Good at Heart: Developing a Tertiary Perinatal Cardiac Service; the First 8 Years Experience

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Blinded Institutes in main text

Mercy Hospital for Women (MHW) = Institute 1 (I1)

Austin Health = Institute 2

Conflict of Interest

There are no conflicts of interest

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Abstract

Background: Maternal cardiac disease is the most common cause of indirect maternal death, and women with pre-existing cardiac disease have complex medical, obstetric and anaesthetic requirements. Our hospital commenced a multidisciplinary perinatal cardiac service in 2009 to optimise outcomes in women with cardiac disease.

Aim: To assess the maternal and perinatal outcomes of women referred to the clinic to evaluate clinical practice and inform future service provision.

Materials and Methods: A single centre retrospective study of women referred to the Perinatal Cardiac Service between 2009-16. Data collected included: demographic details; cardiac diagnosis; pregnancy outcomes, including anaesthetic and delivery complications, and admission to Intensive Care Unit (ICU)/High Dependency Unit (HDU).

Results: 152 women were referred for care in 165 pregnancies. Congenital heart disease was the most common indication for referral (35%), followed by maternal cardiac arrhythmia (26%) and valvular disease (18%). The perinatal mortality rate was 2%, median gestational age at delivery was 38w4d, fetal growth restriction (customized birthweight <10th centile) was 9% although 25 (17%) pregnancies resulted in preterm birth, 36% of which were spontaneous and 64% were iatrogenic. Maternal outcomes were favourable and there were no maternal deaths. However, 51% of women required a Caesarean section, and 23% who achieved a live birth required ICU/HDU admission.

Conclusion: This study confirmed that women with cardiac disease are at increased risk of preterm birth, and high acuity in the peripartum period but otherwise good maternal and perinatal outcomes. An integrated multidisciplinary perinatal cardiac service can optimise perinatal outcomes in these women.

Introduction

Improvements in obstetric care in high-income countries have resulted in a decrease in the incidence of maternal mortality and morbidity attributable to direct causes. In contrast, the relative contribution of cardiac disease to adverse maternal outcomes has increased. The majority of cardiac deaths in the developed world are due to acquired cardiac disease such as ischaemic heart disease.¹ Cardiac disease is now the most

1 common cause of indirect maternal death in most developed countries, including
2 Australia², a trend that may continue as the improvements in diagnosis and cardiac
3 surgery allow more children with congenital heart disease to reach adulthood and
4 aspire to have children of their own³. Accordingly, the profile of cardiac disease in
5 pregnancy has changed in developed countries, with a progressive shift away from
6 disease that is predominantly rheumatic in origin, to disease that has its aetiological
7 roots in congenital abnormalities^{4,5}.

9 Both congenital and acquired heart disease pose significant risks to maternal and fetal
10 wellbeing. The risk of adverse maternal outcome varies according to the cardiac
11 lesion, the patient's functional status, and history of prior cardiac events, such as heart
12 failure, transient ischaemic attack and stroke⁵. Neonatal complications, which
13 includes prematurity, fetal growth restriction (FGR), respiratory distress syndrome,
14 intraventricular haemorrhage and fetal loss, is more than doubled in women with
15 cardiac disease compared to those without⁶. Women with congenital heart disease
16 face the added risk of fetal cardiac abnormalities through familial associations⁷.

18 It is on the background of this changing cardiac profile in women of childbearing
19 years that the Perinatal Cardiac service at Institute 1 was developed, recognizing the
20 complex medical, obstetric, anaesthetic and critical care requirements of these
21 patients. In this study, we describe the first 8 years of this service, summarizing care
22 needs and outcomes in a tertiary centre.

24 **Materials and Methods**

26 This was a single centre retrospective observational study of patients who attended
27 the Institute 1 (I1) Perinatal Cardiology Clinic from January 2009 through December
28 2016. Institute 1 is a tertiary obstetric service located in northeast Melbourne,
29 Victoria, responsible for approximately 5,800 births per annum. I1 is co-located with
30 a tertiary medical and surgical referral centre, Institute 2. The Perinatal Cardiology
31 Clinic accepts referrals both for pre-pregnancy counselling and antenatal care, and is
32 staffed by a Maternal Fetal Medicine specialist, perinatal midwife, cardiologist, and
33 anaesthetist. The cardiac service is supported by the full range of adult cardiac

1 diagnostic (including maternal echocardiography, cardiac magnetic resonance
2 imaging) and surgical services. Anaesthetic care is complemented by on site High
3 Dependency Unit, and adjacent full Intensive Care Unit. Neonatology, paediatric
4 cardiology and genetics support is available for families with familial cardiac
5 conditions or where the fetus is found to be affected with congenital heart defects.

