac conditions (should not normally be advised where pregnancy poses a high or unacceptable risk - WHOME Class 3 and 4 conditions)	1
Depo Provera	All cardiac patients who are not on warfarin	1
	All cardiac patients on warfarin <sup>c</sup>	3
Implants e.g. (Nexplanon®, previously known as Implanon®)	All cardiac patients	1
Intra-Uterine System e.g. Mirena®	Cardiac patients generally even if taking warfarin <sup>d</sup>	1
	Structural heart disease <sup>e</sup>	2
	Prosthetic heart valves <sup>d,e</sup>	3
	Previous endocarditis <sup>e</sup>	3
	Pulmonary hypertension, Fontan circulation or other condition in which vagal reaction at insertion would be poorly tolerated	4(3)
Emergency contraception	All cardiac disease	1

#WHOME: World Heart Organization Medical Eligibility Criteria

<sup>a</sup>Although safe, the standard progestogen-only pill is less effective than all the other progestogen-only methods.

<sup>b</sup>Efficacy reduced by Bosentan

<sup>c</sup>Risk of haematoma at injection site

<sup>d</sup>The INR may be altered after initiation of any progesterone hormone therapy. It needs to be monitored.

<sup>e</sup>Risk of Infective Endocarditis

From: Thorne S, MacGregor A, Nelson-Piercy C. Pregnancy and contraception in heart disease and pulmonary arterial hypertension. J Fam Plann Reprod Health Care. 2006; 32:75-81

# Appendix O

**Appendix O: Risk of Combined Contraceptive Pills for the Different Cardiac Conditions WHOMECA Risk Classification for the Use of Combined Hormonal Contraceptives\***

MEC CLASS	WHOMECA 1	WHOMECA 2	WHOMECA 3	WHOMECA 4
Category of Use	Condition with no restriction for the use of contraceptive method	Condition where the advantages of the method generally outweigh the risks	Condition where the risks of the method usually outweigh the advantages and to consider all alternatives first	Conditions where the method represents an unacceptable health risk
	Always usable	Broadly usable	Caution in use	Do not use
Cardiac Conditions	Physiological murmurs in absence of heart disease	Most arrhythmias other than atrial fibrillation and flutter	Atrial fibrillation or flutter on warfarin	Atrial fibrillation or flutter if not anticoagulated
	Mitral valve prolapse with or trivial mitral regurgitation	Uncomplicated mild native mitral and aortic valve disease	Bi-leaflet mechanical valve in mitral or aortic position taking warfarin	Pulmonary hypertension or pulmonary vascular disease (e.g. Eisenmenger syndrome)
	Bicuspid aortic valve with normal function	Tissue prosthetic valve lacking any of the features noted in WHOMECA 3 and WHOMECA 4	ASD with left to right shunt that may reverse with physiological stress (e.g. Valsalva manoeuvre)	Dilated left atrium > 4 cm
	Mild pulmonary stenosis	Surgically corrected congenital heart disease lacking any features noted in WHOMECA 3 and WHOMECA 4	Marfan syndrome with aortic dilatation unoperated	Fontan heart on warfarin
	Repaired coarctation with no hypertension or aneurysm	Small left to right shunt not reversible with physiological manoeuvres (e.g. small VSD, small PDA)	Past thrombotic event on Warfarin	Cyanotic heart disease
	Simple congenital lesions successfully repaired in childhood and with no sequelae e.g. • Ostium secundum atrial septal defect • VSD • PDA • Total anomalous pulmonary venous drainage	Uncomplicated Marfan syndrome		Pulmonary arteriovenous malformation  Past thromboembolic event (venous and arterial) not on warfarin  Poor left ventricle function of any cause(e.g. dilated cardiomyopathy) Ejection fraction < 30%
		Hypertrophic cardiomyopathy lacking any of the features noted in WHOMECA 3 and WHOMECA 4		Coronary artery disease
		Past cardiomyopathy fully recovered including peripartum cardiomyopathy		Coronary arteritis (e.g Kawasaki's disease with coronary involvement)

\*World Health Organization. Medical Eligibility Criteria (MEC) for Contraceptive use. (5th ed) 2015. Available at: [www.who.int/reproductivehealth/publication/family\\_planning/Ex-SummMec-5/en/](http://www.who.int/reproductivehealth/publication/family_planning/Ex-SummMec-5/en/)  
From: Thorne S et al. Pregnancy and contraception in heart disease and pulmonary arterial hypertension. J Fam Plann Reprod Health Care. 2006; 32:75-81

## References

- Regitz-Zagrosek V, Blomstrom Lundqvist C, Borghi C, Cifkova R, Ferreira R, Foidart J-M, et al. ESC Guidelines on the Management of Cardiovascular Diseases during Pregnancy: The Task Force on the Management of Cardiovascular Diseases during Pregnancy of the European Society of Cardiology (ESC). *Eur Heart J*. 2011; 32(24): 3147-97.
- National Obstetrics Registry Database. Ministry of Health Malaysia. Unpublished Data. Jegannathan R, Karalasingham SD 2014.
- Report on Confidential Enquiries into Maternal Death in Malaysia (CEMD) 2009-2011 Division of Family Health Development Ministry of Health Malaysia. Ed Jegannathan R.
- Report on Confidential Enquiries into Maternal Death in Malaysia (CEMD) 2006-2008 Division of Family Health Development Ministry of Health Malaysia. Ed Krishnan M.
- Dewhurst's Textbook of Obstetrics and Gynaecology. Ed Edmonds K. 8<sup>th</sup> Ed 2012. Wiley-Blackwell.
- Hall ME, George EM, Granger JP. The Heart during Pregnancy. *Rev Esp Cardiol*. 2011 Nov; 64(11): 1045-1050.
- Russel R, Naderi S. Pregnancy and Heart Disease. Cleveland Clinic. Center for Continuing Education. Disease Management. February 2014. Available at: <http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/cardiology/pregnancy-and-heart-disease/>
- Silversides CK, Colman JM. Physiological Changes in Pregnancy in Heart Disease in Pregnancy. Ed Oakley CM, Warnes CA. 2<sup>nd</sup> Ed. 2007. Blackwell Publishers.
- Thorne S, McGregor A, Nelson-Piercy C. Risk of Contraception and Pregnancy in Heart Disease. *Heart*. 2006; 92: 1520-5.
- The Criteria Committee of the New York Heart Association. Nomenclature and Criteria for Diagnosis of Diseases of the Heart and Great Vessels. 9<sup>th</sup> ed. Boston, Mass: Little, Brown & Co; 1994: 253-265.
- Roos-Hesselink JW, Ruys TPE, Stein JI, Thile'n U, Webb GD et al on behalf of the ROPAC Investigators. Outcome of Pregnancy in Patients with Structural or Ischaemic Heart Disease: Results of a Registry of the European Society of Cardiology. *Eur Heart J*. 2013; 34: 657-665.
- Drenthen W, Pieper PG, Roos-Hesselink JW, van Lottum WA, Voors AA et al. Outcome of Pregnancy in Women with Congenital Heart Disease. A Literature Review. *J Am Coll Cardiol*. 2007; 49(24): 2302-11.
- Siu SC, Sermer M, Colman JM, Alvarez A, Mercier L-A et al. Prospective Multicenter Study of Pregnancy Outcomes in Women with Heart Disease. *Circulation*. 2001; 104(5): 515-21.
- Drenthen W, Boersma E, Balci A, Moons P, Roos-Hesselink JW on behalf of the ZAHARA investigators, et al. Predictors of Pregnancy Complications in Women with Congenital Heart Disease. *Eur Heart J*. 2010; 31: 2124-32.
- Tanous D, Siu SC, Mason J, Greutmann M, Wald RM et al. B-Type Natriuretic Peptide in Pregnant Women with Heart Disease. *J Am Coll Cardiol*. 2010; 56: 1247-1253.
- Wenger NK. Recognising Pregnancy-Associated Cardiovascular Risk Factors. *Am J Cardiol*. 2014; 113: 406-409.
- Burn J, Brennan P, Little J, Holloway S, Coffey R, Somerville J, et al. Recurrence Risks in Offspring of Adults with Major Heart Defects: Results from First Cohort of British Collaborative Study. *Lancet*. 1998; 351: 311-6.
- Pierpont ME, Basson CT, Benson DW Jr., Gelb BD, Giglia TM et al. Genetic Basis for Congenital Heart Defects: Current Knowledge: A Scientific Statement from the American Heart Association Congenital Cardiac Defects Committee, Council on Cardiovascular Disease in the Young: Endorsed by the American Academy of Pediatrics. *Circulation*. 2007; 115: 3015-3038.
- Khairy P, Ouyang DW, Fernandes SM, Lee-Parritz A, Economy KE, Landzberg MJ. Pregnancy Outcomes in Women with Congenital Heart Disease. *Circulation*. 2006; 113: 517-524.
- Siu SC, Colman JM, Sorensen S, Smallhorn JF, Farine D et al. Adverse Neonatal and Cardiac Outcomes are More Common in Pregnant Women with Cardiac Disease. *Circulation*. 2002; 105: 2179-2184.
- Kuklina EV, Callaghan WM. Chronic Heart Disease and Severe Obstetric Morbidity among Hospitalisations for Pregnancy in the USA: 1995-2006. *BJOG*. 2011; 118: 345-352.

