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Peer-Reviewed Case Report and Review

Successful pregnancy with centrifugal flow left ventricular assist device: A case report and review of the literature

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Abstract

Successful deliveries from patients supported by axial flow left ventricular devices have been previously reported. We present the first case of a successful pregnancy and birth in a patient with a centrifugal-flow left ventricular assist device. A 24-year-old female with methamphetamine-induced cardiomyopathy and end-stage congestive heart failure supported by a HeartWare™ ventricular assist device (Medtronic) presented two years after device implantation with an unplanned pregnancy at 11-weeks of gestation. Following a multidisciplinary evaluation by experts in advanced heart failure, maternal fetal medicine, cardiothoracic surgery, anesthesia, ethics, psychiatry, and palliative care, an advanced plan of care was established. An elective induction of labor was scheduled for the 34th week of gestation. Given poor labor progression despite maximal induction efforts, the patient was transferred to a cardiothoracic operating room where she delivered a healthy baby boy via Cesarean section under close hemodynamic monitoring by advanced heart failure and cardiothoracic surgery teams.

Background

Left ventricular assist devices (LVADs) are rapidly expanding as an established therapeutic modality in patients with advanced heart failure (AHF) as a destination therapy. In women with end stage heart failure who are supported by LVADs, conception is considered "high risk" for both the mother and the fetus and is contraindicated.[1] We report the case of an unplanned pregnancy and successful delivery in an LVAD-supported patient.

Case Report

A 24-year-old female with a history of stage D, biventricular heart failure secondary to non-ischemic cardiomyopathy (likely from methamphetamine use) was supported by a centrifugal-flow LVAD (HeartWare™ ventricular assist device [HVAD], Medtronic). Her LVAD postoperative recovery required a short course of intravenous milrinone for right ventricular (RV) failure; milrinone was discontinued prior to discharge. Early after LVAD implantation, right heart catherization showed a right atrial pressure (RAP) of 6 mmHg and a pulmonary artery (PA) pressure of 4/17 mmHg at an LVAD speed of 2560 rpm. Despite multidisciplinary efforts, including close follow up with psychiatry to improve compliance, the patient struggled with polysubstance abuse and medication non-compliance, including contraception. Her past medical history was also significant for iron deficiency anemia, deep venous thrombosis, pelvic inflammatory disease, anxiety, depression, post-traumatic stress disorder, and active tobacco use.

Two years post-LVAD implantation, the patient presented to the emergency department complaining of non-exertional chest pain and lethargy.. Her physical examination, device evaluation, electrocardiogram, and cardiac biomarkers were unremarkable, but her urine drug screen was positive for amphetamines, benzodiazepines, phencyclidine, and tetrahydrocannabinol. Her international normalized ratio was 1. She had a positive urine pregnancy test, and an obstetric ultrasound confirmed a single intrauterine fetus with an estimated gestational age of 11-weeks. She reported intentional non-compliance with the recommendation for effective contraception.

A multidisciplinary evaluation was performed by experts in AHF, maternal fetal medicine (MFM), cardiothoracic surgery (CTS), anesthesia, ethics, psychiatry, and palliative care. Inherent and potentially unknown maternal and fetal risks during all stages of pregnancy while on LVAD support as well as risks of intrauterine exposure to potentially teratogenic medications were explained to the patient. Understanding the risks to herself and her baby, the patient elected to continue with the pregnancy.

Enoxaparin was selected as outpatient anticoagulation strategy with close Factor Xa monitoring. In consultation with MFM, CTS, AHF, and anesthesia services, the

patient was scheduled for close outpatient follow up and an elective induction of labor at 34-weeks of gestation. A plan was devised for labor to happen in the CTS intensive care unit (ICU) with invasive hemodynamic monitoring and with all teams physically available during delivery. A contingency plan was also implemented for potential medical admissions prior to delivery. If admission was needed, the patient was to be taken directly to the cardiac ICU with close MFM and CTS consultation and follow up. Weekly followup appointments were schedued with the high-risk obstetric and AHF service.

