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CASE REPORT

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Multifaceted Fontan Patients and Their Response to Pregnancy

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ABSTRACT

We present 4 patients with Fontan circulation who underwent successful pregnancies, albeit with complications that required close monitoring and timely intervention. Each Fontan patient presents with a unique clinical picture, making risk stratification challenging but all the more important. (J Am Coll Cardiol Case Rep 2023;28:102136)

An increasing number of patients with univentricular heart and Fontan-type circulation are reaching adulthood with a good quality of life and satisfactory exercise tolerance. In this paper, we present the cases of 4 women with a Fontan circulation who became pregnant. We describe their pre-pregnancy assessment and their management during pregnancy and delivery.

CASE 1

Patient 1 was born with a double-inlet left ventricle, rudimentary right ventricle (RV), ventriculoarterial discordance, and pulmonary stenosis (PS) (**Table 1**, Video 1). A total cavopulmonary connection (TCPC) was established at age 11 years. She had multiple sinusoids from the left coronary artery to the RV and a fistula from the right coronary artery to the left atrium.

LEARNING OBJECTIVES

- Preconception counseling is a key for all women of childbearing age with Fontan circulation.
- Those who conceive should be referred early to established multidisciplinary obstetric and cardiac services to improve outcomes.

In her first pregnancy, at age 23 years, she delivered a live preterm infant weighing 1,700 g at 33 weeks gestation via an assisted vaginal delivery in a nonspecialist center. The postpartum period was complicated by maternal circulatory collapse attributed to a pulmonary embolism, for which she was treated with therapeutic-dose low-molecular-weight heparin. This caused a postpartum hemorrhage from which she recovered, and both she and the baby were discharged home well.

Her second pregnancy (at age 26 years) was complicated by intrauterine growth restriction (IUGR) requiring delivery by emergency cesarean section (CS) at 29 weeks gestation (a live female newborn weighing 634 g). There were no maternal

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ABBREVIATIONS AND ACRONYMS

BNP = brain natriuretic peptide

CS = cesarean section

IUGR = intrauterine growth restriction

mWHO = modified World Health Organization

PS = pulmonary stenosis

RV = right ventricle

SV = single ventricle

TCPC = total cavopulmonary connection

VSD = ventricular septal defect

complications. The baby had a prolonged stay in the neonatal intensive care unit but no long-term morbidities.

Following this, she had a medical termination of pregnancy at age 28 years and was counseled against further pregnancies. She remained stable with no signs of Fontan failure and resting saturations between 85% and 90%, and her liver ultrasound showed hepatic steatosis. Echocardiogram at age 35 years demonstrated unobstructed TCPC connections, with a dilated single ventricle (SV) and preserved systolic function. She used an etonogestrel-containing implant for contraception and was due to have it replaced when she became pregnant at age 36 years and presented at 22 weeks gestation for her first cardiac antenatal visit. She was taking the following medications once daily: aspirin 75 mg, enoxaparin 40 mg, furosemide 20 mg, and lansoprazole 30 mg. During pregnancy, she became progressively more breathless and developed ankle edema, for which furosemide was increased to 40 mg daily. Amiloride 2.5 mg was started but not tolerated. She developed gestational diabetes requiring insulin and obstetric cholestasis at 26 weeks. At 30 weeks 6 days, she presented with hemoptysis and shortness of breath, but computed tomography pulmonary angiography with a TCPC-specific protocol excluded pulmonary embolism.

Serial echocardiograms showed SV function within the low-normal range, without significant valvular regurgitation and patent TCPC connections. Severe IUGR and abnormal umbilical artery Doppler findings were diagnosed, requiring urgent delivery by CS at 32 weeks of a live male newborn weighing 1,435 g with Apgar scores of 4, 5, and 7 (**Table 2**).

Postdelivery, she reported increased ankle swelling and shortness of breath. Her echocardiogram showed a more dilated SV with reduced/low-normal systolic function. She was followed up at 1-month postdelivery. Brain natriuretic peptide (BNP) level was 38 ng/L, renal function was normal, and resting oxygen saturations were 89%. She was maintained on furosemide 60 mg daily, spironolactone 25 mg daily, and apixaban 5 mg twice daily.

CASE 2

Patient 2 was born with situs solitus, dextrocardia, transposition of the great arteries with PS, small restrictive ventricular septal defect (VSD), and large atrial septal defect (Video 2). At age 7 years, a TCPC was completed. She also had very severe left ventricular hypertrophy, in part secondary to the restrictive VSD (which is the only outflow for the left ventricle, but out of proportion to this). She was genotype-negative for hypertrophic cardiomyopathy. She was clinically stable at preconception counseling, with known exertional desaturation and subnormal exercise capacity on cardiopulmonary exercise test with predicted peak Vo_2 of 54%. BNP was raised but stable at 200 ng/L, and a liver ultrasound showed mild fibrosis. She was counseled on the significant risks of pregnancy.