## References

22. Kaemmerer M<sup>1</sup>, Vigl M, Seifert-Klauss V, Nagdyman N, Bauer U, Schneider KT, Kaemmerer H. Counseling Reproductive Health Issues in Women with Congenital Heart Disease. *Clin Res Cardiol.* 2012 Nov; 101(11): 901-7.
23. Simpson LL. Preconception Considerations. *Seminars in Perinatology.* 2014; 38: 236-239.
24. Wilson RD, Johnson JA, Wyatt P, Allen V, Gagnon A et al. Preconceptional Vitamin/ Folic acid Supplementation 2007: The Use of Folic Acid in Combination with a Multivitamin Supplement for the Prevention of Neural Tube Defects and Other Congenital Anomalies. *J Obstet Gynaecol Can.* 2007; 29: 1003-1026.
25. Romano-Zelekha O, Hirsh R, Bliden L, Green M, Shohat T. The Risk for Congenital Heart Defects in Offspring of Individuals with Congenital Heart Defects. *Clin Genet.* 2001; 59(5): 325-9.
26. Nora JJ. From Generational Studies to a Multilevel Genetic-environmental Interaction. *J Am Coll Cardiol.* 1994; 23: 1468-71.
27. Botto LD, May K, Fernhoff PM, Correa A, Coleman K et al. A Population-based Study of the 22q11.2 Deletion: Phenotype, Incidence, and Contribution to Major Birth Defects in the Population. *Pediatrics.* 2003 Jul; 112(1 Pt 1): 101-7.
28. Calcagni G, Digilio M, Sarkozy A, Dallapiccola B, Marino B. Familial Recurrence of Congenital Heart Disease: An Overview and Review of the Literature. *Eur J Pediatr.* 2007; 166: 111-116.
29. Hyett J, Perdu M, Sharland G, Snijders R, Nicolaides KH. Using Fetal Nuchal Translucency to Screen for Major Congenital Cardiac Defects at 10-14 Weeks of Gestation: Population based Cohort Study. *Br Med J.* 1999; 318: 81-5.
30. Koren G, Pastuszak A, Ito S. Drugs in Pregnancy. *N Engl J Med.* 1998; 338(16): 1128-1137.
31. Niebyl J, Simpson J. Teratology and Drugs in Pregnancy. *Glob. Libr. Women's Med.* (ISSN: 1756-2228) 2008; DOI 10.3843/GLOWM.10096
32. US Food and Drug Administration. Pregnancy and Lactation Labeling Final Rule. Available at <http://www.fda.gov/Drugs/DevelopmentApprovalProcess/DevelopmentResources/Labeling/ucm093307.htm>
33. Peters SL, Lind JN, Humphrey JR, Friedman JM, Honein MA, Tassinari MS, Moore CA, Mathis LL, Broussard CS. Safe Lists for Medications in Pregnancy: Inadequate Evidence Base and Inconsistent Guidance from Web-based Information, 2011. *Pharmacoepidemiol Drug Saf.* 2013; 22: 324-8.
34. Schaefer C. Angiotensin II-receptor-antagonists: Further Evidence of Fetotoxicity but not Teratogenicity. *Birth Defects Res A Clin Mol Teratol.* 2003; 67: 591-594.
35. Lip GH, Churchill D, Beevers M, Auckett A, Beevers DG. Angiotensin-converting-enzyme Inhibitors in Early Pregnancy. *Lancet.* 1997; 350: 1446-7.
36. Centres for Disease Control and Prevention. Postmarketing Surveillance for Angiotensin-converting Enzyme Inhibitor Use during the First Trimester of Pregnancy—United States, Canada, and Israel, 1987–1995. *JAMA.* 1997; 277: 1193-4.
37. Bar J, Hod M, Merlob P. Angiotensin Converting Enzyme Inhibitors Use in the First Trimester of Pregnancy. *Intern J Risk & Safety in Med.* 1997; 10: 23-6.
38. Steffensen FH, Nielsen GL, Sørensen HT, Olesen C, Olsen J. Pregnancy Outcome with ACE-inhibitor Use in Early Pregnancy. *Lancet.* 1998; 351: 596.
39. Cooper WO, Hernandez-Diaz S, Arbogast PG, Dudley JA, Dyer S, Gideon PS, Hall K, Ray WA. Major Congenital Malformations after First-trimester Exposure to ACE Inhibitors. *N Engl J Med.* 2006; 354: 2443-2451.
40. Tranquilli AL, Dekker G, Magee L, Roberts J, Sibai BM et al. The Classification, Diagnosis and Management of the Hypertensive Disorders of Pregnancy: A Revised Statement from the ISSHP. *Pregnancy Hypertension.* 2014; 4: 97-104.
41. Waugh JJS, Gupta M, Rushbrook J, Halligan A, Shennan AH. Hidden Errors of Aneroid Sphygmomanometers. *Blood Pressure Monit.* 2002; 7(6): 309-12.
42. Documents of the Health Protection Agency. Radiation, Chemical and Environmental Hazards. March 2009. RSE-9 Protection of Pregnant Patients during Diagnostic Medical Exposures to Ionising Radiation. Advice from the Health Protection Agency, The Royal College of Radiologists and the College of Radiographers.

