Anesthetic management and outcomes of parturients with dilated cardiomyopathy in an academic centre

Gestion anesthésique et évolution de parturientes atteintes de cardiomyopathie dilatée dans un centre universitaire

Unyime S. Ituk, MBBS · Ashraf S. Habib, MBBS ·
Carrie M. Polin, MD · Terrence K. Allen, MBBS

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Abstract

Purpose This study examines the peripartum anesthetic management and outcomes of women with dilated cardiomyopathy in a large university medical centre over a seven-year period.

Principal findings Twenty-five women were included in this series, 18 with a new diagnosis of cardiomyopathy and seven with a history of cardiomyopathy. Sixteen patients (64%) identified themselves as African American, seven (28%) were Caucasian, and two patients (8%) were Hispanic. The median (range) gestational age at the time of a new diagnosis of cardiomyopathy was 29 (7–38) weeks. Eight women (32%) had New York Heart Association class III/IV symptoms at the time of delivery or in the immediate postpartum period. A multidisciplinary team of obstetricians, anesthesiologists, cardiologists, and pediatricians were involved in the care of these women. The median (range) gestational age at the time of delivery was 33.5 (30–40) weeks. There were nine vaginal deliveries

and 15 operative deliveries. One patient had fetal loss at 19 weeks gestation. Twelve women had labour induced with an intravenous infusion of oxytocin at a rate of 0.001–0.02 IU·min⁻¹. An oxytocin infusion at a variable rate with a maximum dose of 0.05 IU·min⁻¹ was administered after vaginal delivery to maintain uterine tone. Epidural analgesia was initiated prior to induction of labour or in the latent phase of labour. Seven Cesarean deliveries were performed under combined spinal-epidural anesthesia, five were performed under epidural anesthesia, and three women had general anesthesia. Oxytocin was administered via an intravenous infusion at a rate of 0.05–0.2 IU·min⁻¹ after operative delivery. One patient had a cardiac arrest on induction of general anesthesia and was successfully resuscitated. There were no maternal or neonatal deaths. Ten women were followed up at our institution and at six months postpartum; 50% of these patients were still symptomatic.

Conclusion We report favourable outcomes in 25 pregnant women with dilated cardiomyopathy who were managed by a multidisciplinary team.

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U. S. Ituk, MBBS · A. S. Habib, MBBS ·
C. M. Polin, MD · T. K. Allen, MBBS
Department of Anesthesiology, Duke University Medical Center,
Durham, NC, USA

U. S. Ituk, MBBS (✉)
Department of Anesthesia, Carver College of Medicine,
University of Iowa, 200 Hawkins Drive, 6JCP, Iowa City,
IA 52242, USA
e-mail: unyime-ituk@uiowa.edu

Résumé

Objectif Cette étude examine la gestion anesthésique péripartum et l'évolution des femmes atteintes de cardiomyopathie dilatée dans un grand centre médical universitaire sur une période de sept ans.

Constatations principales Vingt-cinq femmes ont été incluses dans cette série: 18 avec un diagnostic récent de cardiomyopathie et 7 avec une anamnèse de cardiomyopathie. Seize patientes (64 %) s'identifiaient comme Afro-américaines, sept (28 %) étaient caucasiennes et deux (8 %) étaient hispaniques. L'âge gestationnel médian (écart) au moment du nouveau diagnostic de cardiomyopathie était de 29 (7 à

38) semaines. Huit femmes (32 %) avaient des symptômes de classe III/IV de la New York Heart Association au moment de l'accouchement ou dans le post-partum immédiat. Une équipe multidisciplinaire d'obstétriciens, anesthésiologistes, cardiologues et pédiatres a été impliquée dans les soins donnés à ces femmes. L'âge gestationnel médian (écart) au moment de l'accouchement était de 33,5 (30 à 40) semaines. Il y a eu neuf accouchements par voie vaginale et 15 naissances par césarienne. Une patiente a perdu son fœtus à 19 semaines de grossesse. Le travail a été déclenché chez douze femmes par une perfusion intraveineuse d'ocytocine administrée à une vitesse de 0,001-0,02 UI·min⁻¹. Une perfusion d'ocytocine à vitesse variable avec une dose maximum de 0,05 UI·min⁻¹ a été administrée après les accouchements par voie vaginale pour maintenir le tonus utérin. Une analgésie péridurale a débuté avant l'induction du travail ou au cours de la phase de latence du travail. Sept césariennes ont été réalisées sous anesthésie combinée péridurale-rachianesthésie, cinq sous péridurale et trois sous anesthésie générale. L'ocytocine a été administrée en perfusion intraveineuse à la vitesse de 0,05 à 0,2 UI·min⁻¹ après la naissance chirurgicale. Une patiente a fait un arrêt cardiaque à l'induction de l'anesthésie générale et a été ressuscitée avec succès. Il n'y a pas eu de décès maternel ou néonatal. Dix femmes ont été suivies dans notre établissement et à six mois après l'accouchement, 50 % de ces patientes étaient encore symptomatiques.