The patient was closely monitored throughout her pregnancy and tolerated the hemodynamic changes of pregnancy well. She remained on chronic low-dose benzodiazepines for management of uncontrollable anxiety. She was also started on buprenorphine/naloxone to prevent heroin and opioid abuse relapse. She underwent frequent urine drug testing, and all screens remained negative. Monthly transthoracic echocardiograms revealed stable RV and left ventricular (LV) systolic function along with minimal progressive increase in LV internal diameter end diastole (Table 1). To optimize the patient's mean arterial pressure (MAP), nifedipine was added after her third outpatient visit. Based on clinical and echocardiographic findings, the VAD speed was increased by 40 and 20 RPM at the 30th and 31st week of gestation, respectively (final speed of 2780 RPM). Her RV size and function remained stable despite the increased LVAD speed, volume expansion, and increased cardiac output related to pregnancy.

She was admitted to the hospital during her 34th week of gestation. Arterial line and pulmonary artery catheters were placed for invasive hemodynamic monitoring. With the LVAD speed at 2780 rpm, the RHC findings were: RAP = 9 mmHg, PA pressure = 35/19 mmHg, MAP = 84 mmHg. Nifedipine was stopped, and as needed intravenous hydralazine was started with the goal MAP of less than 85mmHg. Enoxaparin was held, and a heparin drip started in preparation for labor. Induction of labor was started the next morning in the CTS-ICU with oxytocin infusion and artificial rupture of the membranes. Given failed labor progression despite maximal induction efforts, the patient was transferred to the CTS operating room where she underwent a Cesarean section (CS) with epidural anesthesia. She delivered a 2296 g male with one and five minute APGAR scores of 8 and 9, respectively. A levonorgestrel-releasing intrauterine device was placed inside the uterine cavity before closure of the walls. Beside self-limited, minimal increases in the pulmonary artery pressure, the patient remained hemodynamically stable throughout the procedure.

Her postoperative course was complicated by anemia requiring transfusion. Multifocal pneumonia and bacteremia were successfully treated with broad-spectrum antibiotics in consultation with the infectious disease service. Both mother and the baby remained stable and asymptomatic on their outpatient followups.

Table 1. Hemodynamic and Echocardiographic Monitoring. The patient received an LVAD implantation in 2016; medication and monitoring results are recorded for the entire pregnancy and first follow-up visit.

Event or Gestational Age	MAP	VAD Speed	Transthoracic Echo Findings	Medication Adjustments	Comments
LVAD Implantation	70	2560	LVEF: 10%, LVIDD:6cm, Grade I diastolic dysfunction, Borderline RV systolic function, Biatrial enlargement, mild MR and TR	-	missed follow-up appointments; sub-therapeutic INRs; active tobacco and polysubstance abuse
11Weeks+1/7	80	2720	LVEF: 15%, LVIDD: 5cm, Normal RV size and function, LAE, Mild TR, Trace MR	heparin drip used in hospital; outpatient enoxaparin dose based on Factor Xa level monitoring; prenatal vitamins started	remains on benzodiazepines & buprenorphine/ naloxone
12Weeks+2/7	92	2720	LVEF: 15%, LVIDD: 5.31cm, No AV opening, Normal RV size and function. LAE, Trace MR and TR	nifedipine added	-
13Weeks+2/7	78	2720	-	-	-
16Weeks+2/7	92	2720	LVEF: 15%, LVIDD: 5.4cm, Variable AV opening, Normal RV size mildly reduced RV function. LAE, Trace MR and TR	nifedipine up-titrated	missed follow-up appointment
22Weeks+5/7	90	2720	-	Education on nifedipine non-compliance	missed follow-up appointment
28Weeks+2/7	82	2720	LVEF: 15%, LVIDD: 5.74cm, Intermittent AV opening, Normal RV size mildly reduced RV function. Biatrial enlargement, Mild to Moderate MR and TR	-	-
30Weeks+2/7	76	2720	LVEF: 15%, LVIDD: 5.8cm, Intermittent AV opening, Normal RV size and function. Mild biatrial enlargement, Mild MR and TR	LVAD speed increased by 40 rpm	mildly increased dyspnea with exertion
31Weeks+2/7	82	2760	-	LVAD Speed increased by 20 rpm	-
33Weeks+5/7	84	2780	-	-	referred for admission
34Weeks+1/7	84	2780	-	nifedipine & enoxaparin halted; IV hydralazine as needed; heparin drip initiated	arterial line and pulmonary artery catheter placed
34Weeks+2/7	73	2780	-	-	labor induction followed by cesarean section
Follow up visit (POD8)	75	2720	LVEF: 10%, LVIDD: 5.4cm, Intermittent AV opening, Normal RV size and mildly reduced function. Moderate LAE, Mild TR	Speed decreased to baseline	

