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ORIGINAL ARTICLE

Dilated Cardiomyopathy in Pregnancy: Outcomes From an Australian Tertiary Centre for Maternal Medicine and Review of the Current Literature

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Background Peripartum cardiomyopathy is associated with significant risks of decline in left ventricular function and adverse maternal and fetal outcome in subsequent pregnancy. The risks of pregnancy in women with dilated cardiomyopathy are unclear. We aimed to assess the outcome of pregnancy in women with dilated cardiomyopathy seen at our institution and to review the literature on this subject.

Methods A retrospective audit of the outcomes of 14 pregnancies to 12 women with dilated cardiomyopathy.

Results There were no cardiac events and no woman had a decline in left ventricular function during pregnancy. There was a high rate of prematurity and adverse fetal outcome related to this, including four neonatal deaths.

Conclusion Maternal outcomes in this small series were satisfactory though only three women had moderate-severe left ventricular dysfunction at baseline. There was a high rate of premature delivery and adverse neonatal outcome.

Keywords Cardiac • Dilated cardiomyopathy • Heart failure • Maternal mortality • High risk pregnancy

Background

Peripartum cardiomyopathy (PPCM) and dilated cardiomyopathy (DCM) share similar clinical characteristics, echocardiographic appearance, and a similar distribution of truncating gene variants [1]. A subset of PPCM may occur as an initial manifestation of familial DCM [2]. PPCM is associated with a significant rate of deterioration of left ventricular function in subsequent pregnancies, accompanied by maternal and fetal morbidity and mortality. The outcome of pregnancy in women with DCM is less clear. Case series have varied considerably with respect to risk of deterioration in left ventricular function and the frequency of cardiac events during pregnancy in women with DCM. This disparity leads to considerable difficulty in counselling women with DCM with respect to pregnancy. The pregnancy outcome of 14 women thought to have DCM is presented, and the previous literature, management issues and possible future research directions discussed.

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Methods

Women with possible DCM were identified by interrogation of the database of the Cardiac Echocardiographic service at a quaternary referral obstetric hospital in Brisbane, Australia, between January 2006 and December 2015. Women with PPCM were excluded on clinical criteria. Data on fetal and maternal outcomes were obtained by review of the hospital medical records.

Results

There were 14 pregnancies in 12 women with DCM (Table 1). This corresponded to a prevalence of 29 women with dilated cardiomyopathy per 100,000 deliveries. The majority of patients had idiopathic dilated cardiomyopathy, two patients had familial cardiomyopathy and two patients had cardiomyopathy in the setting of alcohol excess. The mean maternal age was 29 years. Two patients were primigravida. None of the 12 multigravida women had a prior history of PPCM.

The median and mean left ventricular ejection fraction (LVEF) was 40%, and baseline New York Heart Association (NYHA) functional class was I or II in all patients. Pre-existing maternal conditions included type 2 diabetes, hypertension, chronic renal impairment, anxiety and substance abuse. Two of the pregnancies were to a mother with type 2 diabetes mellitus. An additional four pregnancies were complicated by gestational diabetes mellitus. One (1) half of the patients were smokers. Ten (10) (71%) of the patients were prescribed beta blocker therapy during pregnancy, five (36%) were prescribed aspirin, and three (21%) received hydralazine.

Antenatal complications included a miscarriage at 10 weeks gestation, intrauterine growth restriction, polyhydramnios, chorioamnionitis and preterm premature rupture of membranes. Significant neonatal morbidity and mortality was seen in this series, three pregnancies resulted in neonatal death (25%). There was a high rate of preterm delivery with eight pregnancies (62%) resulting in delivery prior to 37 weeks' gestation.