Conclusion Nous décrivons une évolution favorable chez 25 femmes enceintes porteuses de cardiomyopathie dilatée qui ont été prises en charge par une équipe multidisciplinaire.

Cardiomyopathy is an increasing cause of pregnancy-related deaths in the USA. It accounted for > 12% of maternal deaths from 1998-2005 compared with 8% of deaths from 1991-1997.^{1,2} In the state of North Carolina where our institution is located, a study in 2002 reported that cardiomyopathy was the leading cause of pregnancy-related deaths, accounting for > 20% of deaths.³ In the United Kingdom, the report from the Centre for Maternal and Child Enquiries (CMACE) for 2006-2008 showed a similar trend of cardiac disease being the leading cause of maternal mortality, with cardiomyopathy accounting for 25% of all cardiac deaths.⁴ The two most common forms of cardiomyopathy are hypertrophic cardiomyopathy and dilated cardiomyopathy (which includes peripartum cardiomyopathy). Dilated cardiomyopathy is characterized by ventricular enlargement and systolic dysfunction with normal left ventricle wall thickness.⁵ Peripartum

cardiomyopathy is a type of dilated cardiomyopathy with the following characteristics: new onset cardiac failure in the last month of pregnancy or in the first five months postpartum, absence of an identifiable cause for cardiac failure, absence of recognizable heart disease prior to the last month of pregnancy, and left ventricular systolic dysfunction demonstrable on an echocardiogram.⁶

Previous studies and reviews have focused largely on the medical and obstetric management of these patients.⁷⁻⁹ Literature on anesthetic management has been limited to individual case reports.¹⁰⁻¹² The purpose of this case series was to report on the peripartum anesthetic management and outcomes of women with dilated cardiomyopathy in a large university medical centre.

Methods

After approval by the Institutional Review Board, we used the Duke Heart Disease in Pregnancy Registry and the electronic anesthesia database to identify women with a diagnosis of dilated cardiomyopathy in pregnancy. The Duke Heart Disease in Pregnancy Registry is a database of all pregnant women referred for cardiology review during pregnancy or in the puerperium. All entries into the database from January 1, 2003 to November 30, 2010 were reviewed. Information was collected on anesthetic management, maternal and fetal survival, as well as intrapartum and peripartum complications. We also reviewed demographic data, maternal pre-conception comorbidities, functional status at time of delivery (using the New York Heart Association [NYHA] classification), and echocardiographic diagnosis. The obstetric variables examined included parity, gestational age at diagnosis, gestational age at delivery, and mode of delivery. Fetal Apgar scores and weight were also recorded. Descriptive statistics are reported.

Results

There were 27,152 deliveries at the Duke University Hospital birthing centre from January 1, 2003 to November 30, 2010. During this seven-year period, 43 women with a history or diagnosis of cardiomyopathy delivered at the birthing centre (prevalence rate of 0.16%). Twenty-five women were included in the analysis. The Figure is a flowchart summary of cases included in this review. Fifteen women were excluded from the review because they had no clinical features consistent with cardiomyopathy or the medical records were unavailable. Characteristics of the excluded patients are summarized in the [Appendix](#). All pregnancies in the review were single gestation except for one patient (patient #9) who had a twin gestation.

Figure Flowchart of the cases included in the review

Patient characteristics

Sixteen patients (64%) identified themselves as African American, seven (28%) were Caucasian, and two patients (8%) were Hispanic. The ethnic distribution of patients in our general obstetric population is 32% Caucasian, 31% African American, 25% Hispanic, and 12% other ethnic groups. The median (range) age of patients in this series was 32 (24–43) yr and the median (range) body mass index was 38 (26–60) $\text{kg}\cdot\text{m}^{-2}$. Our overall obstetric population in 2010 had a median age of 29 yr and body mass index of 31.2 $\text{kg}\cdot\text{m}^{-2}$.

The commonest underlying comorbidities in this group of patients were chronic hypertension (44%), diabetes mellitus (20%), and gestational diabetes (8%). This is higher compared with our general obstetric population in 2010 with 17%, 15%, and 6% prevalence of hypertension, diabetes mellitus, and gestational diabetes, respectively.

The median (range) gestational age at time of new diagnosis of cardiomyopathy was 29 (7–38) weeks. Eight women (32%) had NYHA class III/IV symptoms at the time of delivery or in the immediate postpartum period. Four patients (16%) were designated as peripartum cardiomyopathy because their presentation and symptoms met the criteria for diagnosis by the National Institutes of Health.⁶ Table 1 summarizes the characteristics of patients in the review.

