JACC: CASE REPORTS VOL. 29, 2024

CONGENITAL HEART DISEASE

CASE REPORT: HEART CARE TEAM/MULTIDISCIPLINARY TEAM LIVE

Fetal Pericardial Teratoma

Perinatal Management and Example of Preterm Cesarean Birth to Resection

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ABSTRACT

A very large fetal pericardial teratoma was diagnosed at 28 weeks' gestation, prompting urgent multidisciplinary expert consultations to weigh the risks and benefits of various prenatal invasive procedures and preterm delivery for postnatal surgical management. Ultimately, the infant was born by planned cesarean section and underwent immediate cardiopulmonary bypass and surgical resection. (J Am Coll Cardiol Case Rep 2024;29:102169) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

A 32-year-old woman, gravida 1, with a previously uncomplicated pregnancy and normal results of anatomical evaluation was sent for a third-trimester growth scan and noted to have a large fetal extracardiac mass at 28 weeks and 2 days of gestation. Ultrasonography described a 3.5-cm × 2.7-cm complex heterogenous mass as a likely intrapericardial teratoma adjacent to the right atrium, compressing the right atrium and ventricle. A pericardial effusion and moderate bilateral pleural effusions were noted (Figure 1). She was promptly transferred to a quaternary care center, and prenatal imaging showed new-onset polyhydramnios and new fetal ascites and scalp edema (fetal hydrops). The estimated fetal weight was 1,400 g. A fetal heart tracing was notable for minimal variability and recurrent variable decelerations. A multidisciplinary consultation with maternal fetal medicine, neonatology, cardiology, and cardiothoracic surgery specialists took place as well as discussions with fetal surgeons and cardiologists across the United States to weigh the risks and benefits associated with tapping the pericardial fluid, placing a pericardial shunt, performing fetal surgery,

LEARNING OBJECTIVES

- To be familiar with prenatal and postnatal treatment options for fetal cardiac masses.
- To understand the possible progression of fetal cardiac teratomas and identify indications for prenatal procedures versus delivery for postnatal intervention.

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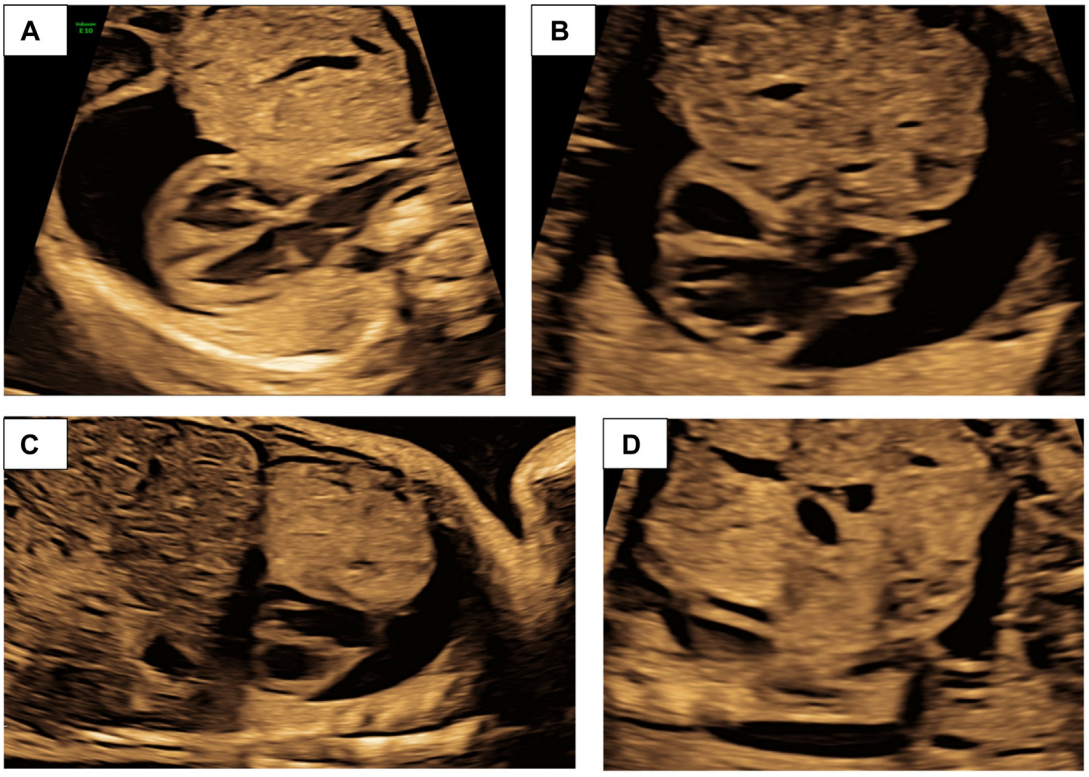
The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received August 9, 2023; revised manuscript received November 15, 2023, accepted November 22, 2023.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2023.102169