## References

43. Royal College of Obstetricians and Gynaecologists. Good Practice No 13. Cardiac disease in Pregnancy. June 2011.
44. Roche-Kelly E, Piercy CN. Managing Cardiovascular Disease during Pregnancy: Best Practice to Optimise Outcomes. *Future Cardiol.* 2014; 10: 421-433.
45. Jozwiak M, Bloemenkamp KW, Kelly AJ, Mol BW, Iiron O, Boulvain M. Mechanical Methods for Induction of Labour. *Cochrane Database Syst Rev.* 2012 Mar 14; 3: CD001233.
46. Taher SE, Inder JW, Soltan SA, Eliaho J, Edmonds DK, Bennett P. Prostaglandin E2 Vaginal Gel or Tablets for the Induction of Labour at Term: A Randomised Controlled Trial. *BJOG.* 2011; 118(6): 719-725.
47. Thomas J, Fairclough A, Kavanagh J, Kelly AJ. Vaginal Prostaglandin (PGE2 and PGF2a) for Induction of Labour at Term. *Cochrane Database Syst Rev.* 2014 Jun 19; 6: CD003101.
48. Royal College of Obstetricians and Gynaecologists. Tocolysis for Women in Pre Term Labor. GreenTop Guideline No 1b. February 2011.
49. Hubinont C, Debieve F. Prevention of Preterm Labour: 2011 Update on Tocolysis. *Journal of Pregnancy.* Volume 2011 (2011), Article ID 941057.
50. Siu S, Colman J. Heart Disease and Pregnancy. *Heart.* 2001; 85: 710-715.
51. Ministry of Health Malaysia. Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism. 2013.
52. Gelson E, Johnson M, Gatzoulis M, Uebing A. Cardiac Disease in Pregnancy Part 1. Congenital Heart Disease. Review. *The Obstetrician & Gynaecologist.* 2007; 9: 15-20.
53. Brent RL. The Effect of Embryonic and Fetal Exposure to X-ray, Microwaves, and Ultrasound: Counselling the Pregnant and Nonpregnant Patient about these Risks. *Semin Oncol.* 1989; 16: 347-368.
54. American College of Obstetricians and Gynecologists. Committee Opinion No 656, February 2016. (replaces No. 299, September 2004). Guidelines for Diagnostic Imaging during Pregnancy and Lactation. *Obstet Gynecol.* 2016; 127: e75-80.
55. Iscan ZF, Mavioglu L, Vural KM, Kucukler S, Birincioglu L. Cardiac Surgery during Pregnancy. *J Heart Valve Dis.* 2006; 15: 686-690.
56. Weiss BM, von Segesser LK, Alon E, et al. Outcome of Cardiovascular Surgery and Pregnancy: A Systematic Review of the Period 1984-1996. *Am J Obstet Gynecol.* 1998; 179(6 Pt 1): 1643-53.
57. Parry AJ, Westaby S. Cardiopulmonary Bypass during Pregnancy. *Ann Thorac Surg.* 1996; 61: 1865-9.
58. Salazar E, Espinola N, Molina FJ, Reyes A, Barragán R. Heart Surgery with Cardiopulmonary Bypass in Pregnant Women. *Arch Cardiol Mex.* 2001; 71: 20-27.
59. Sepehripour AH, Lo TT, Shipolini AR, McCormack DJ. Can Pregnant Women be Safely Placed on Cardiopulmonary Bypass? *Interact Cardiovasc Thorac Surg.* 2012 Dec; 15(6): 1063-1070.
60. John AS, Gurley F, Schaff HV, Warner CA, Phillips SD et al. Cardiopulmonary Bypass During Pregnancy. *Ann Thorac Surg.* 2011; 91(4): 1191-1196.
61. Kapoor MC. Cardiopulmonary Bypass in Pregnancy. *Ann Card Anaesth.* 2014; 17: 33.
62. Baschat AA, Cosmi E, Bilardo CM, Wolf H, Berg C et al. Predictors of Neonatal Outcome in Early-onset Placental Dysfunction. *Obstet Gynecol.* 2007; 109: 253-261.
63. Yuan SM. Indications for Cardiopulmonary Bypass during Pregnancy and Impact on Fetal Outcomes. *Geburtshilfe Frauenheilkd.* 2014; 74(1): 55-6.
64. Jafferani A, Malik A, Khawaja RD, et al. Surgical Management of Valvular Heart Diseases in Pregnancy. *Eur J Obstet Gynecol Reprod Biol.* 2011; 159: 91-4.
65. Mahli A, Izdes S, Coskun D. Cardiac Operations during Pregnancy: Review of Factors Influencing Fetal Outcome. *Ann Thorac Surg.* 2000; 69: 1622-6.
66. Pomini F, Mercogliano D, Cavalletti C, Caruso A, Pomini P. Cardiopulmonary Bypass in Pregnancy. *Ann Thorac Surg.* 1996; 61: 259-68.
67. Patel A, Asopa S, Tang At et al. Cardiac Surgery during Pregnancy. *Tex Heart Inst J.* 2008; 35(3): 307-12.
68. Abdul Aziz KA, Meduoye A. Is pH-stat or Alpha-stat the Best Technique to Follow in Patients Undergoing Deep Hypothermic Circulatory Arrest? *Interact Cardiovasc Thorac Surg.* 2010; 0(2): 271-82.

## References

69. Dob DP, Yentis S M. Practical Management of the Parturient with Congenital Heart Disease. *Int J Obstet Anesth.* 2006; 15: 137-144.
70. Burt CC, Jacqueline D. Management of Cardiac Disease in Pregnancy. *Contin Educ Anaesth Crit Care Pain.* 2009; 9: 44-47.
71. Goldszmidt E, Macarthur A, Silversides C, Colman J, Sewrmer M, Sie S. Anaesthetic Management of a Consecutive Cohort of Women with Heart Disease for Labour and Delivery. *Int Journal of Obs Anesthesia.* 2010; 19: 266-272.
72. Obstetric Anaesthesia & Analgesia Service, Policies and Guidelines, HKL/OAS 2014.
73. Chestnut DH, Wong CA, Tsen LC, Kee WDN, Beilin Y, Mhyre J. Chestnut's Obstetric Anesthesia Principle and Practice, 5<sup>th</sup> Ed. 2014. Elsevier's Saunders.
74. Vahanian A, Baumgartner H, Bax J, Butchart E, Dion R et al. Guidelines on the Management of Valvular Heart Disease: the Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology. *Eur Heart J.* 2007; 28: 230–268.
75. Martinez MV, Rutherford JD. Pulmonary Hypertension in Pregnancy. *Cardiol Rev.* 2013; 21: 167-73.
76. Orme RMLE, Grange CS, Ainsworth QP, Grebenik CR. General Anaesthesia using Remifentanil for Caesarean Section in Parturients with Critical Aortic Stenosis: A Series of Four Cases. *Int J of Obst Anaesth.* 2004; 13: 183-187.
77. Basillai-Marcus AM, Yuan C, Oropello J, Manasia A, Kohli-Seth R, Benjamin E. Pulmonary Hypertension in Pregnancy: Critical Care Management. *Pulmonary Medicine.* 2012. Available at: <http://dx.doi.org/10.1155/2012/709407>
78. Hamlyn EL, Duoglass CA, Plaat F, Crowhurst JA, Stocks GM. Low Dose Sequential Combined Spinal-epidural: An Anaesthetic Technique for Caesarean Section with Significant Cardiac Disease. *Int J of Obst Anaesth.* 2005; 14: 355-361.
79. Francis S, May A. Pregnant Women with Significant Medical Conditions: Anaesthetic Implications. *Contin Educ Anaesth Crit Care Pain.* 2004; 4: 95-97.
80. Silversides CK, Colman JM, Sermer M, Siu SC. Cardiac Risk in Pregnant Women with Rheumatic Mitral Stenosis. *Am J Cardiol.* 2003; 91: 1382-1385.
81. Lesniak-Sobelga A, Tracz W, Kostkiewicz M, Podolec P, Pasowicz M. Clinical and Echocardiographic Assessment of Pregnant Women with Valvular Heart Diseases—Maternal and Fetal Outcome. *Int J Cardiol.* 2004; 94: 15-23.
82. Nishimura RA, Otto CM, Benow RO, Carabello BA, Ervin JP et al. 2014 AHA/ACC Guidelines for the Management of Patients with Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol.* 2014; 63: 2438-2488.
83. al Kasab SM, Sabag T, al Zaibag M, Awaad M, al Bitar I, Halim MA, Abdullah MA, Shahed M, Rajendran V, Sawyer W. Beta-adrenergic Receptor Blockade in the Management of Pregnant Women with Mitral Stenosis. *Am J Obstet Gynecol.* 1990; 163(1 Pt 1): 37-40.
84. Desai PA, Tafreshi J, Pai RG. Review. Beta Blocker Therapy for Valvular Disorders. *J Heart Valve Dis.* 2011; 20: 241-253.
85. Bhargava B, Agarwal R, Yadav R, Bahl VK, Manchanda SC. Percutaneous Balloon Aortic Valvuloplasty during Pregnancy: Use of the Inoue Balloon and the Physiologic Antegrade Approach. *Cathet Cardiovasc Diagn.* 1998; 45: 422-425.
86. Elkayam U, Bitar F. Valvular Heart Disease and Pregnancy: Part II: Prosthetic Valves. *J Am Coll Cardiol.* 2005; 46: 403-410.
87. Presbitero P, Somerville J, Stone S, Aruta E, Spiegelhalter D, Rabajoli F. Pregnancy in Cyanotic Congenital Heart Disease. Outcome of Mother and Fetus. *Circulation.* 1994; 89: 2673-6.
88. Pieper PG, Lameijer H, Hoendermis ES. Pregnancy and Pulmonary Hypertension. *Best Practice & Research in Clinical Obstetrics & Gynaecology.* 2014; 28: 579-591.
89. Ouyang DW, Khairy P, Fernandes SM, Landzberg MJ, Economy KE. Obstetric outcomes in pregnant women with congenital heart disease. *Int. J. Cardiol.* 2009; 144: 195-199.
90. Gelson E, Curry R, Gatzoulis MA, Swan L, Lupton M, Steer P, Johnson M. Effect of Maternal Heart Disease on Fetal Growth. *Obstet Gynecol.* 2011; 117: 886-891.
91. Stout K. Pregnancy in Women with Congenital Heart Disease: The Importance of Evaluation and Counseling. *Heart.* 2005; 91: 713-714.