Labour and delivery

Prior to scheduled delivery, 12 patients were admitted for optimization of cardiac status. The goals of optimization

were reduction of preload and afterload using diuretics and or vasodilators and inhibition of excess neurohormonal activation using beta-blockers. Table 2 summarizes the medications and abnormal laboratory values on admission. The median (range) gestational age at the time of delivery was 33.5 (30–40) weeks. Nine deliveries were vaginal and 15 were Cesarean delivery. One patient had fetal loss at 19 weeks gestation and subsequently had an uneventful dilatation and evacuation. Labour was induced in 12 (48%) women with a variable intravenous oxytocin infusion at a rate of 0.001–0.02 $\text{IU}\cdot\text{min}^{-1}$. The infusion was started at 0.001 $\text{IU}\cdot\text{min}^{-1}$ and increased by 0.001–0.002 IU every 45 min depending on response. Nevertheless, three of these patients (patients #10, 20, and 21) had emergent Cesarean deliveries because of non-reassuring fetal heart rate, and a fourth patient (patient #19) had an emergent Cesarean delivery due to severe preeclampsia. Passive second stage with assisted vaginal delivery was used in all women who delivered vaginally. The oxytocin infusion was continued after delivery at a variable rate with a maximum dose of 0.05 $\text{IU}\cdot\text{min}^{-1}$ to maintain uterine tone. The commonest indication for Cesarean delivery was breech presentation (20%) followed by deteriorating cardiovascular function (16%).

Anesthetic management

In the 12 women who had induction of labour and vaginal delivery, epidural analgesia was initiated either before

Table 1 Patient characteristics

Patient	Age (yr)	BMI (kg·m ⁻²)	Gravidity/ Parity	Gestational age at diagnosis (weeks)	LVEF (%)	Interval between LVEF measurement and delivery (weeks)	NYHA class	Other Medical history
1	43	28	G1P0	31	35	< 1	III	HTN
2	26	38	G1P0	28	15	2	IV	GDM
3	34	50	G6P4	29	30	7	II	HTN, GDM
4	37	42	G6P2	19	15	< 1	II	HTN
5	34	37	G11P0	30	35	1	II	HTN, DM
6	30	36	G4P1	29	35	3	II	AICD
7	32	27	G4P1	25	40	7	I	-
8	30	28	G5P4	Pre-existing	30	3	II	Congenital endocardiofibroelastosis
9	39	40	G12P8	31	25	< 1	II	HTN
10	28	26	G7P2	38	35	< 1	II	-
11	40	28	G1P0	35	35	< 1	III	DM, HTN, CAD
12	29	40	G1P0	34	15	< 1	IV	DM, HTN
13	32	50	G4P2	18	40	4	III	Sleep apnea
14	29	43	G3P2	36	35	< 1	III	Preeclampsia
15	28	29	G4P2	24	20	2	III	-
16	27	44	G5P3	Pre-existing	40	4	I	HTN
17	33	27	G1P0	Pre-existing	35	7	I	A-V block, pacemaker
18	29	28	G2P1	7	40	9	II	-
19	36	60	G6P3	Pre-existing	45	6	II	HTN, Preeclampsia
20	37	48	G3P2	Pre-existing	20	2	III	DM
21	34	48	G11P0	29	35	5	II	HTN, DM
22	24	28	G2P1	Pre-existing	40	2	II	-
23	25	50	G8P4	22	35	4	II	HTN, DM
24	32	38	G4P3	8	40	8	II	ASD
25	31	43	G4P2	Pre-existing	40	2	II	Atrial fibrillation

BMI = body mass index; A-V block = atrioventricular block; LVEF = left ventricular ejection fraction; NYHA = New York Heart Association; HTN = hypertension; GDM = gestational diabetes mellitus; DM = diabetes mellitus; AICD = automatic implantable cardioverter-defibrillator; CAD = coronary artery disease; ASD = atrial septal defect

induction of labour or in the latent phase of labour. The standard mixture for epidural analgesia infusion at our institution is 0.1% bupivacaine with fentanyl 2 µg·mL⁻¹. Epidural analgesia was initiated with a 15-20 mL bolus of 0.1% isobaric bupivacaine given in divided doses and fentanyl 50 µg. Patient-controlled epidural analgesia was maintained with 0.125% bupivacaine with fentanyl 2 µg·mL⁻¹ using a bolus of 5 mL with an eight-minute lockout period and a continuous infusion of 5 mL·hr⁻¹. Intra-arterial blood pressure monitoring was initiated prior to epidural catheter placement in six women, and two women had a central venous catheter placed for central venous pressure monitoring in labour. All labouring patients except one (patient #9) had pulse oximetry and electrocardiographic telemetry monitoring. Table 3 summarizes the mode of delivery and anesthetic management of the included patients.