6
7 All referrals received since the commencement of service in 2009 until 2016 using the
8 Integrated Patient Management (IPM) outpatient records were reviewed.
9 Demographic information was recorded, along with details of the maternal cardiac
10 condition. Cardiac information recorded included the maternal diagnosis,
11 echocardiographic assessment and medications. Cardiac complications such as
12 worsening cardiac failure, arrhythmias and pulmonary hypertension were also noted.
13 Obstetric history was obtained, as well as perinatal outcomes including gestational
14 age, birthweight, and need for special care nursery (SCN) and/or neonatal intensive
15 care unit (NICU) admission. Customised birthweight centiles were calculated
16 adjusting birthweight for maternal height, weight, parity and fetal gender using the
17 customized birthweight centile calculator derived by Mongelli et al⁸. Maternal
18 outcomes collected included anaesthetic and critical care requirements in the
19 peripartum period. Pre-eclampsia was defined as per the Society of Obstetric
20 Medicine of Australia and New Zealand (SOMANZ) 2014 Guidelines, with
21 development of hypertension and involvement of one or more organ systems +/- the
22 fetus after 20 weeks gestation⁹.

23
24 Ethics approval was obtained from the Mercy Health Human Research Ethics
25 Committee, Project Number R12/08.

26 27 **Results**

28
29 Over the 8-year study period, the clinic received referrals for 165 pregnancies in 152
30 women. One referral was for concerns regarding a fetal cardiac condition, and her
31 care was transferred to our Fetal Cardiac Service. Twelve patients were referred twice
32 over the study period: 11 women for separate pregnancies and only one patient
33 attended for pre-conceptual counselling and subsequently became pregnant. A further

1 patient was referred three times for separate pregnancies. There was significant
2 growth in the service over the first eight years, with only six deliveries in 2010, the
3 first full year of service, increasing to thirty-one in 2016, while the overall number of
4 births at our institution remained stable at with 5752 births in 2010 and 5988 births in
5 2016.

6
7 The median age was 31 years (range 17-51 years old), and 51% of women were
8 nulliparous. There were 165 pregnancies in total. Six of these ended in miscarriage or
9 termination of pregnancy (TOP); 3 of the 4 TOPs were on the basis of maternal
10 cardiac disease status. Ten women delivered at either their referring institution or
11 overseas after initial assessment, one was transferred to the fetal cardiac service and
12 one woman was lost to follow up. This left 147 ongoing pregnancies in the final
13 analysis, with 2 fetal death in utero's (FDIU) and 145 live births, summarized in
14 Figure 1.

15 16 Cardiac Disease Profile

17 The referral cardiac diagnosis of the study cohort is summarized in Table 1.
18 Consistent with other published series in developed countries, congenital heart disease
19 (CHD) was the most common referral group, with atrial septal defect being the most
20 common congenital cardiac lesion. This was followed by arrhythmia (26%), valvular
21 heart disease (18%), cardiomyopathy (9%), ischaemic heart disease (3%), heart
22 failure (1%), pulmonary hypertension (1%) and not otherwise specified (9%).

23
24 The majority of patients were New York Heart Association (NYHA) Class I-II, with
25 only two patients being classed as NYHA Class III-IV. One required a TOP for
26 primary pulmonary hypertension at 22 weeks and one was delivered early due to
27 severe peripartum cardiomyopathy. Both NYHA III-IV patients required admission to
28 HDU/ICU for treatment.