## References

92. Zuber M, Gautschi N, Oechslin E, Widmer V, Kiowski W, Jenni R. Outcome of Pregnancy in Women with Congenital Shunt Lesions. *Heart*. 1999; 81: 271-5.
93. Warnes CA. Pregnancy and Pulmonary Hypertension. *Int J Cardiol*. 2004; 97(Suppl 1): 11-13.
94. Katsuragi S, Kamiya C, Yamanaka K, et al. Risk Factors for Maternal and Fetal Outcome in Pregnancy Complicated by Ebstein Anomaly. *Am J Obstet Gynecol*. 2013; 209:452.e1-6.
95. Balci A, Drenthen W, Mulder BJM et al. Pregnancy in Women with Corrected Tetralogy of Fallot: Occurrence and Predictors of Adverse Events. *Am Heart J*. 2011; 161: 307-13.
96. Veldtman GR, Connolly HM, Grogan M, Ammash NM, Warnes CA. Outcomes of Pregnancy in Women with Tetralogy of Fallot. *J Am Coll Cardiol*. 2004; 44: 174-80.
97. Silversides CK, Colman JM, Sermer M, Farine D, Siu SC. Early and Intermediate-term Outcomes of Pregnancy with Congenital Aortic Stenosis. *Am J Cardiol*. 2003; 91:1386-9.
98. Yap SC, Drenthen W, Pieper PG, Moons P, Mulder BJ et al, ZAHARA investigators. Risk of Complications during Pregnancy in Women with Congenital Aortic Stenosis. *Int J Cardiol*. 2008; 126(2): 240-6.
99. Drenthen W, Pieper PG, Roos-Hesselink JW, Schmidt ACM, Mulder BJM, van Dijk APJ, Vliegen HW, Sollie KM, Voors AA, Ebels T, van Veldhuisen DJ, on behalf of the ZAHARA investigators. Non-cardiac Complications during Pregnancy in Women with Isolated Congenital Pulmonary Valvar Stenosis. *Heart*. 2006; 92: 1838-1843.
100. Beauchesne LM, Connolly HM, Ammash NM, Warnes CA. Coarctation of the Aorta: Outcome of Pregnancy. *J Am Coll Cardiol*. 2001; 38: 1728-33.
101. Vriend JW, Drenthen W, Pieper PG, Roos-Hesselink JW, Zwinderman AH, van Veldhuisen DJ, et al. Outcome of Pregnancy in Patients after Repair of Aortic Coarctation. *Eur Heart J*. 2005; 26: 2173-8.
102. Connolly HM, Grogan M, Warnes CA. Pregnancy among Women with Congenitally Corrected Transposition of Great Arteries. *J Am Coll Cardiol*. 1999; 33: 1692-5.
103. Kowalik E, Klisiewicz A, Biernacka EK, Hoffman P. Pregnancy and Long-term Cardiovascular Outcomes in Women with Congenitally Corrected Transposition of the Great Arteries. *Int J of Gynecol and Obstet*. 2014; 125: 154-157.
104. Guedes A, Mercier LA, Leduc L, Berube L, Marcotte F, Dore A. Impact of Pregnancy on the Systemic Right Ventricle after a Mustard Operation for Transposition of the Great Arteries. *J Am Coll Cardiol*. 2004; 44: 433-437.
105. Drenthen W, Pieper PG, Ploeg M, Voors AA, Roos-Hesselink JW, Mulder BJ, et al. Risk of Complications during Pregnancy after Senning or Mustard (Atrial) Repair of Complete Transposition of the Great Arteries. *Eur Heart J*. 2005 ;26 : 2588-95.
106. Canobbio MM, Morris CD, Graham TP, Landzberg MJ. Pregnancy Outcomes after Atrial Repair for Transposition of the Great Arteries. *Am J Cardiol*. 2006; 98: 668-72.
107. Gouton M, Nizard J, Patel M, Sassolas F, Jimenez M, Radojevic J et al. Maternal and Fetal Outcomes of Pregnancy with Fontan Circulation: A Multicentric Observational Study. *Int J Cardiol*. 2015; 187: 84-89.
108. Drenthen W, Pieper PG, Roos-Hesselink JW, van Looftum WA, Voors AA et al. Pregnancy and Delivery in Women after Fontan Palliation. *Heart*. 2006; 92(9): 1290-4.
109. Hooper MM, Bogaard HJ, Condliffe R, Frantz R, Khanna D, Kurzyna M, Langenberg D, Manes A, Satoh T, Torres F, Wilkins MR, Badesch DB. Definitions and Diagnosis of Pulmonary Hypertension. *J Am Coll Cardiol*. 2013;c62(Suppl): D42-D50.
110. Simonneau G, Gatzoulis MA, Adatia I, Celermajer D, Denton C, Ghofrani A, Gomez Sanchez MA, Krishna Kumar R , Landzberg M , Machado RF , Olschewski H, Robbins IM, Souza R. Updated Clinical Classification of Pulmonary Hypertension. *J Am Coll Cardiol*. 2013 Dec 24; 62(25 Suppl): D34-41.
111. Galie N, Humbert M, Vachiery JL, Gibbs S, Lang I et al. 2015 ESC/ERS Guidelines for the Diagnosis and Treatment of Pulmonary Hypertension – Web Addenda The Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and of the European Respiratory Society (ERS) Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC), International Society for Heart and Lung Transplantation (ISHLT). *Eur Heart J*. 2015; doi:10.1093/eurheartj/ehv317

## References

112. Hemnes AR, Kiely DG, Cockrill BA, Safdar Z, Wilson VJ et al. Statement on Pregnancy in Pulmonary Hypertension from the Pulmonary Vascular Research Institute. *Pulm Circ.* 2015 Sep; 5(3): 435–465.
113. Bedard E, Dimopoulos K, Gatzoulis MA. Has There been Any Progress Made on Pregnancy Outcomes among Women with Pulmonary Arterial Hypertension? *Eur Heart J.* 2009; 30: 256–65.
114. Weiss BM, Zemp L, Seifert B, et al. Outcome of Pulmonary Vascular Disease in Pregnancy: A Systematic Overview from 1978 through 1996. *J Am Coll Cardiol.* 1998; 31: 1650–7.
115. Katsuragi S, Yamanaka K, Neki R, Kamiya C, Sasaki Y, Osato K. Maternal Outcome in Pregnancy Complicated with Pulmonary Arterial Hypertension. *Circ J.* 2012; 76: 2249–2254.
116. Subbaiah M, Kumar S, Roy KK, Sharma JB, Singh N. Pregnancy Outcome in Women with Pulmonary Arterial Hypertension: Single-center Experience from India. *Arch Gynecol Obstet.* 2013; 288: 305–9.
117. Goland S, Tsai F, Habib M, Janmohamed M, Goodwin TM, Elkayam U. Favorable Outcome of Pregnancy with an Elective Use of Epoprostenol and Sildenafil in Women with Severe Pulmonary Hypertension. *Cardiology.* 2010; 115(3): 205–208.
118. Hsu CH, Gomberg-Maitland M, Glassner C, Chen JH. The management of Pregnancy and Pregnancy-related Medical Conditions in Pulmonary Arterial Hypertension Patients. *Int J Clin Pract Suppl.* 2011; 172: 6–14.
119. Jaïs X, Olsson KM, Barbera JA, Blanco I, Torbicki A, Peacock A, Vizza CD, Macdonald P, Humbert M, Hoeper MM. Pregnancy Outcomes in Pulmonary Arterial Hypertension in the Modern Management Era. *Eur Respir J.* 2012; 40: 881–5.
120. Kurihara Y, Kurihara H, Oda H et al. Aortic Arch Malformations and Ventricular Septal Defect in Mice Deficient in Endothelin-1. *J Clin Investig.* 1995; 96(1): 293–300.
121. Momma K, Nakanishi T, Imamura S. Inhibition of in Vivo Constriction of Fetal Ductus Arteriosus by Endothelin Receptor Blockade in Rats. *Pediatr Res.* 2003; 53(3): 479–485.
122. Bonnin M, Mercier FJ, Sitbon O, Roger-Christoph S, Jaïs X et al. Severe Pulmonary Hypertension during Pregnancy: Mode of Delivery and Anesthetic Management of 15 Consecutive Cases. *Anesthesiology.* 2005; 102(6): 1133–1137.
123. Duggan AB, Katz SG. Combined Spinal and Epidural Anaesthesia for Caesarean Section in a Parturient with Severe Primary Pulmonary Hypertension. *Anaesth Intensive Care.* 2003; 31(5): 565–569.
124. Ghai B, Mohan V, Khetarpal M, Malhotra N. Epidural Anesthesia for Caesarean Section in Patient with Eisenmenger's Syndrome. *Int J Obstet Anesth.* 2002; 11: 44–47.
125. Blaise G, Langleben D, Hubert B: Pulmonary Arterial Hypertension: Pathophysiology and Anesthetic Approach. *Anesthesiology.* 2003; 99: 1415–1432.
126. Barash PG, Nardi D, Hammond G, Walker-Smith G, Capuano D, Laks H, Kopriva CJ, Barre AE, Geha AS: Catheter-induced Pulmonary Artery Perforation: Mechanisms, Management, and Modifications. *J Thorac Cardiovasc Surg.* 1981; 82: 5–12.
127. Weiss BM, Maggiorini M, Jenni R, Lauper U, Popov V, Bombeli T, Spahn DR: Pregnant Patient with Primary Pulmonary Hypertension: Inhaled Pulmonary Vasodilators and Epidural Anesthesia for Cesarean Delivery. *Anesthesiology.* 2000; 92: 1191–4.
128. Price LC, Forrest P, Sodhi V, Adamson DL, Nelson-Piercey C et al. Use of Vasopressin after Caesarean Section in Idiopathic Pulmonary Arterial Hypertension. *Br J Anaesth.* 2007; 99: 552–555.
129. Cunningham JA, Devine PC, Jelic S. Extracorporeal Membrane Oxygenation in Pregnancy. *Obstet Gynecol.* 2006; 108(3Pt2): 792–795.
130. King PT, Rosalion A, McMillan J, Buist M, Holmes PW. Extracorporeal Membrane Oxygenation in Pregnancy. *Lancet.* 2000; 356(9223): 45–46.
131. Sylvia De Biea S, De Paepela, Delvauxa I, Davies S, Hennekamrc RCM. Marfan Syndrome in Europe A Questionnaire Study on Patient Perceptions. *Community Genet.* 2004; 7: 216–225.
132. Meijboom LJ, Mulder BJM. Management of pregnancy in Marfan's syndrome, Ehler's Danlos Syndrome and Other Heritable Connective Tissue Disorders. In *Heart Disease in Pregnancy*, Oakley CM, Warnes CA Ed. 2<sup>nd</sup> Ed 2007. Blackwell Publishing.
133. Oakley CM, Child A, Jung B, Presbitero P, Tornos P et al. Expert Consensus Document on Management of Cardiovascular Diseases during Pregnancy. *Eur Heart J.* 2003; 24: 761–781.