Seven Cesarean deliveries were performed under combined spinal-epidural (CSE), and in five patients, epidural anesthesia was used for Cesarean delivery. The spinal component of the CSE was used to deliver 0.75% hyperbaric bupivacaine 7.5 mg, fentanyl 15-20 µg, and preservative-free morphine 150 µg for postoperative analgesia. Two percent lidocaine with epinephrine 1:200,000 was administered via the epidural to augment or prolong surgical anesthesia in all patients who had a CSE. If the patient did not receive intrathecal morphine, preservative-free morphine 3 mg was administered via the epidural catheter for postoperative analgesia.

Two women (patients #14 and 19) had general anesthesia for Cesarean delivery because of failure of the neuraxial anesthesia technique to establish adequate surgical anesthesia. A third woman (patient #12) received general anesthesia for cardioversion of refractory

Table 2 Pre-delivery optimization

Patient	Pre- delivery medications	Pre-delivery Optimization	Abnormal Pre-delivery Laboratory results
1	Labetalol, Furosemide	Admitted to CICU pre-delivery for management of pulmonary edema and optimization of blood pressure	BNP: 559 pg·mL ⁻¹
2	Furosemide, Hydralazine, Isosorbide dinitrate, Heparin	Admitted to CICU pre-delivery for management of pulmonary edema	-
3	Carvedilol, Furosemide	No pre-delivery admission	-
4	Furosemide, Spironolactone, Hydralazine, Methyldopa, Labetalol, Isosorbide dinitrate, Enoxaparin	Admitted to antepartum ward for diuresis and management of malignant hypertension	BNP: 10,405 pg·mL ⁻¹ Creatinine: 1.4 mg·dL ⁻¹
5	Furosemide, Hydralazine, Methyldopa, Metoprolol, Enoxaparin, Insulin	Admitted to CICU pre-delivery for management of pulmonary edema and hyperkalemia	K: 6.9 mEq·L ⁻¹ Creatinine: 1.4 mg·dL ⁻¹
6	Metoprolol, Acetylsalicylic acid, Enoxaparin	No pre-delivery admission	-
7	Acetylsalicylic acid	No pre-delivery admission	-
8	Acetylsalicylic acid, Metoprolol	Admitted to antepartum ward	BNP: 923 pg·mL ⁻¹
9	Amitriptyline, Olanzapine	Cardiomyopathy occurred postpartum	Platelet count: 23 x 10 ⁹ ·L ⁻¹ AST: 65 U·L ⁻¹
10	-	Cardiomyopathy occurred postpartum	-
11	Labetalol, Methyldopa, Acetylsalicylic acid, Insulin	Admitted to antepartum ward	-
12	Metoprolol, Furosemide, Enoxaparin, glyburide	Admitted to CICU pre-delivery for management of pulmonary edema	BNP: 3,359 pg·mL ⁻¹
13	Enoxaparin	No pre-delivery admission	-
14	Metoprolol, Furosemide, Albuterol	Admitted to CICU pre-delivery for management of pulmonary edema	BNP: 672 pg·mL ⁻¹ K: 2.5 mEq·L ⁻¹
15	Metoprolol, Digoxin, Heparin	Admitted to antepartum ward for observation and management of SVT	-
16	Metoprolol	Admitted to antepartum ward with antepartum hemorrhage	-
17	-	No pre-delivery admission	-
18	Metoprolol, Acetylsalicylic acid	No pre-delivery admission	-
19	-	No pre-delivery admission	Troponin 0.41 ng·mL ⁻¹
20	Metoprolol, Torsemide, Isosorbide dinitrate, Hydralazine, Enoxaparin, Insulin	Admitted pre-delivery to the CICU	BNP: 452 pg·mL ⁻¹
21	Acetylsalicylic acid	No pre-delivery admission	BNP: 596 pg·mL ⁻¹
22	Carvedilol, Furosemide, Pravastatin, Hydralazine, Acetylsalicylic acid, Heparin, Albuterol, Insulin	Admitted to antepartum ward	-
23	-	No pre-delivery admission for optimization	-
24	Metoprolol, Furosemide	No pre-delivery admission for optimization	BNP: 658 pg·mL ⁻¹
25	-	No pre-delivery admission for optimization	-

CICU = cardiac intensive care unit; BNP = brain natriuretic peptide; K = potassium; AST = aspartate transaminase; SVT = supraventricular tachycardia

supraventricular tachycardia that was triggered during internal jugular vein cannulation. Patient #14 had general anesthesia induced with propofol 150 mg and

succinylcholine 100 mg, and patient #19 had general anesthesia induced with fentanyl 100 mg, propofol 150 mg, and succinylcholine 100 mg. The third patient