Abbreviations: MAP: Mean Arterial Pressure; LVAD: Left Ventricular Assist Device; OP: outpatient; LVEF: Left Ventricular Ejection Fraction; LVIDD: Left Ventricular Internal Diameter at End Diastole; MR: Mitral regurgitation; MAP: Mean Arterial Pressure; TR: tricuspid Regurgitation; INR: international Normalized ratio; RV: Right Ventricle; LAE: Left Atrial Enlargement.

Discussion and Literature Review

This is the first reported case of a successful pregnancy and delivery in a patient with a centrifugal-flow HVAD. The first two cases of pregnancy on LVAD support were reported by LaRue, et al.[1] and Sims, et al.[2] in 2011, and the third case was reported in 2017 by Makdisi et al.[3] Table 2 provides details about characteristics of prior reported cases. All three prior cases involved patients with HeartMate II devices (Abbott) that were implanted 6 to 11-months prior to the diagnosis of pregnancy. The gestational age at presentation ranged from 6 to 34-weeks. The first two cases delivered by CS;[1,2] however, Sims et al reported a normal vaginal delivery.[3] All cases involved switching from warfarin to heparin and/or low molecular heparin. To meet the increased cardiac output associated with pregnancy, the LVAD speed was increased in a stepwise fashion in all three cases with echocardiographic and clinical response monitoring. Postpartum anemia was reported in all three cases.

Our patient's clinical course differed in some aspects with the prior reported cases. Our patient had an HVAD—a centrifugal pump with lower rotational speeds (2000-3000 RPM) as compared to HeartMate II, an axial-flow device which has higher rotational speeds (9000-10,000 RPM). Unlike our patient, in the two prior cases, newborns had complications mostly related to prematurity. Despite remaining on benzodiazepines and the buprenorphine/naloxone combination during pregnancy, our patient's newborn had normal APGAR scores and an uncomplicated newborn transition.

Our patient also had history of biventricular failure requiring a short course of milrinone after her initial HVAD implantation. Despite the increased LVAD speeds during gestation and the expected increase in maternal plasma volume of up to 40–50% near term, her RV did not require any inotropic support.

Even though our case and the three prior reported cases had favorable outcomes, risks and potential complications of pregnancy and labor while on LVAD remain largely unknown and potentially catastrophic. A multidisciplinary approach involving the AHF team, CTS, anesthesiology, MFM, psychiatry, psychology, ethics, and palliative care as well as social workers and case managers is key in optimal management. Patients will require close outpatient monitoring and advanced planning for a multidisciplinary inpatient care prior to scheduled delivery.

With increasing use of LVAD in treatment of non-ischemic cardiomyopathy, addtional cases of unplanned pregnancy are inevitable. The uteroplacental unit is characterized by a high-flow, low-resistance circulation, but there is limited data on normal placental growth with LVAD. These reported cases of successful pregnancy on LVAD with appropriately grown fetuses provide anecdotal evidence to the theory that continuous flow from LVADs can potentially support the uteroplacental circulation in an otherwise normal pregnancy. Comparative studies are necessary regarding anticoagulation strategies and to identify optimal targets for Factor Xa levels in different devices. Future multicenter studies should redefine