29 30 Maternal and Perinatal Outcomes

31
32 Of the 145 live births, 56 (39%) women had a normal vaginal delivery and 14 (10%)
33 had an assisted vaginal delivery (Figure 2). Thirty-seven (26%) women had a planned
34 caesarean, while 38 (26%) women who attempted a vaginal delivery required an

1 emergency caesarean. Of the thirty-seven planned caesarean births, 17 (46%) were
2 repeat caesarean, 7 (19%) were due to cardiac disease, 6 (16%) were due to
3 malpresentation, 2 (5%) due to maternal request, 4 (11%) due to other indications
4 and 1 (3%) is unknown. The median (SD) gestational age at delivery was 38w4d
5 (17d), and the mean (SD) customised fetal centile weight was 47.6% (29). Thirteen
6 (9%) babies were born with a customised fetal weight centile less than 10%, of which
7 six were delivered preterm. The perinatal mortality rate (PNMR) was 2%, with one
8 stillbirth following TOP for primary pulmonary hypertension at 22 weeks' gestation
9 and 2 FDIU's. The first FDIU occurred at 27 weeks with severe fetal growth
10 restriction in the setting of maternal severe aortic regurgitation. The second was due
11 to haemolytic uraemic syndrome at 37 weeks on the background of maternal
12 idiopathic ventricular tachycardia.

13 14 Cardiac Complications

15 With respect to maternal events, there were 21 women with cardiac complications.
16 One of these patients required termination of pregnancy for pulmonary hypertension
17 at 22 weeks and one with idiopathic ventricular tachycardia, had a FDIU at 37 weeks
18 and was admitted to ICU with haemolytic uraemic syndrome. Of the remaining 19
19 pregnancies with cardiac complications, 14 women experienced arrhythmia, three had
20 worsening cardiac failure – two of which developed acute pulmonary oedema and one
21 had clinical deterioration; one had syncopal episodes and one had undifferentiated
22 chest pain. Of note, there were no episodes of venous thromboembolism, peripartum
23 ischaemic events or maternal deaths in our study population. While cardiomyopathy
24 affected only 13 (9%) of patients, this condition contributed 29% of cardiac
25 complications. Of the 13 cardiomyopathy patients one was transferred and two had
26 two deliveries each. Of the 14 live births (II) 21% delivered prematurely and 42% of
27 them required HDU/ICU care. Beta blockers were the most commonly used cardiac
28 medications, being used in thirty (18%) of the 165 pregnancies. This was followed by
29 digoxin, flecainide and methyldopa.

30 31 Obstetric Complications

32 Primary postpartum haemorrhage (PPH) was the most common intrapartum
33 complication, and was reported in 38% of live births. The average estimated blood
34 loss for PPH was 717mls (range 500ml-2500ml). Active management of the third

stage is recommended for all women delivering at our hospital. This comprises cutting and clamping the cord, 10 units of syntocinon intramuscularly, and controlled cord traction for delivery of placenta. In general, ergometrine is not recommended for routine third stage management of women with known cardiac disease, although early recourse to the use of ergometrine is employed in the setting of PPH and was used in sixteen women (29%) with PPH.

Neonatal Complications

Twenty five (17%) pregnancies were delivered prior to 37 weeks; among those born preterm, the median (SD) gestational age was 34w2d (20d) weeks. Of these preterm births, 9 (36%) were spontaneous preterm births, 4 of which were inductions for preterm ruptured membranes. Of the iatrogenic preterm births, 7 (28%) were induced due to cardiac disease, 4 (16%) were for suspected fetal compromise (fetal growth restriction or fetal distress prior to labour), 4 (16%) due to pre-eclampsia, and 1 (4%) were for a combination of indications. Fifteen (60%) of preterm births resulted in Caesarean birth.

Of the 145 live deliveries, 12 (8%) infants required admission to the NICU and 14 (10%) to the SCN; the majority of these (69%) were premature. No babies of mothers with a congenital/familial cardiac condition were diagnosed antenatally or postnatally with a cardiac malformation.

Maternal Anaesthetic and Critical Care Requirements

Regional anaesthesia was administered in 27 (40%) women who achieved vaginal birth. General anaesthetic (GA) was required in 9 of the 75 (12%) patients having a Caesarean, 5 of these patients were emergency caesareans. Invasive haemodynamic monitoring (most commonly, arterial line) was required in 17 (12%) women. Arterial lines were placed when there was concern from the anaesthetist about intra/peripartum haemodynamic instability. Arterial lines in the operating theatre would commonly be employed in this patient cohort to provide a more rapid recognition if instability occurs. The use of arterial lines in labour ward is an uncommon event but its logistics have been managed via specific critical care education for midwives. They would usually be left in-situ for post operative high dependency care.

Our policy was to electively admit women who were felt to be at high risk of post partum deterioration (e.g. those with cardiomyopathy) or those who had evidence of compromise during labour to the ICU/HDU. 33 (23%) of all women that achieved a live birth required ICU/HDU admission. A further 3 patients that did not achieve a live birth required ICU/HDU admission: 1 patient with a late miscarriage, 1 patient that required a TOP for pulmonary hypertension and delivered in ICU and 1 patient that had a FDIU.