## References

134. Immer FF, Bansi AG, Immer-Bansi AS, McDougall J, Zehr KJ, Schaff HV, Carrel TP. Aortic Dissection in Pregnancy: Analysis of Risk Factors and Outcome. *Ann Thorac Surg.* 2003; 76: 309–314.
135. Meijboom LJ, Vos FE, Timmermans J, Boers GH, Zwinderman AH, Mulder BJ. Pregnancy and Aortic Root Growth in the Marfan Syndrome: A Prospective Study. *Eur Heart J.* 2005; 26: 914–920.
136. Goland S, Elkayam U. Cardiovascular Problems in Pregnant Women with Marfan Syndrome. *Circulation.* 2009; 119: 619–623.
137. Lalchandani S, Wingfield M. Pregnancy in Women with Marfan's Syndrome. *Eur J Obstet Gynecol.* 2003; 110: 125–130.
138. Donnelly RT, Pinto NM, Kocolas I, Yetman AT. The Immediate and Long Term Impact of Pregnancy on Aortic Growth Rate and Mortality in Women with Marfan Syndrome. *J Am Coll Cardiol.* 2012; 60: 224–229.
139. Akashi H, Tayama K, Fujino T, et al. Surgical Treatment for Acute Type A Aortic Dissection in Pregnancy: A Case of Aortic Root Replacement Just after Cesarean Section. *Jpn Circ J.* 2000; 64: 729–730.
140. Pacini L, Digne F, Boumendil A, Muti C, Detaint D, Boileau C, Jondeau G. Maternal Complication of Pregnancy in Marfan Syndrome. *Int J Cardiol.* 2009; 136: 156–161.
141. Lind J, Wallenburg HC. The Marfan Syndrome and Pregnancy: A Retrospective Study in a Dutch Population. *Eur J Obstet Gynecol Reprod Biol.* 2001; 98: 28–35.
142. Keane MG, Pyeritz RE. Aortic Diseases. Medical Management of Marfan Syndrome. *Circulation.* 2008; 117: 2802–2813.
143. Gordon CF 3<sup>rd</sup>, Johnson MD. Anesthetic Management of the Pregnant Patient with Marfan Syndrome. *J Clin Anesth.* 1993; 5: 248–251.
144. Allyn J, Guglielminotti J, Omnes S, Guezouli L, Egan M et al. Marfan's Syndrome during Pregnancy: Anesthetic Management of Delivery in 16 Consecutive Patients. *Anesth Analg.* 2013; 116: 392–8.
145. James AH, Jamison MG, Biswas MS, Brancazio LR, Swamy GK, Myers ER. Acute Myocardial Infarction in Pregnancy. A United States Population-Based Study. *Circulation.* 2006; 113: 1564–1571.
146. Roth A, Elkayam U: Acute Myocardial Infarction Associated with Pregnancy. *Ann Intern Med.* 1996; 125: 751–762.
147. Roth A, Elkayam U: Acute Myocardial Infarction Associated with Pregnancy. *J Am Coll Cardiol.* 2008; 52: 171–180.
148. Kealey AJ. Coronary Artery Disease and Myocardial Infarction in Pregnancy: A Review of Epidemiology, Diagnosis, and Medical and Surgical Management. *Can J Cardiol.* 2010; 26: e185–e189.
149. Shade GH, Jr, Ross G, Bever FN, Uddin Z, Devireddy L, Gardin JM. Troponin I in the Diagnosis of Acute Myocardial Infarction in Pregnancy, Labor, and Post-partum. *Am J Obstet Gynecol.* 2002; 187: 719–20.
150. Sadeghi MRT, Aslanabadi N, Aghdam NK, Parizad R , Namdar H. Pregnancy-related Acute Myocardial Infarction: A Review of Epidemiology, Diagnosis, Medical and Surgical Management. *IJWHR.* 2014; 2: 272–277.
151. Imperiale TF, Petruis AS. A Meta-analysis of Low-dose Aspirin for the Prevention of Pregnancy-induced Hypertensive Disease. *JAMA.* 1991 Jul 10; 266(2): 260–4.
152. Bates SM, Greer IA, Hirsh J, Ginsberg JS. Use of Antithrombotic Agents during Pregnancy: The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest.* 2004 Sep; 126(3 Suppl): 627S-644S.
153. Yarrington CD, Valente AM, Economy KE. Cardiovascular Management in Pregnancy. Antithrombotic Agents and Antiplatelet Agents. *Circulation.* 2015; 132: 1354–1364.
154. Karamermer Y, Roos-Hesselink JW. Coronary Heart Disease in Pregnancy. *Future Cardiol.* 2007; 3: 559–567.
155. Elliott P, Andersson B, Arbustini E, Bilinska Z, Cecchi F et al. A Classification of the Cardiomyopathies: A Position Statement from the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. *Eur Heart J.* 2008; 29: 270–276.