Pregnancy 2 was in a woman with uncontrolled type 2 diabetes mellitus, hypertension, chronic kidney disease, a history of substance abuse, poor medication adherence and non-attendance. An emergency Caesarean section was performed at 32 weeks' gestation at a peripheral hospital after she presented with polyhydramnios and was noted to have abnormal fetal Doppler ultrasound. The neonate developed seizures, global cerebral ischaemia, disseminated intravascular coagulation and respiratory distress syndrome and died on the third day of life. Three years later, in a subsequent pregnancy in the same mother (pregnancy # 3 in Table 1) the woman had developed end stage renal failure. During the pregnancy she was managed with haemodialysis 6 days per week, her medications being given at the time of dialysis. Elective Caesarean section was performed at 33 weeks gestation because of the development of significant polyhydramnios and fetal concerns.

Table 1 **Summary of pregnancy outcomes.**

#	Aet	Age	G	P	LVEF early pregnancy (%)	LVEF end pregnancy (%)	K	Mode of delivery	Birth weight (g)	Neonatal outcome
1	I	23	4	1	40	55	38	VD	3824	Live
2*	I	22	1	0	40	40	32	Em LSCS	1884	NND
3*	I	25	2	1	30	50	33	El LSCS	1830	Live
4	I	36	9	4	40	50	37	VD	2524	Live
5	I	34	6	3	40	40	32	El LSCS	2020	Live
6	I	29	3	2	45	45	37	VD	3848	Live
7	I	25	10	6	50	50	37	VD	2090	Live
8	F	36	8	4	40	40	n/a	n/a	n/a	Mc
9	A	31	10	6	30	30	30	VD	1674	Live
10	I	40	3	1	40	50	37	VD	2630	Live
11	A	28	5	3	50	55	32	El LSCS	1330	Live
12+	I	25	7	5	40	40	35	VD	2640	Live
13+	I	28	8	6	40	50	22	VD after PPROM; TTTS	536 538	NND * 2
14	F	18	1	0	35	40	31	Em LSCS	N/A	NND

Abbreviations: Aet, aetiology of cardiomyopathy; I, idiopathic; A, alcohol; F, familial; G, gravida; P, para; K, gestation delivery; VD, vaginal delivery; El LSCS, Elective Caesarean section; Em LSCS, Emergency Caesarean Section; NND, neonatal death; Mc, miscarriage; PPROM, Preterm Premature Rupture of Membranes; TTTS, Twin to Twin Transfusion Syndrome.

*Pregnancies 2 and 3 to same mother.

+Pregnancies 12 and 13 to same mother.

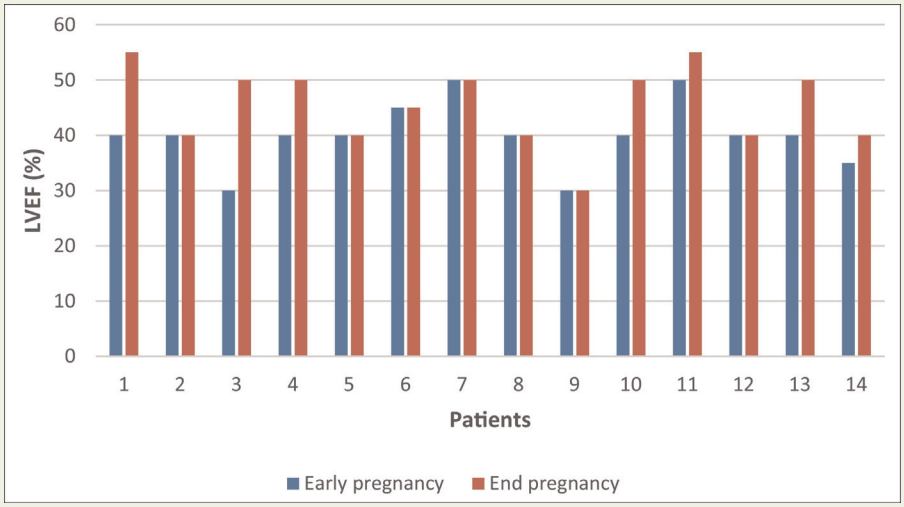

Figure 1 Change in LVEF during pregnancy.
Abbreviation: LVEF, left ventricular ejection fraction.