Discussion

This study provides insights into the variety of maternal, obstetric and perinatal risks faced by women with cardiac disease in pregnancy, and highlights the need for multidisciplinary units to optimise maternal and perinatal outcomes.

Cardiac disease is the leading cause of indirect maternal death and major morbidity in high income countries^{2,10,11}, and maternal cardiac disease is associated with increased risks of preterm birth, FGR and fetal death⁶. The breakdown of cardiac aetiologies in our study is comparable to that of other developed countries, with congenital heart disease the most common cardiac disease, and tetralogy of Fallot one of the most common congenital lesions^{4,3,10}. The increased incidence of CHD in pregnancy is in keeping with studies that show that approximately 90% of children with CHD are surviving to adulthood and 40% of these require little ongoing support^{12,13}. The observed decline in rheumatic heart disease in Australia was reflected by the study only having five affected patients, all of whom had immigrated from low or middle income countries, where the disease is still highly prevalent¹⁴. While only 8% of our patients received pre pregnancy counselling from our service, many had received pre pregnancy advice from their cardiologist. Improving the uptake of preconception counselling was observed over time, with increasing community awareness of the perinatal cardiac service. To optimise referrals further, we suggest it may be beneficial to contact local cardiac services, including paediatric cardiac services, to make them aware of our services and to encourage women to access them prior to pregnancy.

1
2 Pregnancy places increased demands on the cardiovascular system, such as increase
3 in stroke volume, heart rate and cardiac output; which is poorly tolerated by those
4 with impaired cardiac function¹³. Patients with a NYHA classification of III-IV are
5 known to be at higher risk of cardiac complications^{15,16}. In our study, women with
6 NYHA III/IV were more likely to be admitted to HDU/ICU than the less severe
7 disease subtypes (NYHA I/II) (100% vs 21%, $p<0.05$). This functional class was also
8 responsible for our single mid-trimester termination for a woman with severe primary
9 pulmonary hypertension. Our study is limited by its paucity of high-risk patients
10 (NYHA Class III-IV). While the underrepresentation of more severe cardiac disease
11 is not easily explained, this may reflect our setting, with access to high quality cardiac
12 care and pre pregnancy counselling in a well-resourced setting in Australia. A
13 national population-based dataset would enable outcomes in this subset of women to
14 be better quantified to inform clinical care. The Australasian Maternity Outcomes
15 Surveillance System (AMOSS), a national surveillance system for serious conditions
16 with an estimated incidence of less than 1 in 1,000 births per year is a system already
17 in place that would enable this data to be captured nationally.

18
19 We reported no maternal deaths, which is in contrast to other studies^{10,15} and likely
20 reflects the small number of extreme risk patients with ongoing pregnancies. The
21 most common obstetric complication was primary postpartum haemorrhage occurring
22 in 38% of deliveries, which is significantly higher than that of our institution and
23 other published cohorts¹⁷. This may reflect heightened surveillance and recording of
24 blood loss in cardiac disease patients, or a reticence to use oxytocics such as
25 ergometrine due to its effect on the cardiovascular system¹⁸. Active management of
26 third stage is recommended for all patients delivering in our hospital and includes the
27 use of 10 units of oxytocin intramuscularly. Among patients with cardiac disease the
28 dose and administration route of oxytocin is individualised and is being increasingly
29 aligned with the European Society of Cardiology Guidelines of giving a slow
30 intravenous oxytocic infusion for management of third stage to avoid systemic
31 hypotension in women with cardiac disease¹⁸.

32
33 Other maternal and perinatal outcomes were comparable to previously published
34 cohorts. While vaginal birth is generally favoured in patients with cardiac lesions¹⁹,

our caesarean section rate was 52% which is significantly higher than the general Australian population (35%)²⁰ but is comparable to that reported in other cardiac disease cohorts²¹ and likely reflects both the maternal medical complexities and increased risk of fetal complications. 107 (74%) of patients were planned for vaginal delivery but a relatively high proportion, 38 patients (36%), ended up with an emergency Caesarean. Of these emergencies 5 patients (13%) required a GA which highlights the need for tertiary anaesthetic and critical care services when managing a high risk cardiac population.