## References

156. Pearson GD, Veille JC, Rahimtoola S, Hsia J, Oakley CM et al. Peripartum Cardiomyopathy: National Heart, Lung, and Blood Institute and Office of Rare Diseases (National Institutes of Health) Workshop. Recommendations and Review. *JAMA*. 2000; 283: 1183-1188.
157. Chee KH, Azman W. Prevalance and Outcome of Peripartum Cardiomyopathy in Malaysia. *Int J Clin Pract*. 2009; 63: 722-725.
158. Whitehead SJ, Berg CJ, Chang J. Pregnancy-related Mortality due to Cardiomyopathy: United States, 1991-1997. *Obstet Gynecol*. 2003; 102: 1326-1331.
159. Fett JD. Peripartum Cardiomyopathy. Insights from Haiti regarding a Disease of Unknown Etiology. *Minn Med*. 2002; 85: 46-48.
160. Johnson-Coyle L, Jensen L, Sobey A. Peripartum Cardiomyopathy: Review and Practice Guidelines. *Am J Crit Care*. 2012; 21: 89-98.
161. Elkayam U. Risk of Subsequent Pregnancy in Women with a History of Peripartum Cardiomyopathy. *J Am Coll Cardiol*. 2014; 64: 1629-1636.
162. Habli M, O'Brien T, Nowack E, Khoury S, Barton JR, Sibai B. Peripartum Cardiomyopathy: Prognostic Factors for Long-term Maternal Outcome. *Am J Obstet Gynecol*. 2008; 199: 415.e411-e415.
163. Dorbala S, Brozena S, Zeb S, Galatro K, Homel P et al. Risk Stratification of Women with Peripartum Cardiomyopathy at Initial Presentation: A Dobutamine Stress Echocardiography Study. *JASE*. 2005; 18: 45-48.
164. Ministry Of Health. Clinical Practice Guidelines. Management of Heart Failure 3<sup>rd</sup> Edition, 2014. Available at [www.acadmed.com.my](http://www.acadmed.com.my)
165. Elkayam U, Akjter MW, Singh H, Khan S, Bitar F, Hameed A, Shotan A. Pregnancy-associated Cardiomyopathy: Clinical Characteristics and a Comparison between Early and Late Presentation. *Circulation*. 2005; 111: 2050-5.
166. Cooper LT, Mather PJ, Alexis JD, Pauly DF, Torre-Amione G et al for the IMAC2 Investigators. Myocardial Recovery in Peripartum Cardiomyopathy: Prospective Comparison with Recent Onset Cardiomyopathy in Men and Nonperipartum Women. *J Card Fail*. 2012; 18: 28-33.
167. Pillarisetti J, Kondu A, Alanai A, Reddy M, Reddy M et al. Peripartum Cardiomyopathy. Predictors of Recovery and Current State of Implantable Cardioverter Defibrillator Use. *J Am Coll Cardiol*. 2014; 63(25 PA): 2831-2839.
168. Ramaraj R, Sorell V. Peripartum Cardiomyopathy: Causes, Diagnosis and Treatment. *Clev Clin Med*. 2009; 76(5): 289-296.
169. Sliwa K, Blauwet L, Tibazarwa K, Libhaber E, Smedema J-P et al. Evaluation of Bromocriptine in the Treatment of Acute Severe Peripartum Cardiomyopathy: A Proof of Concept Pilot Study. *Circulation*. 2010; 121: 1465-1473.
170. Fett JD, Christie LG, Carraway RD, Murphy JG. Five Year Prospective Study of the Incidence and Prognosis of Peripartum Cardiomyopathy at a Single Institution. *Mayo Clin Proc*. 2005; 80(12): 1602-1606.
171. Elkayam U. Clinical Characteristics of Peripartum Cardiomyopathy in the United States. Diagnosis, Prognosis and Management. *J Am Coll Cardiol*. 2011; 58: 659-670.
172. Abboud J, Murad Y, Scarabelli TM, Saravolatz I. Peripartum Cardiomyopathy: A Comprehensive Review. *Int J Cardiol*. 2007; 118: 295-303.
173. Felker GM, Thompson RE, Hare JM, Hrubaian HR, Clemetson DE et al. Underlying Causes and Long-term Survival in Patients with Initially Unexplained Cardiomyopathy. *N Engl J Med*. 2000; 342: 1077-1084.
174. Sliwa K, Hilfiker-Kleiner D, Petrie MC, Mebazaa A, Pieske B et al. Current State of Knowledge on Aetiology, Diagnosis, Management, and Therapy of Peripartum Cardiomyopathy: A Position Statement from the Heart Failure Association of the European Society of Cardiology Working Group on Peripartum Cardiomyopathy. *Eur J Heart Fail*. 2010; 12: 767-778.
175. Elkayam U, Tummala PP, Rao K, et al. Maternal and Fetal Outcomes of Subsequent Pregnancies in Women with Peripartum Cardiomyopathy. *N Engl J Med*. 2001; 344 : 1567-71.
176. Rakar S, Sinagra G, Di Lenarda A, Poletti A, Bussani R, Silvestri F, et al. Epidemiology of Dilated Cardiomyopathy. A Prospective Post-mortem Study of 5252 Necropsies. The Heart Muscle Disease Study Group. *Eur Heart J*. 1997 Jan. 18(1): 117-23.

## References

177. Bollen IAE, Van Deel ED, Kuster DWD and Van Der Velden J. Peripartum Cardiomyopathy and Dilated Cardiomyopathy: Different at Heart. *Front physiol.* 2015; 5: 531.
178. Grewal J, Siu SC, Ross HJ, Mason J, Balint OH, Sermer M, Colman JM, Silversides CK. Pregnancy Outcomes in Women with Dilated Cardiomyopathy. *J Am Coll Cardiol.* 2009; 55: 45–52.
179. Autore C, Conte MR, Piccininno M, Bernabo P, Bonfiglio G, Bruzzi P, Spirito P. Risk Associated with Pregnancy in Hypertrophic Cardiomyopathy. *J Am Coll Cardiol.* 2002; 40: 1864–1869.
180. Spirito P, Autore C. Management of Hypertrophic Cardiomyopathy. *Br Med J.* 2006; 332:1251–1255.
181. Joglar JA, Page RL. Management of Arrhythmia Syndromes during Pregnancy. *Curr Opin Cardiol.* 2014 Jan; 29(1): 36–44.
182. Enriquez AD, Economy KE, Tedrow UB. Advances in Arrhythmia and Electrophysiology. Contemporary Management of Arrhythmias during Pregnancy. *Circulation: Arrhythmia and Electrophysiology.* 2014; 7: 961–967.
183. Li JM, Nguyen C, Joglar JA, Hamdan MH, Page RL. Frequency and Outcome of Arrhythmias Complicating Admission during Pregnancy: Experience from a High-volume and Ethnically-diverse Obstetric Service. *Clin Cardiol.* 2008; 31: 538–541.
184. Shotan A, Ostrzega E, Mehra A, Johnson JV, Elkayam U. Incidence of Arrhythmias in Normal Pregnancy and Relation to Palpitations, Dizziness, and Syncope. *Am J Cardiol.* 1997; 79: 1061–1064.
185. Silversides CK, Harris L, Haberer K, Sermer M, Colman JM, Siu SC. Recurrence Rates of Arrhythmias during Pregnancy in Women with Previous Tachyarrhythmia and Impact on Fetal and Neonatal Outcomes. *Am J Cardiol.* 2006; 97(8): 1206–1212.
186. Baig M. Arrhythmia-centered Treatment Review of Tachyarrhythmia during Pregnancy. An Article from the e-journal of the ESC Council for Cardiology Practice 2014; 12: N° 13.
187. Perez-Silva A, Merino JL. Tachyarrhythmias and Pregnancy. An article from the e-journal of the ESC Council for Cardiology Practice. 2011; 9: N° 31
188. Page RL, Joglar JA, Caldwell MA, Hammill SC, Calkins H et al. 2015 ACC/AHA/HRS Guideline for the Management of Adult Patients With Supraventricular Tachycardia A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *Circulation.* 2015; 132: e000–e000.
189. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE et al. 2014 AHA/ACC/HRS Guideline for the Management of patients with Atrial Fibrillation. Executive summary. A Report of The American College of Cardiology/American Heart association Task Force on Practice guidelines and the Heart Rhythm Society. *J Am Coll Cardiol.* 2014; 64: 2246–2280.
190. Szumowski L, Szufładowicz E, Orczykowski M, Bodalski R, Derejko P et al. Ablation of Severe Drug-resistant Tachyarrhythmia during Pregnancy. *J Cardiovasc Electrophysiol.* 2010; 21: 877–882.
191. Hidaka N, Chiba Y, Fukushima K, Wake N. Pregnant women with complete atrioventricular block: perinatal risks and review of management. *Pacing Clin Electrophysiol.* 2011; 34: 1161–1176.
192. Lip G, Beevers M, Chruchill D, Shaffer L, Beevers G. Effect of Atenolol on Birth Weight. *Am J Cardiol.* 1997; 79; 1436–38.
193. Butters L, Kennedy S, Rubin P. Atenolol in Essential Hypertension during Pregnancy. *Br Med J.* 1990; 301: 587–9.
194. Wan Ahmad WA, Khanom M, Yaakob ZH. Heart Failure In Pregnancy: An Overview. *Int J Clin Pract.* 2011; 65(8): 848–51.
195. Whitlock RP, Sun JC, Fremes SE, Rubens FD, Teoh KH. Antithrombotic and Thrombolytic Therapy for Valvular Disease: Antithrombotic Therapy and Prevention of Thrombosis, 9<sup>th</sup> ed.: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest.* 2012; 141(2 Suppl): e576S–600S.
196. Abildgaard U, Sandset PM, Hammerstrom J, Gjestvang FT, Tveit A. Management of Pregnant Women with Mechanical Heart Valve Prosthesis: Thromboprophylaxis with Low Molecular Weight Heparin. *Thromb Res.* 2009; 124: 262–267.
197. Elkayam U, Bitar F. Valvular Heart Disease and Pregnancy. Part II. *J am Coll Cardiol.* 2005; 46: 403–410.