Pregnancy 5 was delivered electively at 32 weeks' gestation predominantly because of severe maternal anxiety despite stability of her cardiomyopathy. Pregnancy 9 was delivered at 30 weeks' gestation because of chorioamnionitis. Pregnancy 11 was delivered by elective Caesarean section at 32 weeks' gestation because of fetal concerns in the setting of preterm premature rupture of membranes, intrauterine growth restriction and abnormal fetal Doppler ultrasound. Pregnancy 12 was a twin pregnancy to a woman with a history of recurrent preterm premature rupture of membranes (PPROM). In this pregnancy PPROM occurred at 22 weeks gestation. Pregnancy 14 presented to another hospital with placental abruption and the fetal heart could not be detected on Doppler ultrasound.

Elective induction of labour with vaginal delivery was the most common mode of delivery with five women delivering via LSCS (~ 38%).

There were no maternal cardiac events, maternal deaths or patients with decline in left ventricular function during pregnancy. Left ventricular ejection fraction improved from baseline during pregnancy in half of the 14 pregnancies. In the remainder of patients left ventricular ejection fraction did not alter during pregnancy (Figure 1). The median and mean LVEF at end of pregnancy was 45%. There was no statistically significant difference between early pregnancy and end pregnancy LVEF.

Discussion

The interpretation of previous literature regarding the outcome of pregnancy in women with dilated cardiomyopathy is complicated by several factors including retrospective design issues, selection bias, varying definitions of cardiac events, manuscripts presenting combined outcomes for women with previous PPCM and DCM, and the difficulty in differentiating between DCM and previous PPCM in multigravida women. Just as a subset of PPCM may represent an initial manifestation of familial DCM, it is possible that some parous women diagnosed with DCM may have had PPCM that was undiagnosed. While some authors have reported relatively good pregnancy outcomes with limited adverse cardiac events in women with DCM, others have reported high rates of cardiac events. Tables 2 and 3 summarise the published data on case series and case reports of pregnancy outcomes in women with DCM. Moderate-severe left ventricular dysfunction, New York Heart Association functional class III or IV, and left ventricular ejection fraction of less than 40% have been shown to be predictive of adverse maternal cardiac outcomes in pregnancy [3].

Investigations

Levels of brain natriuretic peptide (BNP) are unchanged in healthy pregnancy, though patients with pre-eclampsia have a significant rise in BNP which persists for 3–6 months postpartum [23]. Serial NTproBNP levels may be a better clinical tool than echocardiography in the monitoring and management of pregnant women with DCM, as a rise appears to predict the occurrence of significant adverse events [9]. Cardiac troponin levels are also unchanged in healthy pregnancy. Studies examining the influence of pre-eclampsia on troponin levels have yielded contradictory results [24]. To date, no studies have assessed levels of high sensitivity troponin in pregnancy. The MB isoenzyme of creatine kinase (CK-MB) is found in uterus and placenta. Levels of CK-MB rise significantly on the first postpartum day, being above the non-pregnant reference range in 36% of women in one study [25].

Echocardiography is the cardiac imaging modality of choice in pregnancy. Cardiac magnetic resonance imaging (MRI) may be performed in all trimesters of pregnancy provided the magnet strength is not greater than 3 Tesla.

Table 2 Case Series of Pregnancy Outcomes in Women with DCM.

	n	P0	Initial LVEF	Fall in LVEF (%)	K/preterm	Cardiac events
Hines [4]	26 post-cancer	NS	NS	31%	NS	NS
Ituk [5]	18 DCM 14 PPCM 4	5	32%	NS	33.5/13	1 urgent delivery for worsening cardiac function
Katsuragai [6]	29 DCM	16	23% (FS)	7%	36/NS	3 maternal deaths (2 pp)
Grewal [3]	36 DCM	16	50% mod-severe dysfunction	NS	38/5	39% maternal adverse cardiac events; all in women with moderate–severe LV dysfunction
Siu [7]	23 DCM + PPCM	NS	NS	NS	NS	12 maternal cardiac events, 7 neonatal deaths
Bernstein [8]	8 DCM	NS	33%	12.5%	NS	Nil except 1 TOP
Blatt [9]	7 DCM	4	35%	0	39/NS	2 APO pp; 1 PE

Abbreviations: P0, primigravid; LVEF, mean initial ejection fraction; Fall in LVEF, percentage of subjects who experienced a fall in LVEF during pregnancy; NS, not stated; K, preterm–mean gestation delivery/number delivered preterm; APO, pulmonary oedema; PE, pulmonary embolism; TOP, termination of pregnancy; pp, postpartum.