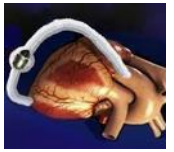

Table 2. Characteristics of prior reported cases of pregnancy while on LVAD

Year Author	Type of LVAD	Time since LVAD	Maternal Age at Diagnosis	Fetal age at Diagnosis	Fetal Age at Delivery	Delivery method	Pre-partum complications	Intrapartum Events	Post-Partum Complications	APGAR Score/ Compli-cations	Adjustments after pregnancy
2011 LaRue, et al.[1]	HM-II	11 Months	19 Years	~ 34 Weeks	~34+1/7 Weeks	CS	Bloody vaginal discharge, cervical effacement forcing an urgent CS	Momentary, self-limited rise in PAP	Anemia requiring total of 8u of pRBC transfusion	6, 8, 9 Mild respiratory distress, apnea & bradycardia of prematurity	Heparin drip, Betamethasone
2011 Sims, et al.[2]	HM-II	6 Months	26 Years	~ 6 Weeks	~34+5/7 Weeks	NVD	Vaginal Bleeding, Acquired vWF deficiency	Stalled cervical dilatation requiring amniotomy. Increased LVIDD and MR and worsened RV function requiring diuretic, nitrate and milrinone drip	None	Unknown APGAR score No compli-cations	Heparin drip, Cryoprecipitate, Cerclage placement, stepwise increase in LVAD speed
2017 Makdisi, et al.[3]	HM-II	9 Months	36 Years	~ 20 Weeks	32 Weeks	CS	None	None	None	2, 3, 3 Apnea requiring intubation	Lisinopril, furosemide, spironolactone, and warfarin discontinued, Enoxaparin started, betamethasone, step-wise increase in LVAD speed
2019 Hosseini Dehkordi, et al.	HVAD	23 Months	24 Years	~ 11 Weeks	34+2/7 Weeks	CS	None	Stalled cervical dilatation and inadequate progression of labor requiring CS	Anemia requiring 1U of pRBC transfusion; multifocal pneumonia with subsequent bacteremia requiring antibiotics	8,9 No compli-cations	Enoxaparin, Prenatal vitamin, Stepwise increase in LVAD speed

Abbreviations: LVAD: Left Ventricular Assist Device; HM-II: Heart Mate-II; HVAD: Heartware ventricular assist device; CS: Cesarean Section; NVD: Normal Vaginal Delivery; vWF: von Willebrand Factor; LVIDD: left Ventricular Internal diameter at End Diastole; MR: Mitral regurgitation; RV: Right Ventricle; pRBC; packed Red Blood Cell

strategies regarding optimal timing and standardization of LVAD speed increments at various stages of pregnancy.

Pregnancy after LVAD presents signficant risk for both mother and fetus and is generally contraindicated. However, many young women of childbearing age with an LVAD may desire children. Some of these patients will receive cardiac transplantation. While there have been many successful pregnancies in post-cardiac transplant patients reported in the literature, long-term outcome data is limited. Moreover, many patients might not be eligible for cardiac transplantation due to different reasons (e.g. high antibody titers); therefore, many young women of childbearing age could be deprived of a life-fulfilling experience after LVAD implantation as a destination therapy. Theoretically, certain fetal risks during pregnancy with LVAD are likely to be less due to minimal exposure to teratogenic medications that are used in patients with cardiac transplantation. We need to build a consensus, integrate research and identify centers that are willing to support and invest in research on pregnancy with LVAD support via a multidisciplinary approach. It remains to be seen whether maternal and fetal risks can be minimized so that certain childbearing women can have successful delivery while being supported with LVAD.

References:

1) LaRue S, Shanks A, Wang IW, Ewald G, Anderson D, Joseph S. Left ventricular assist device in pregnancy. Obstet Gynecol. 2011;118(2 Pt 2):426–428.

2) Sims DB, Vink J, Uriel N, Cleary KL, Smiley RM, Jorde UP, Restaino SW. A successful pregnancy during mechanical circulatory device support. J Heart Lung Transplant. 2011;30(9):1065-1067.

3) Makdisi G, Jan MY, Dungy-Poythress L, Wang I-W, Caccamo MA. Successful Delivery in a Patient With Left Ventricular Assist Device and Unplanned Pregnancy. Ann Thorac Surg. 2017;104(1):e31-e33.