## References

198. Chan WS, Anand S, Ginsberg JS. Anticoagulation of Pregnant Women with Mechanical Heart Valves: A Systematic Review of the Literature. *Arch Intern Med.* 2000; 160: 191–196.
199. Nishimura RA, Warnes CA. Anticoagulation during Pregnancy in Women with Prosthetic Valves: Evidence, Guidelines and Unanswered Questions. *Heart.* 2015; 0: 1–6.
200. van Driel D, Wesseling J, Sauer PJ, Touwen BC, van der Veer E, Heymans HS. Teratogen Update: Fetal Effects after in Utero Exposure to Coumarins. Overview of Cases, Follow-up Findings, and Pathogenesis. *Teratology.* 2002; 66: 127–140.
201. Cotrufo M, De Feo M, De Santo LS, Romano G, Della Corte A, Renzulli A, Gallo C. Risk of Warfarin during Pregnancy with Mechanical Valve Prostheses. *Obstet Gynecol.* 2002; 99: 35–40.
202. Oran B, Lee-Parritz A, Ansell J. Low Molecular Weight Heparin for the Prophylaxis of Thromboembolism in Women with Prosthetic Mechanical Heart Valves during Pregnancy. *Thromb Haemost.* 2004; 92: 747–751.
203. Elkayam U, Singh H, Irani A, Akhter MW. Anticoagulation in Pregnant Women with Prosthetic Heart Valves. *J Cardiovasc Pharmacol Ther.* 2004; 9: 107–115.
204. McLintock C, McCowan LM, North RA. Maternal Complications and Pregnancy Outcome in Women with Mechanical Prosthetic Heart Valves Treated with Enoxaparin. *BJOG.* 2009; 116: 1585–1592.
205. Quinn J, Von Klemperer K, Brooks R, Peebles D, Walker F, Cohen H. Use of High Intensity Adjusted Dose Low Molecular Weight Heparin in Women with Mechanical Heart Valves during Pregnancy: A Single-center Experience. *Haematologica.* 2009; 94: 1608–1612.
206. Yinon Y, Siu SC, Warshafsky C, Maxwell C, McLeod A, Colman JM, Sermer M, Silversides CK. Use of Low Molecular Weight Heparin in Pregnant Women with Mechanical Heart Valves. *Am J Cardiol.* 2009; 104: 1259–1263.
207. Schaefer C, Hannemann D, Meister R, Elefant E, Paulus W, Vial T, Reuvers M, Robert-Gnansia E, Arnon J, De Santis M, Clementi M, Rodriguez-Pinilla E, Dolivo A, Merlob P. Vitamin K Antagonists and Pregnancy Outcome. A Multi-centre Prospective Study. *Thromb Haemost.* 2006; 95: 949–957.
208. van Hagen IM, Roos-Hesselink JW, Ruys TPE, Merz WM, Goland S etc on behalf of the ROPAC Investigators and the EURObservational Research Programme (EORP) Team. Pregnancy in Women With a Mechanical Heart Valve. Data of the European Society of Cardiology Registry of Pregnancy and Cardiac Disease. *Circulation.* 2015; 132: 132–142.
209. Butchart EG, Gohlke-Barwolf C, Antunes MJ, Tornos P, De Caterina R et al. Recommendations for the Management of Patients after Heart Valve Surgery. *Eur Heart J.* 2005; 26: 2463–2471.
210. Bates SM, Greer IA, Middeldorp S, Veenstra DL, Prabulos A-M, Vandvik PO. VTE, Thrombophilia, Antithrombotic Therapy, and Pregnancy: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest.* 2012; 141(2\_suppl): e691S-e736S.
211. Vitale N, De Feo M, De Santo LS, Pollice A, Tedesco N, Cotrufo M. Dose-dependent Fetal Complications of Warfarin in Pregnant Women with Mechanical Heart Valves. *J Am Coll Cardiol.* 1999; 33: 1637–1641.
212. Goland S, Elkavam U. Anticoagulation in Pregnancy. *Cardiol Clin.* 2012; 30(3): 395–405.
213. Barbour LA, Oja JL, Schultz LK. A Prospective Trial that Demonstrates that Dal-teparin Requirements Increase in Pregnancy to Maintain Therapeutic Levels of Anticoagulation. *Am J Obstet Gynecol.* 2004; 191: 1024–1029.
214. Friedrich E, Hameed AB. Fluctuations in Anti-factor Xa Levels with Therapeutic Enoxaparin Anticoagulation in Pregnancy. *J Perinatol.* 2010; 30: 253–257.
215. Lebaudy C, Hulot JS, Amoura Z, Costedoat-Chalumeau N, Serreau R, Ankri A, Conard J, Cornet A, Dommergues M, Piette JC, Lechat P. Changes in Enoxaparin Pharmacokinetics during Pregnancy and Implications for Antithrombotic Therapeutic Strategy. *Clin Pharmacol Ther.* 2008; 84: 370–377.
216. Thromboembolism in Pregnancy. ACOG Practice Bulletin 123. American College of Obstetricians and Gynecologists. *Obstet Gynecol.* 2011; 118: 718–729.

## References

217. Douketis JD, Spyropoulos AC, Kaatz S, Becker RC, Caprini JA, Dunn AS, Garcia DA, Jacobson A, Jaffer AK, Kong DF, Schulman S, Turpie AG, Hasselblad V, Ortel TL; BRIDGE Investigators. Perioperative Bridging Anticoagulation in Patients with Atrial Fibrillation. *N Engl J Med.* 2015 Aug 27; 373(9): 823-33.
218. January CT, Wann LS, Alpert JS, Calkins C, Cigarroa JE et al. 2014 AHA/ACC/HRS Guideline for the Management of Patients with Atrial Fibrillation: Executive Summary: A report of the American College of Cardiology/American Heart Association. *J Am Coll Cardiol.* 2014; 64: 2246-2280.
219. Cox SM, Hanks GDV, Leveno KJ, Cunningham FG. Bacterial Endocarditis: A Serious Pregnancy Complication. *J Reprod Med.* 1988; 33: 671-4.
220. Montoya ME, Karnath BM, Ahmad M. Endocarditis during Pregnancy. *South Med J.* 2003; 96: 1156-1157.
221. Kebed KY, Bishu K, Adham A, Baddour LM, Connolly HM et al. Pregnancy and Postpartum Infective Endocarditis: A Systematic Review. *Mayo Clin Proc.* 2014; 89(8): 1143-52.
222. Yuan SH. Infective Endocarditis during Pregnancy. *J Coll Phys and Surg Pak.* 2014; 25: 134-139.
223. Ministry Of Health, Malaysia. National Antibiotic Guideline 2014. Available at [www.pharmacy.gov.my](http://www.pharmacy.gov.my)
224. Malhotra A, Prendergast BD. Evaluating Treatment Options for Patients with infective Endocarditis: When is it the Right Time for Surgery? *Future Cardiol.* 2012; 8: 847-861.
225. Habib G, Lancelotti P, Antunes MJ, Bongiorni MG, Casalta J-P et al. 2015 ESC Guidelines for the Management of Infective Endocarditis. *Eur Heart J.* 2015; 36: 3075-3128.
226. Warnes CA, Williams RG, Bashore TM, Child JS, Connolly HM et al. ACC/AHA 2008 Guidelines for the Management of Adults With Congenital Heart Disease. A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Writing Committee to Develop Guidelines on the Management of Adults with Congenital Heart Disease. *Circulation.* 2008; 118: e714-e833.
227. Van Schalkwyk J, Van Eyk N, Yudin MH, Boucher M, Cormier B et al. Antibiotic Prophylaxis in Obstetric Procedures. SOGC Clinical Practice Guideline. *J Obstet Gynaecol Can.* 2010; 32(9): 878-892.
228. The Royal College of Obstetricians and Gynaecology and the Royal College of Midwives. NICE Guidelines (CG 107). Hypertension in Pregnancy: Management of Hypertensive Disorders in Pregnancy. August 2010. (Revised reprint January 2011) Available at [www.nice.org.uk/guidance/cg107](http://www.nice.org.uk/guidance/cg107)
229. Division of Family Health Development Division. Ministry of Health, Malaysia. Training Manual on Hypertensive Disorders in Pregnancy. Revised 2014.
230. Brown MA, Lindheimer MD, deSwiet Am, Van Assche A, Moutquin JM. The Classification and Diagnosis of the Hypertensive Disorders in Pregnancy: Statement from the International Society for the Study of Hypertension in Pregnancy (ISHHP). *Hypertension in Pregnancy.* 2001; 20(1): ix-xiv.
231. Report of the National High Blood Pressure Education Program Working Survey on High Blood Pressure in Pregnancy. *Am J Obstet Gynecol.* 2000; 183: S1-22.
232. Levine RJ, Ewell MG, Hauth JC, Curet LB, Catalano PM et al. Should the Definition of Preeclampsia Include a Rise in Diastolic Blood Pressure of  $\leq$  15 mmHg to a Level  $<$  90 mmHg in Association with Proteinuria? *Am J Obstet Gynecol.* 2000; 183: 787-792.
233. Franklin SS, Thijss L, Hansen TW, O'Brien E, Staessen JA. White-coat Hypertension: New Insights from Recent Studies. *Hypertension.* 2013; 62(6): 982-7.
234. Brown MA, Mangos G, Davis G, Homer C. The Natural History of White Coat Hypertension during Pregnancy. *BJOG.* 2005; 112(5): 601-6.
235. NICE Guidance. Hypertension in pregnancy. NICE Quality Standard. Quality Statement 2. QS 35. July 2013. Available at [www.nice.org.uk/guidance/qs35](http://www.nice.org.uk/guidance/qs35)
236. Hofmeyr G, Lawrie TA, Atallah ÁN, Duley L, Torloni MR. Calcium Supplementation during Pregnancy for Preventing Hypertensive Disorders and Related Problems. *Cochrane Library* June 2014. Available at : [http://www.cochrane.org/CD001059/PREG\\_calcium-supplementation-during-pregnancy-for-preventing-hypertensive-disorders-and-related-problems](http://www.cochrane.org/CD001059/PREG_calcium-supplementation-during-pregnancy-for-preventing-hypertensive-disorders-and-related-problems)