Table 3 Mode of delivery and anesthetic management

Patient	Gestation (weeks) at delivery	Mode of delivery	Urgency of delivery	Indication for Cesarean delivery	Type of Anesthesia	Invasive Monitoring	Neonatal weight (grams)/APGAR score	Peripartum Complications
1	31	Cesarean	Scheduled	Breech presentation	CSE	ABP	1,860/6,1	-
2	31	Cesarean	Scheduled	Breech presentation	CSE	ABP, PAC	1,865/8,9	Cardiogenic shock, LV clot
3	36	Cesarean	Scheduled	Breech presentation	CSE	ABP	3,875/9,9	-
4	19	D & E (IUFD)	-	-	CSE	ABP	-	-
5	32	Cesarean	Scheduled	Breech presentation	CSE	ABP	1,560/9,9	Wound sepsis
6	32	FAVD	-	-	Epidural	ABP	1,420/3,6	-
7	37	FAVD	-	-	Epidural	ABP	2,480/8,9	-
8	31	FAVD	-	-	Epidural	ABP	1,780/4,8	-
9	31	SVD	-	-	None	None	1,820/8,9 1,730/4,8	Precipitous labour
10	38	Cesarean	Emergent	NRFHT*	Epidural	ABP, CVC	3,645/9,9	Uterine atony
11	35	Cesarean	Urgent	Deteriorating cardiac function	Epidural	ABP	2,250/7,8	-
12	34	Cesarean	Urgent	Deteriorating cardiac function	General	ABP, PAC	2,080/9,9	SVT requiring cardioversion
13	39	FAVD	-	-	Epidural	None	3,070/8,9	-
14	36	Cesarean	Urgent	Deteriorating cardiac function	General (Failed epidural)	ABP, CVC	2,800/5,8	Pulmonary edema
15	34	FAVD	-	-	Epidural	ABP, CVC	2,620/8,9	-
16	33	Cesarean	Urgent	Placenta previa	CSE	CVC	2,030/6,7	-
17	40	Cesarean	Scheduled	Breech presentation	CSE	None	3,905/8,9	-
18	38	FAVD	-	-	Epidural	None	3,150/9,9	-
19	38	Cesarean	Emergent	Severe Preeclampsia*	General (Failed epidural)	ABP, CVC	3,120/1,5	Cardiac Arrest
20	32	Cesarean	Emergent	NRFHT*	Epidural	ABP, CVC	1,890/8,9	PVC, atrial fibrillation
21	32	Cesarean	Emergent	NRFHT*	Epidural	None	1,560/9,9	Wound sepsis
22	33	Cesarean	Urgent	Deteriorating cardiac function	Epidural	None	2,080/9,9	-
23	32	Cesarean	Urgent	Previous Cesarean x3	CSE	None	1,760/6,7	-
24	39	FAVD	-	-	Epidural	None	3,070/8,9	-
25	30	FAVD	-	-	Epidural	None	3,785/8,9	SVT

CSE = combined spinal-epidural; ABP = intra-arterial blood pressure; PAC = pulmonary artery catheter; LV = left ventricle; D & E = dilatation and evacuation; IUFD = intrauterine fetal demise; FAVD = forceps-assisted vaginal delivery; SVD = spontaneous vaginal delivery; NRFHT = non-reassuring fetal heart tone; CVC = central venous catheter; SVT = supraventricular tachycardia; PVC = premature ventricular contraction. APGAR scores were measured at one and five minutes. *Labouring prior to Cesarean delivery

had general anesthesia induced with a combination of fentanyl 50 µg, etomidate 14 mg, and succinylcholine 120 mg. Surgical anesthesia was maintained with isoflurane in 50% nitrous oxide and oxygen. Intra-arterial blood pressure monitoring was initiated prior to induction of neuraxial or general anesthesia in ten of the 15 Cesarean deliveries. Central venous pressure monitoring was used in five of the Cesarean deliveries, and a pulmonary artery catheter was used in two patients. Maternal systolic blood pressure was maintained using a low-dose phenylephrine infusion or boluses titrated to effect. Patient #2 required a dopamine infusion for 48 hr post delivery for management of cardiogenic shock. No other vasopressors or inotropic agents were used in the peripartum period.

Oxytocin was given as an intravenous infusion at a rate of 0.05–0.2 IU.min⁻¹ after operative delivery, and the infusion rate was titrated to achieve satisfactory uterine tone. Except for one patient (patient #10) who required two intramuscular doses of carboprost 250 µg for uterine atony, no other supplemental uterotonics were required. The standard volume of fluids administered in the perioperative period in our general obstetric population is 2–3 L of crystalloid, and the median (range) in this group of patients was 1,200 mL (550–1,600 mL). Two women (patients #12 and 14) had femoral artery and vein cannulation prior to Cesarean delivery. This was done to provide vascular access for emergent initiation of extracorporeal membrane oxygenation (ECMO) if required, and the delivery was done in the cardiac operating room.

The median (range) length of hospital stay was nine (3–75) days. Fourteen women (56%) were transferred to the cardiac intensive care unit (CICU) in the immediate post-delivery period, and the median (range) duration of stay was one (0–8) day. The ten women who weren't transferred to the CICU remained in the delivery unit for 24 hr postpartum before transfer to the postpartum unit.