Intravenous gadolinium should be avoided in pregnancy until there is further information about safety of its use. Concerns over fetal exposure to ionising radiation include the risk of teratogenesis and miscarriage in the first trimester, fetal injury and the later risk of childhood cancer. Fetal radiation doses up to 1 mGy are considered to be acceptable without incurring a risk of carcinogenesis or fetal injury. Doses of less than 50 mGy have not been associated with fetal malformation or abortion. The relative risk for childhood cancer from diagnostic-level radiation has been estimated to be approximately 3.19 in the first trimester, 1.29 in the second trimester and 1.30 in the third trimester. The excess childhood cancer incidence for a fetal radiation dose of 50 mGy is 1.1–3.0 patients per 1000. Cardiovascular

Table 3 Case reports of Pregnancy Outcomes in Women with DCM.

Author		P0	Initial LVEF	Fall EF	K	Events
Oki [10]	DCM 1x	Yes	47%	No	35	Nil
Singh [11]	DCM/FH	Yes	25%	No	36	Nil
Fadol [12]	Cancer	Yes	30%	No	39	Nil
Kozelj [13]	DCM	No	30%	Yes	28	Maternal death
Gevaert [14]	FDCM	Yes	33%	Yes	37	Nil
	Isch CMP	Yes	37%	No	38	Nil
Torloni [15]	Gauchers	Yes	NS	NS	40	Nil
	Gauchers	No	NS	NS	39	Nil
Chan [16]	DCM	Yes	35%	No	31	Premature delivery – fetal concerns
Mazor [17]	DCM	No	FS 12%	No	36	Nil
Fall [18]	MD	Yes	20%	NS	34	PO at k = 34; Maternal death 8 weeks pp
Yacoub [19]	DCM	Yes	50%	No	20	Urosepsis at k = 20; TOP
Morton [20]	Alcohol	No	35%	No	39	Nil
	Alcohol	No	35%	No	38	Nil
	Alcohol	No	35%	No	30	Chorioamnionitis
Davies [21]	Duchenne	NS	22%	NS	36	APO at k = 36; VAD;?PPCM
Pan [22]	Doxo	Yes	30%	Yes	36	APO at k = 36

Abbreviations: FH, familial hypercholesterolaemia; FDCM, familial dilated cardiomyopathy; Isch, ischaemic; MD, myotonic dystrophy; Doxo, doxorubicin; APO, pulmonary oedema; P0, primigravid; VAD, ventricular assist device; K, gestation delivery; pp, postpartum.

Table 4 Fetal doses from cardiac examinations in pregnancy.

Examination	Fetal dose (mGy)
CCTA	3.0
Coronary angiography	0.074
Direct fluoroscopy	0.09–0.24 mGy/min
Myocardial perfusion scan	5-17
PET viability	6-8

Abbreviation: CCTA, coronary computed tomography angiography.

computed tomography angiography, coronary angiography, myocardial perfusion studies, and positron emission tomography (PET) are all associated with radiation doses of less than 20 mGy and may be considered in pregnancy (Table 4) [26].

Dobutamine stress echocardiography has been used in women with previous PPCM to try to predict contractile reserve in subsequent pregnancy [27,28]. The authors are not aware of any similar studies in women with DCM, although stress echocardiography is frequently used in clinical practice to assess suitability for pregnancy. Increased right ventricular 18G-fludeoxyglucose uptake on PET may be a prognostic predictor of all-cause mortality or heart transplantation in patients with DCM [29]. Combining features of global longitudinal strain and delayed gadolinium enhancement on cardiac MRI may be useful for risk stratification and prognostic assessment in DCM [30]. Further studies examining as to whether these features on PET/MRI may be of prognostic value in women with DCM contemplating pregnancy would be worthwhile. Similarly, studies examining whether features on imaging may help differentiate between prior PPCM and DCM would be useful.