## References

237. Buppasiri P, Lumbiganon P, Thinkhamrop J, Ngamjarus C, Laopaiboon M, Medley N. Calcium Supplementation (Other than for Preventing or Treating Hypertension) for Improving Pregnancy and Infant Outcomes. *Cochrane Database Syst Rev.* 2015 Feb 25; 2: CD007079. doi: 10.1002/14651858.CD007079.pub3.
238. WHO. Guideline: Calcium Supplementation in Pregnant Women. Geneva, World Health Organization, 2013.
239. Firas A Ghanem FA, Movahed A. Use of Antihypertensive Drugs during Pregnancy and Lactation. *Cardiovascular Drug Reviews.* 2008; 26: 38-49.
240. Magee LA, Cham C, Waterman EJ, Ohlsson A, von Dadelszen P. Hydralazine for Treatment of Severe Hypertension in Pregnancy: A Meta-analysis. *Br Med J.* 2003; 327(7421): 955-960.
241. Brown MA, Buddle ML, Farrel T, Dove GS. Efficacy and Safety of Nifedipine Tablets for the Acute Treatment of Severe Hypertension in Pregnancy. *Am J Obstet Gynecol.* 2001; 187: 1046-1050.
242. Firoz T, Magee LA, MacDonell K, Payne BA, Gordon R, Vidler M, von Dadelszen P; Community Level Interventions for Pre-eclampsia (CLIP) Working Group. Oral Antihypertensive Therapy for Severe Hypertension in Pregnancy and Postpartum: A Systematic Review. *BjOG.* 2014 Sep; 121(10): 1210-8.
243. Koopmans CM, Bijlenga D, Groen H, Vijgen SMC, Aarnoudse JG et al for the HYPITAT study group. Induction of Labour versus Expectant Monitoring for Gestational Hypertension or Mild Pre-edema after 36 Weeks' Gestation (HYPITAT): A Multicentre, Open-label Randomised Controlled Trial. *Lancet.* 2009; 374(9694): 979-988.
244. Ministry of Health. 5<sup>th</sup> Ed Malaysian CPG on Management of Diabetes Mellitus. 2015. Available at [www.acadmed.com.my](http://www.acadmed.com.my)
245. NICE Guideline. Diabetes in Pregnancy: Management of Diabetes and its Complications from Preconception to the Postnatal Period. Feb 2015. Available at : [www.nice.org.uk/guidance/ng3/resources/diabetes-in-pregnancy-management-of-diabetes-and-its-complications-from-preconception-to-the-postnatal-period-51038446021](http://www.nice.org.uk/guidance/ng3/resources/diabetes-in-pregnancy-management-of-diabetes-and-its-complications-from-preconception-to-the-postnatal-period-51038446021)
246. Hod M, Kapur A, Sacks DA, Hadar E, Agarwal M et al. The International Federation of Gynecology and Obstetrics (FIGO) Initiative on Gestational Diabetes Mellitus: A Pragmatic Guide for Diagnosis, Management, and Care. *Int J Gynaecol and Obstet.* 2015; 131(Suppl 3): S173-211.
247. Pomp ER, Lenselink AM, Rosendaal FR, Doggen CJ. Pregnancy, the Postpartum Period and Prothrombotic Defects: Risk of Venous Thrombosis in the MEGA Study. *J Thromb Haemost.* 2008 Apr; 6(4): 632-7.
248. Heit JA, Kobbervig CE, James AH, Petterson TM, Bailey KR, Melton LJ 3<sup>rd</sup>. Trends in the Incidence of Venous Thromboembolism during Pregnancy or Postpartum: A 30-year Population-based Study. *Ann Intern Med.* 2005 Nov 15; 143(10): 697-706.
249. Pabinger I, Grafenhofer H, Kyre PA, et al. Temporary Increase in the Risk for Recurrence during Pregnancy in Women with a History of Venous Thromboembolism. *Blood.* 2002 Aug 1; 100(3): 1060-2.
250. Clark SL, Belfort MA, Dildy GA, Herbst MA, Meyers JA, Hankins GD. Maternal Death in the 21st Century: Causes, Prevention, and Relationship to Cesarean Delivery. *Am J Obstet Gynecol.* 2008; 199(1): 36.e1-5.
251. Ginsberg JS, Brill-Edwards P, Burrows RF, et al. Venous Thrombosis during Pregnancy: Leg and Trimester of Presentation. *Thromb Haemost.* 1992 May 4; 67(5): 519-20.
252. Jacobsen AF, Skjeldstad FE, Sandset PM. Incidence and Risk Patterns of Venous Thromboembolism in Pregnancy and Puerperium—A Register-based Case-control study. *Am J Obstet Gynecol.* 2008 Feb; 198(2): 233.e1-7.
253. RCOG. Reducing the Risk of Venous Thromboembolism during Pregnancy and the Puerperium. Green-top Guideline No. 37a April 2015.
254. Kent N. SOGC Clinical Practice Guidelines. Prevention and Treatment of Venous thromboembolism (VTE) in Obstetrics. No 95, 2000.
255. Bates SM, Greer IA, Pabinger I, Sofaer S, Hirsh J. Venous Thromboembolism, Thrombophilia, Antithrombotic Therapy, and Pregnancy: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition). *Chest.* 2008 Jun; 133(6 Suppl): 844S-886S.

## References

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256. Mantha S, Karp R, Raghavan V, Terrin N, Bauer KA, Zwicker JI. Assessing the Risk of Venous Thromboembolic Events in Women Taking Progestin-only Contraception: A Meta-analysis. *Br Med J.* 2012; 345: e4944. doi:10.1136/bmj.e4944.
257. Jain JK, Mishell DR Jr. A Comparison of Intravaginal Misoprostol with Prostaglandin E2 for Termination of Second-trimester Pregnancy. *N Engl J Med.* 1994; 331: 290–293.
258. Secher NJ, Thayssen P, Arnsbo P, Olsen J. Effect of Prostaglandin E2 and F2 alpha on the Systemic and Pulmonary Circulation in Pregnant Anesthetized Women. *Acta Obstet Gynecol Scand.* 1982; 61: 213–218.
259. Guidelines on the Termination of Pregnancy (TOP) for Hospitals in the Ministry of Health, Malaysia. 2012. Available at: [http://www.moh.gov.my/images/gallery/Garispanduan/\\_Guideline%20On%20TOP%20for%20Hospitals%20in%20MOH.pdf](http://www.moh.gov.my/images/gallery/Garispanduan/_Guideline%20On%20TOP%20for%20Hospitals%20in%20MOH.pdf)
260. Valentin J, Editor, Annals of the ICRP, Publication 84: Pregnancy and Medical Radiation, International Commission on Radiological Protection, Volume 30, No. 1. Tarrytown, New York: Pergamon, Elsevier Science, Inc., 2000.

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