Peripartum complications and neonatal outcomes

On induction of general anesthesia for Cesarean delivery with propofol 150 mg, fentanyl 100 µg, and succinylcholine 120 mg, one of the parturients (patient #19) developed hypotension and cardiac arrest; however, she had return of spontaneous circulation after approximately two minutes of cardiopulmonary resuscitation. There was no documented neurological deficit on follow up. Patient #12 developed a supraventricular tachycardia during internal jugular vein cannulation. The patient received two doses of esmolol (50 mg each), two doses of adenosine (6 mg each), and a loading dose of amiodarone (150 mg), but the arrhythmia did not cardiovert. Therefore, an electrical cardioversion was performed to restore normal sinus rhythm. Patient #14 developed pulmonary edema intraoperatively after receiving approximately 1,500 mL of intravenous fluids. She received intravenous furosemide and was transferred to the CICU with her trachea intubated. Other peripartum complications included atrial fibrillation, hemorrhage, and wound sepsis. There were no reported deaths in the puerperium.

Median (range) neonatal weight was 2,080 (1,420–3,905) g. There were no neonatal deaths; however, neonatal morbidity was not reviewed.

Long-term follow up

Only ten women attended a follow-up appointment at our institution. A summary of clinical status during this visit is presented in Table 4.

Discussion

We reviewed the peripartum anesthetic management and outcomes of 25 women with dilated cardiomyopathy who

Table 4 Six months postpartum cardiology review

Patient#	LVEF (%)	Comments
1	-	Improved symptoms, but patient didn't return for repeat echocardiogram
2	15	Clinically stable, AICD implanted
3	-	Clinically stable with NYHA class II symptoms
5	-	NYHA class II symptoms
6	45	NYHA class II symptoms
12	25	No signs of heart failure
13	50	NYHA class III symptoms
17	25	NYHA class I symptoms, commenced on beta-blocker
18	50	NYHA class I symptoms
19	50	No signs of heart failure

LVEF = left ventricular ejection fraction; AICD = automatic implantable cardioverter-defibrillator; NYHA = New York Heart Association

delivered during 2003–2010. Four of these women fulfilled the diagnostic criteria of peripartum cardiomyopathy.⁶ We also included other cases of dilated cardiomyopathy since the presentation and outcomes in patients with cardiomyopathy who present before the last month of gestation are similar to those with peripartum cardiomyopathy.⁸

The incidence of cardiomyopathy was highest among the African-American women and women with hypertension. This association is consistent with previous studies, but the literature is unclear if race is an independent risk factor or whether race interacts with hypertension to increase the risk of cardiomyopathy.⁷ The parity of the women in this series is comparable with that of the general obstetric population at our centre.

Forty-eight percent of women laboured before delivery, and all labouring parturients received neuraxial analgesia. More than half of the cohort delivered their babies by Cesarean delivery, with the majority receiving neuraxial anesthesia. The anesthetic management of these women at our institution begins in the antepartum period when they are referred for outpatient consultation by the obstetric anesthesiologist or when admitted for assessment and symptomatic management. Most cases are referred as soon as the diagnosis is made, and thus, they are typically reviewed in the late second trimester or early third trimester. Therefore, their referral depends on how early the obstetricians identify significant symptoms. The clinical progress and management of these patients are discussed at weekly multidisciplinary case conferences attended by obstetricians, anesthesiologists, cardiologists, and neonatologists. During these meetings, a consensus is reached on when to proceed with delivery and the anesthetic plan and concerns are also addressed. All the obstetric anesthesiologists are regularly notified and updated of the patient's progress. Echocardiograms to assess cardiac function are done in each trimester of pregnancy and more frequently if necessary depending on the patient's symptoms and response to therapy. The CMACE report for 2006–2008 recommends a multidisciplinary team approach to managing the care of women whose pregnancies are likely to be complicated by serious medical conditions.⁴

All the labouring parturients except patient #9 received epidural analgesia compared with an 80% rate of epidural uptake in our healthy population. Our standard epidural mixture was used, but the dosing was titrated carefully thereby avoiding hypotension. It is routine obstetric practice in our institution to minimize maternal expulsive effort and stress in high-risk cardiac patients by utilizing forceps or vacuum to assist the second stage of labour.

The Cesarean delivery rate in this cohort was 60%, which is higher than the overall rate of 38% in our institution. Nevertheless, only four Cesarean deliveries (patients #11, 12, 14, and 22) were performed primarily because of deteriorating maternal cardiac function, and their cardiovascular status could not be optimized further.