Management

Medications shown to improve survival in the setting of dilated cardiomyopathy include angiotensin- converting-enzyme inhibitors (ACEI), angiotensin receptor blockers (ARB), beta blockers, aldosterone-receptor antagonists (ARA) and hydralazine-nitrate combinations. In addition, a meta-analysis of six studies demonstrated that therapy with HMG Co-A reductase inhibitors significantly improved long-term survival in patients with non-ischaemic cardiomyopathy [31]. Digoxin has been shown to reduce hospital admissions but not to improve survival. Recently, neprilysin inhibition (sacubitril) in combination with angiotensin receptor blockade has been shown to significantly reduce risk of death and hospitalisation for heart failure when compared with ACE inhibition.

ACEI and ARB are fetotoxic in second and third trimester. The evidence as to whether ACEI and ARB are teratogenic and should be ceased prior to attempting conception is conflicting [32]. A study suggesting an increased risk of fetal malformations with maternal exposure to ACEI and ARB was possibly confounded by factors including maternal obesity, undiagnosed diabetes mellitus and undiagnosed hypertension. Six (6) subsequent studies including a meta-analysis performed by the Motherisk program found no increased risk of malformations with the maternal use of ACEI and ARB in first trimester. Given the benefits of ACEI and ARB therapy, and the uncertainty regarding time to conception, it may be reasonable to continue taking an ACEI or ARB and ceasing as soon as pregnancy is confirmed. Captopril, enalapril and quinapril are safe for use during breastfeeding. There is no safety data regarding the use of ARB while breastfeeding.

There is extensive experience with the use of metoprolol tartrate in pregnancy without evidence of adverse maternal or fetal effect. Metoprolol clearance is significantly increased during mid- and late-pregnancy and increases in dose and dose frequency may be required [33]. Atenolol should be avoided because of an association with intrauterine growth restriction. No adverse effects have been noted with the use of metoprolol succinate, bisoprolol or carvedilol in pregnancy though the numbers of exposed mothers is small. Metoprolol has minimal excretion in breast milk and is safe for the infant. There is minimal published data regarding the safety of carvedilol and bisoprolol during breastfeeding. Atenolol is excreted extensively in breast milk and its use should be avoided during lactation.

Spironolactone is not recommended in pregnancy because of the potential anti-androgenic effect on the male fetus. A single study published in 1980 reported demasculinisation of the external genitalia of exposed male rats. A similar study 5 years earlier had found no anti androgenic effect in male rats whose mothers were exposed to the human equivalent of 400 mg spironolactone per day from day 14 of pregnancy until delivery. Prior to 1980 spironolactone was used extensively during pregnancy in the management of hypertension, preeclampsia, liver disease and myasthenia gravis without adverse effect. Since 1980 spironolactone has been used in 18 human pregnancies without complication [34]. The use of eplerenone has only been reported in four pregnancies, two of these were prior to conception. Of note, the placental production of progesterone increases progressively throughout gestation, progesterone acting as an antagonist at the mineralocorticoid receptor. Spironolactone is safe for use during breastfeeding. No data has been published regarding the safety of eplerenone during breastfeeding.

Hydralazine, long acting nitrates and digoxin are safe in pregnancy and during lactation. Significantly higher doses of digoxin (0.5–1 mg/day) are often required to achieve therapeutic levels in pregnancy. Frusemide may be safely used in pregnancy, but generally very small doses will be required for diuresis. Thiazides are safe to use during lactation, though there is no safety data regarding the use of loop diuretics during breastfeeding.

Pregnancy is associated with a three-fold increased risk of thromboembolism compared with non-pregnant women. While several cases of left ventricular thrombus have been reported with PPCM, intracardiac thrombus has not been

demonstrated in women with DCM in pregnancy. There are no consistent guidelines recommending anticoagulation in this setting.