While our perinatal mortality rate (PMR) of 2% and preterm birth rates of 17% were higher than the background Australian population rates of 1% and 9% respectively, our admissions to NICU/SCN were on par at 18%²⁰. Our perinatal outcomes were comparable to other maternal cardiac studies¹⁰. The majority of our preterm births were iatrogenic due to concern regarding either the fetus or mother. Maternal cardiac disease has been shown to increase the risk of FGR²², but FGR was not increased in our study compared to the baseline of 11% in our institution. The combination of close monitoring and timely delivery may have contributed to this, although this likely contributes to an increased risk of late preterm birth. Unsurprisingly, this cohort demonstrated a high anaesthetic and critical care requirement with 23% of patients requiring admission to either HDU or ICU, and 12% of caesarean sections performed under general anaesthetic which is double our institutions baseline rate of 7%. Of note, our HDU was an obstetric HDU and allowed invasive monitoring and nursing ratios of one to two providing closer monitoring. This highlights the importance of these women having access to tertiary anaesthetic care and critical care facilities.

Cardiomyopathy is responsible for up to 11% of maternal deaths²³. Even though cardiomyopathy represented only a small portion of the overall study population, these patients had a higher incidence of cardiac complications and 43% of patients with cardiomyopathy that achieved a livebirth required admission to HDU/ICU. This is in keeping with other studies, which have confirmed worse outcomes in patients with cardiomyopathy, and highlight the need to closely monitor this subset of patients^{15,21}. These patients should be assessed for their functional baseline status,

1 severity of systolic dysfunction and history of prior cardiac events as these are all
2 significant predictors of adverse outcomes²³.

3
4
5
6 This study reports the outcomes of 165 consecutive referrals to a tertiary perinatal
7 cardiac service. We report that a comprehensive cardiac service results in excellent
8 clinical outcomes, and this model may be useful for others establishing a maternal
9 cardiac service. The increased risks associated with cardiomyopathy inform care
10 needs of this patient group, and have usefully influenced our clinical care guidelines.
11 Weaknesses include the relatively small numbers of women with very severe cardiac
12 disease. This is common to all services, and establishing outcomes for these women to
13 inform pre-pregnancy counselling and pregnancy care would be best addressed by the
14 development of a national database and integration of risk stratification indices to
15 help predict maternal cardiac complications and adverse outcomes^{24,25}.

16
17 This study confirms the changing profile of maternal cardiac disease in pregnancy in
18 high income settings. Given the diverse antenatal, intrapartum and postpartum risks
19 facing women with cardiac disease, multidisciplinary units provide an opportunity to
20 optimize maternal and perinatal outcomes.

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- 7
8
9

- 1 **Table 1** Distribution of cardiac disease
- 2 **Fig. 1** Summary of Referrals and Outcomes
- 3 **Fig. 2** Mode of delivery, decision for Caesarean delivery and anaesthetic technique.
- 4 GA: general anaesthesia; RA: regional anaesthesia.

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Table 1 Distribution of cardiac disease

Cardiac condition	N (%)
Congenital heart disease	53 (35%)
Atrial Septal Defect	9
Tetralogy of Fallot	8
Patent Foramen Ovale	6
Aortic Coarctation	5
Congenital Pulmonary Stenosis	3
Bicuspid Aortic Valve	3
Patent Ductus Arteriosus	3
Ventricular Septal Defect	3
Ehlers-Danlos Syndrome	2
Other	11
Arrhythmia	39 (26%)
Supraventricular Tachycardia	11
Palpitations	9
Atrial Fibrillation	5
WPW	5
Ventricular ectopics	2
Long QT Syndrome	2
Sinus tachycardia	2
Heart Block	1
Premature ventricular complexes	1
Ventricular tachycardia	1
Valvular heart disease	27 (18%)
Mitral valve prolapse	7
Mitral regurgitation	6
Rheumatic	4
Aortic Regurgitation	4
Mitral valve repair/replacement	3
Aortic Stenosis	2
Tricuspid valve thrombosis	1
Cardiomyopathy	13 (9%)
Peripartum cardiomyopathy	8
Dilated cardiomyopathy	4
Hypertrophic cardiomyopathy	1
Ischaemic heart disease	5 (3%)
Pulmonary hypertension	1 (1%)
Heart Failure	1 (1%)
Not otherwise specified (e.g. heart murmur, fetal concerns, genetic condition with no cardiac issues)	13 (9%)

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