Other studies have attributed this increased rate of Cesarean delivery to the high incidence of gestational hypertension, twin pregnancy, and older maternal age in women presenting with dilated cardiomyopathy.⁹ Almost 50% of patients had either chronic hypertension or preeclampsia. This might be related to the fact that 64% of the patients in this series were of African American/black ethnicity compared with 31% in our overall obstetric population. The other factor that probably influenced the high rate of Cesarean delivery was breech presentation in 20% of pregnancies compared with 4.7% in our general obstetric population. This increased incidence of breech presentation is likely due to the higher preterm delivery in this group of patients.

The choice of anesthesia technique depends on the clinical status and the ability to maintain hemodynamic goals during the peripartum period. There have been favourable outcomes with both general and neuraxial anesthesia techniques, and there is lack of evidence showing difference in outcomes.^{10–12} The rate of general anesthesia for Cesarean delivery in this cohort was 20% compared with 4% in our general obstetric population. Nevertheless, general anesthesia was reserved for cases of worsening heart failure, hemodynamic instability, difficulty tolerating the supine position, or failed neuraxial technique (patients #14 and #19). Our preferred anesthetic technique was CSE or epidural anesthesia because of the ability to titrate the block with a resultant gradual onset of anesthesia. It has also been suggested that the gradual reduction in systemic vascular resistance due to sympathectomy is desirable provided the blood pressure is maintained.¹³ In our institution, the standard dosing of local anesthetics for spinal anesthesia for Cesarean delivery is 12 mg of hyperbaric bupivacaine. In this group of patients, a CSE with a reduced spinal dose of 7.5 mg of hyperbaric bupivacaine was used. The patients remained hemodynamically stable with this dose probably due to limited cephalic spread because they were positioned in a semi-recumbent position after the block was initiated.

The clinical status of the patient should guide the choice of induction agents for general anesthesia as well as the dose administered. The standard induction agent for general anesthesia in our obstetric patients is propofol; however, this is used without the addition of fentanyl in healthy parturients. The use of fentanyl confers hemodynamic

stability and allows a reduction in the dose of propofol required. In our opinion, the dose of propofol (150 mg) used for induction of general anesthesia in patients #14 and 19 might have been excessive considering their ventricular function at the time of induction of anesthesia, and this may have contributed to the cardiopulmonary arrest in patient #19. Intravenous fluids should be used cautiously in these parturients to avoid triggering acute pulmonary edema and further ventricular strain. When determining the amount of fluid to administer, the anesthesiologist needs to consider the amount of fluids the patient may have been administered preoperatively in addition to their current volume status. Excess administration of intravenous fluids in the perioperative period probably contributed to the onset of pulmonary edema in patient #14.

All parturients at our centre have pulse oximetry measured routinely while in labour. In this group of parturients with cardiac dysfunction, the SpO_2 may be the first indicator of impending pulmonary edema before clinical signs are apparent. Electrocardiographic telemetry monitoring is particularly important because of the increased risk of life-threatening arrhythmias that can occur in these patients during the peripartum period. The decision for using invasive monitoring was based on the clinical status of the patient at the time of presenting for delivery. Women with severe symptoms and increased probability of obstetric complications had intra-arterial blood pressure monitoring. Intra-arterial blood pressure monitoring was used in over half of the patients, more frequently during operative delivery. Intra-arterial blood pressure monitoring should also be considered in patients when noninvasive blood pressure monitoring may be unreliable due to their body habitus. Patient #17 was asymptomatic despite having a history of an atrioventricular block managed with a pacemaker, and so there was no indication for invasive monitoring. A recent position statement by the European Society of Cardiology working group on peripartum cardiomyopathy recommended continuous invasive hemodynamic monitoring, but there is lack of evidence to show it improves outcome.^{14,15} Two women (patients #10 and 15) had central venous monitoring during labour because the managing team thought it would be beneficial for monitoring intravascular volume status. Central venous access may also be required in women with poor peripheral venous access due to either edema or obesity. A central venous access is also useful for administration of vasopressors if required, as might be the case in this patient population. Then again, parturients may not tolerate the recumbent or Trendelenburg position required for securing the access, and it could be a risk for triggering arrhythmias as it did in one of our patients.

Central venous pressure monitoring was performed in the patient who had the refractory arrhythmia because of marked symptoms despite optimization. In our opinion, intra-arterial blood pressure monitoring in addition to the American Society of Anesthesiologists' standard basic anesthesia monitoring should be the minimum in symptomatic patients. Noninvasive and minimally invasive cardiac output monitoring based on either electrical bioimpedance or pulse contour waveform analysis may be useful in this group of patients.¹⁶ We have used LiDCo (<http://www.lidco.com>) cardiac output monitoring in other parturients with severe cardiac disease, especially if intra-arterial blood pressure monitoring was already indicated. This may provide additional information on trends in the cardiac indices in response to labour induction, epidural top ups, delivery, and oxytocic agents.