Five studies did not detect a significant teratogenic effect of statins, although the studies did not have adequate statistical power to completely exclude an increased risk of malformations [35–39]. Pravastatin has been demonstrated to improve pregnancy outcomes in obstetric antiphospholipid syndrome refractory to treatment with low molecular weight heparin and aspirin [40]. Two (2) trials are evaluating the safety and efficacy of pravastatin in the prevention and management of preeclampsia [41].

Implantable cardioverter-defibrillators are safe in pregnancy [42]. Two (2) pregnancies to women with left ventricular assist devices have been reported with excellent maternal and fetal outcomes [43].

Extracorporeal membrane oxygenation during pregnancy is effective and can be used with favourable maternal and fetal outcomes [44].

Sleep disordered breathing (SDB) is highly prevalent in patients with DCM [45,46]. Pregnancy may exacerbate underlying SDB [47]. Treatment with nocturnal positive airway pressure has been demonstrated to significantly improve left ventricular ejection fraction and reduce BNP in patients with SDB and DCM [48]. SDB is associated with increased risk of preeclampsia, gestational hypertension and gestational diabetes mellitus, as well as adverse fetal outcomes including preterm delivery, intrauterine growth restriction and low birth weight. Clinicians caring for women with DCM in pregnancy should have a low threshold for ordering polysomnography to exclude SDB.

Surrogacy may be a consideration for women at high risk. Pregnancy outcomes following cardiac transplantation are excellent and storage of embryos while waiting transplantation may be reassuring and reduce pressure on the need to conceive where the time of transplantation may be uncertain.

Contraception

Combination oral contraceptive agents are not recommended for women with DCM because of the risks of thrombosis, fluid retention and arrhythmia [49]. Progestogen-only pills, intrauterine contraceptive devices, barrier methods and depot medroxyprogesterone acetate are all considered reasonable for use.

Conclusion

Women with PPCM have an elevated risk of fetal and maternal morbidity and mortality in subsequent pregnancies related to a decline in cardiac function, especially those who do not recover cardiac function after the index pregnancy. A significant limitation of our study is that only three of the women had an ejection fraction less than 40%. Nonetheless, none of 14 patients had a decline in left ventricular function or cardiac events during pregnancy. There was a high rate of prematurity and significant rate of adverse neonatal outcomes and neonatal death related to this.

One of the ongoing difficulties is differentiating between PPCM and DCM. Efforts should be made to accurately establish the chronicity of the cardiomyopathy for future publications in this area to make sure that the emerging guidance on the management of dilated cardiomyopathy in pregnancy is a true reflection of the relevant population. Ideally, to ensure that patients with peripartum cardiomyopathy are excluded (given their potentially very different prognosis in pregnancy) data would come from studies in patients diagnosed prior to 35 weeks gestation in their first pregnancy.

Early risk stratification is beneficial in patients with dilated cardiomyopathy in whom pregnancy is achievable and desirable. New imaging modalities and techniques previously not routinely required or available in pregnancy such as dobutamine stress echocardiogram, PET, cardiac MRI imaging, serial measurements of left ventricular global longitudinal strain on transthoracic echocardiography, and serial measurement of NTproBNP may improve the sensitivity of detecting those patients with dilated cardiomyopathy who are at the highest risk of declining cardiac function in pregnancy.

Prior to conception cardiac function should be optimised with maximal tolerated medical therapy and where appropriate, cardiac device therapy. Women with dilated cardiomyopathy should be fully informed prior to pregnancy of the associated maternal and fetal risks. The role of the multidisciplinary obstetric team is extremely valuable and regular follow-up with assessment of symptoms, co-morbidities and cardiac function as assessed on transthoracic echocardiography is recommended.

In some cases, where the mother is at significantly elevated risk of adverse outcomes surrogacy may be a consideration.

A registry of women with dilated cardiomyopathy in pregnancy would aid clinicians in their role of advising and managing patients with this complex condition.

Declaration of Conflicting Interests

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Ethical Approval

Ethical approval was received from the Ethics Committee of the institution where research was performed.

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