At the age of 26 years, she became pregnant and was counseled regarding the high risk of miscarriage as well as fetal and maternal complications and, because she was considered to be class IV on the modified World Health Organization (mWHO) classification, a termination was offered. Her medications included levothyroxine 100 μg daily, folic acid, vitamin D, aspirin 75 mg, and enoxaparin 40 mg daily.

She remained clinically stable, with oxygen saturations of >90% throughout pregnancy, without heart failure or arrhythmia. Serial echocardiograms showed preserved univentricular systolic function and patent TCPC connections until 30 weeks, when her echocardiogram demonstrated signs of systemic ventricular dysfunction and new-onset TCPC pathway obstruction. Her newborn was delivered by CS at 31 weeks for maternal cardiac reasons (live female newborn; 1,443 g) (**Table 2**). Postdelivery echocardiography demonstrated sluggish blood flow in the TCPC, with good ventricular function. Thrombus was excluded, and she is fully anticoagulated.

CASE 3

Patient 3 was born with tricuspid atresia and a rudimentary RV, ventriculoarterial concordance, and large nonrestrictive VSD (Videos 3A and 3B). At age 2 years, she underwent her first Fontan operation with a homograft connecting the right atrium to the pulmonary artery. At age 22 years, this was converted to TCPC. She had a history of recurrent atrial arrhythmias and had undergone 3 ablations, and she was stable on bisoprolol 2.5 mg daily. An epicardial dual-chamber pacemaker was implanted at 26 years because of sinus arrest. Her resting oxygen saturation was 98%, with preserved ventricular function on echocardiography, without significant valvular disease. She had received prepregnancy counseling and had 3 first trimester miscarriages.

She next conceived at age 34 years and remained clinically stable throughout the pregnancy, on daily enoxaparin 40 mg and aspirin 75 mg. Her pregnancy remained uncomplicated until the 30-week fetal growth scan, which confirmed severe IUGR and

TABLE 1 Diagnosis and Treatment With Prepregnancy Status

	Patient 1	Patient 2	Patient 3	Patient 4
Anatomy	Double-inlet left ventricle with a rudimentary RV, ventriculoarterial discordance, and PS. The aortic arch was right sided, and there was a small PDA.	Situs solitus, dextrocardia, TGA with PS, small restrictive VSD, and large ASD	Tricuspid atresia and a rudimentary RV, ventriculoarterial concordance, and large nonrestrictive VSD	Double-inlet left ventricle and transposition of the great arteries
Age at intervention, y	11	7	2 and then 24	2
Type of Fontan	TCPC with an extracardiac 22-mm fenestrated conduit and PDA closure in 1998	TCPC	At the age of 2 y, atriopulmonary Fontan; converted to TCPC at age 24 years	TCPC followed by DKS operation for LVOTO
Other lesions	Multiple sinusoids from the LCA to the RV and a fistula from the RCA to the left atrium, without a target for intervention	Severe LVH likely in keeping with the diagnosis of hypertrophic cardiomyopathy	–	Venovenous collateral
Comorbidities				
Arrhythmias	No	No	Yes: 3 ablations, medication, and dual-chamber pacemaker	No
Heart failure	Yes	No	No	No
Fontan failure	No	No	No	No
Liver disease	Hepatic steatosis	No	No	No
Thromboembolism	No	No	No	No
Collaterals	No	No	No	Yes: failed to close
NYHA functional class	II	II	I	I
Saturation, %	88	90	98	87
Baseline echocardiogram, prepregnancy				
Ventricular function	FAC of 42% visually preserved	Preserved left ventricle function with EF of 54%	Normal with EF of 59%	Normal with EF of 60%
Valvular regurgitation	Mild AV	None	Mild AV	None
Patency of Fontan circulation	Patent TCPC with fenestration	Patent TCPC	Patent TCPC	Patent TCPC

ASD = atrial septal defect; AV = aortic valve; DKS = Damus-Kaye-Stansel; EF = ejection fraction; FAC = fractional area change; LCA = left coronary artery; LVH = left ventricle hypertrophy; LVOTO = left ventricular outflow tract obstruction; PDA = patent ductus arteriosus; PS = pulmonary stenosis; RCA = right coronary artery; RV = right ventricle; TCPC = total cavopulmonary connection; TGA = transposition of the great arteries; VSD = ventricular septal defect.

abnormal Doppler findings. She underwent an emergency CS at 32 weeks without complication. Postnatally, she remained asymptomatic and stable, with no neonatal complications.

CASE 4

Patient 4 was born with double-inlet left ventricle and transposition of the great arteries. TCPC was performed, followed by a Damus-Kaye-Stansel operation for left ventricular outflow tract obstruction. Her resting oxygen saturation was 87%. She had developed venovenous collaterals, and previous percutaneous attempts to close these had failed. Prepregnancy cardiac magnetic resonance showed unobstructed TCPC connections and good Damus-Kaye-Stansel function, some flow acceleration in the left ventricular outflow tract without significant obstruction, and preserved ventricular function (Video 4). She had near-normal exercise capacity on cardiopulmonary exercise test (peak Vo_2: 79% of predicted). BNP level was 97 ng/L.