The cardiac anesthesiologist and cardiothoracic surgeons were consulted on the management of two patients with severe left ventricular dysfunction. They advised that these patients should have femoral vessel cannulation to provide access for ECMO if there was significant hemodynamic compromise refractory to drug therapy. Nevertheless, in our view, this is indicated in a very limited number of patients.

Oxytocin was administered via a continuous infusion after both vaginal and Cesarean delivery. This avoids the potential tachycardia, hypotension, and myocardial ischemia associated with bolus intravenous dosing, which could be detrimental in these parturients.¹⁷ It is important, however, to take into consideration the total fluid administered; therefore, using a more concentrated oxytocin infusion or an intramuscular bolus in the hemodynamically stable patient may be preferable. Nevertheless, if administering intramuscular oxytocin, the absorption may be unpredictable. Second-line uterotonics, methylergonovine and carboprost, should be avoided in these patients, especially if they have underlying hypertension or increased pulmonary vascular resistance. Rectal misoprostol may be a more suitable alternative uterotonic if these patients develop postpartum hemorrhage secondary to uterine atony.

The follow-up of postpartum patients in our general obstetric population is low due to a high attrition rate of approximately 40%. This is because many high-risk parturients referred to our tertiary referral centre are followed up postpartum at other institutions. This was also true for this group of patients, so we couldn't examine the outcomes after 42 days postpartum in most of the included cases. It has been reported that patients with severe myocardial dysfunction due to cardiomyopathy are unlikely to regain normal cardiac function at follow-up. Habli *et al.* reported that women with a left ventricular

ejection fraction of $\leq 25\%$ were more likely to need a heart transplant.¹⁸ Elkayam *et al.* reported that subsequent pregnancies in patients with peripartum cardiomyopathy were associated with significant decrease in left ventricular function and functional status.¹⁹ Fifty percent of the women who were followed up at our institution were still symptomatic at six months postpartum.

There are limitations to our review. The methodology is retrospective, and so, records of some patients with dilated cardiomyopathy could have been inadvertently missed during the medical records search. Other limitations include the failure to retrieve medical records from other institutions, so both the history and long-term follow-up were unavailable for many of the patients included in the review. Lastly, our outcomes should be analyzed cautiously because of the relatively small number of cases reported. Nevertheless, we consider this series large when compared with others reported on peripartum

anesthetic management of women with dilated cardiomyopathy.

In this review, our overall results were favourable, likely as a result of a multidisciplinary approach to the management of these high-risk parturients. Early recognition of the symptoms and referral for evaluation allow for better planning of peripartum care and improved maternal and neonatal outcomes.

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Conflicts of interest Unyime Ituk, Ashraf Habib, Carrie Polin, and Terrence Allen have no potential competing financial interests relating to patents and/or share holdings in corporations involved in the development and/or marketing of medications or medical devices evaluated in this study.

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Appendix

Characteristics of patients with a history of cardiomyopathy excluded from the review

No.	Age (yr)	LVEF	GA (weeks) @ LVEF Assessment	Interval (yr) since diagnosis	GA @ Delivery (weeks)	IOL	Mode of Delivery (indication)	Complications	Medications	Other Medical History
1	32	>55%	28	4	39	No	CD (repeat)	-	-	-
2	39	>55%	33	3	39	No	CD (NRFHT)	-	Acetylsalicylic acid	-
3	24	>55%	28	3	39	No	CD (repeat)	-	-	Obesity, Asthma
4	27	50%	28	4	39	No	CD (breech presentation)	-	-	Peripheral neuropathy
5	32	>55%	26	17	39	No	SVD	-	-	Viral myocarditis
6	42	50%	27	6	30	No	CD (PPROM)	-	Acetylsalicylic acid, Labetalol, Nitroglycerin Furosemide	CAD, HTN, CKD
7	25	>55%	32	1	38	No	SVD	-	-	Substance abuse
8	31	>55%	30	2	37	Yes	SVD	-	Insulin	Polyhydramnios, GDM
9	22	NA	NA	2	NA	No	SVD	-	-	-
10	36	50%	28	NA	36	No	CD (placental abruption)	Low APGAR score	-	Substance abuse
11	32	50%	29	3	32	No	SVD (PPROM)	-	-	CKD
12	35	>55%	29	2	39	No	CD (repeat)	-	-	-
13	27	>55%	28	4	38	No	SVD	-	-	-
14	32	>55%	30	3	37	No	SVD	-	Acetylsalicylic acid	CAD
15	32	>55%	29	3	37	No	SVD	-	Acetylsalicylic acid	-

LVEF = left ventricular ejection fraction; GA = gestational age; IOL = induction of labour; CD = Cesarean delivery; SVD = spontaneous vaginal delivery; PPROM = preterm premature rupture of membranes; CAD = coronary artery disease; HTN = hypertension; CKD = chronic kidney disease; GDM = gestational diabetes mellitus; NRFHT = non-reassuring fetal heart tones; NA = data unavailable

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