She conceived at age 29 years and tolerated pregnancy well, with no decline in oxygen saturations. She was hospitalized at 35 weeks with raised blood pressure (>140/90 mm Hg). The 36-week scan showed IUGR and abnormal Doppler findings. She had an uncomplicated CS at 36 weeks and delivered a live male newborn (2,300 g). She remained clinically stable postdelivery with preserved univentricular systolic function.

DISCUSSION

The Fontan procedure is palliative surgery for patients with a functional SV. It decreases cyanosis but results in an abnormal circulation with low cardiac output and systemic venous congestion. The normal physiologic changes of pregnancy put additional pressure on an already impaired cardiovascular system and explain the significant pregnancy-related risk, for which Fontan patients are classified into the highest categories of the mWHO classification for pregnancy and heart disease. Previous studies have

TABLE 2 Antenatal and Postdelivery Information and Fetal Outcomes

	Case 1	Case 2	Case 3	Case 4
Pregnancy at last conception				
Gravida and parity	G4 P2+1 (1× termination)	G1 P0	G4 P0+3 (3 miscarriages at <12 weeks each)	G1 P0
Age, y	36	26	34	29
BMI, kg/m^2	35	29	20	26
Arrythmia	No	No	Yes: bisoprolol	No
Heart failure	Yes	No	No	No
Fontan failure	No	No	No	No
Liver disease	Yes: hepatic steatosis	No	No	No
Thromboembolism	Suspected, not confirmed	No	No	No
Diabetes	Yes (gestational diabetes)	No	No	No
Pregnancy-induced hypertension	No	No	No	No
Medication	Increased dose of furosemide as well as amiloride, enoxaparin, metformin, and insulin	Enoxaparin, aspirin, and levothyroxine	Enoxaparin and bisoprolol	Enoxaparin
Echocardiogram (third trimester)				
Ventricular function	FAC of 37% visually preserved	Ventricular dysfunction—mild	Normal EF of 64%	Normal EF of 64%
Valvular regurgitation	Mild AV	Mild AV	Mild AV	None
Patency of Fontan circulation	Patent TCPC with fenestration	Signs of TCPC obstruction	Patent TCPC	Patent TCPC
Delivery				
Gestation	32 weeks 2 days	31 weeks 1 day	32 weeks	36 weeks
Mode	Cesarean section	Cesarean section	Cesarean section	Cesarean section
Reason	Fetal growth restriction and heart failure	Failing Fontan	Fetal growth restriction	Fetal growth restriction
Fetal outcome				
Weight, g	1,435	1,443	1,315	2,300
Apgar at birth	4/5/7	Not available	8/9/9	6/9/10
Inpatient stay, d				
ITU	2	5	4	
HDU	5	11	3	
SCBU	4	7	20	7
	Discharged to local hospital on day 11	Discharged to local hospital on day 23	Discharged home after 27 days	Discharged home on day 7
Current state	4 mo and well	2 mo and well	2 y	1.5 y
Postpartum				
Arrythmia	No	No	No	No
Heart failure	Yes	Yes	No	No
Fontan failure	No	No: settled	No	No
Liver disease	No	No	No	No
Echocardiogram postdelivery				
Ventricular function	FAC of 36% visually preserved	Mild ventricular dysfunction	Normal, with EF of 64%	Normal, with EF of 64%
Aortic valve regurgitation	Mild	Mild	Mild	None
Patency of Fontan circulation	Patent TCPC with fenestration	Patent TCPC with sluggish flow	Patent TCPC	Patent TCPC

AV = aortic valve; BMI = body mass index; EF = ejection fraction; FAC = fractional area change; G = gravida; HDU = high-dependency unit; ITU = intensive care unit; P = para; SCBU = special care baby unit; TCPC = total cavopulmonary connection.

shown various maternal complications in these patients, including arrhythmias, heart failure, and thromboembolism, as well as antepartum and postpartum haemorrhage.[1,2] Fetal complications include miscarriage, IUGR, prematurity, and emergency and operative delivery.[3]

We present 4 women with a Fontan circulation who underwent pregnancy. Preconception counseling is essential in this cohort, along with genetic testing when indicated. In our small case series, those with preserved cardiac function were less likely to experience complications.

The patients differed in background anatomy, type and timing of the operation, residual lesions, and long-term sequelae. Hence, the maternal risk profiles vary and are difficult to accurately estimate using current risk scores, meaning that each patient requires personalized care and counseling by an expert team of physicians.[4] Our ability to give accurate counseling is limited by the lack of published literature, meaning that more research is needed to facilitate better counseling. Two of our cases were in mWHO class IV and were counseled against pregnancy but went on to deliver successfully.

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APPENDIX For supplemental videos, please see the online version of this paper.