FIGURE 1 Prenatal Echocardiogram Series



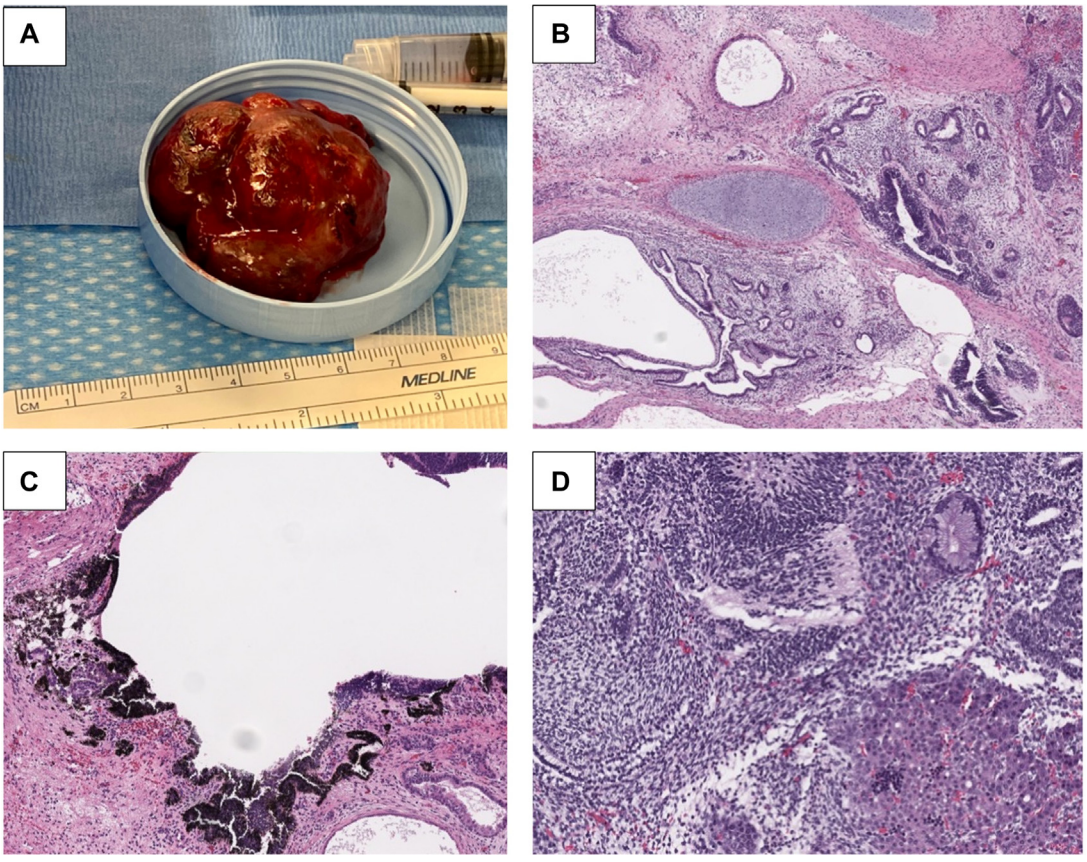
(A, B) Echocardiograms demonstrating large pericardial mass and large pericardial effusions. (C) Sagittal view demonstrating large mass in thorax, compressed heart, and large pericardial effusion. (D) Large mass leading to outflow tract obstruction.

and awaiting birth for postnatal surgery. After extensive counseling and discussion, the patient and her partner desired full resuscitation and delivery for fetal indications if they arose. Betamethasone was given for neonatal lung maturation.

Ultrasonography on the second day of admission revealed enlargement of the cardiac mass, worsening fetal hydrops, and reversal of flow through the ductus venosus. The morbidity and mortality associated with each intervention listed, versus expectant management, were considered, and the teams believed that the benefit of delivery for surgical decompression and resection outweighed the benefit of continuing pregnancy in the setting of worsening hydrops. The patient underwent primary cesarean birth at 29 weeks and 0 days of gestation after extensive multidisciplinary discussions and preparations focused on postnatal management.

While receiving placental circulation before umbilical cord clamping, the infant demonstrated good tone, color, and spontaneous breathing. After 15 seconds, the umbilical cord was clamped and cut, and the infant was immediately handed to the neonatology team for resuscitation. The newborn's color quickly worsened, and positive pressure ventilation and orogastric suctioning were performed. She was intubated with a 3.0 cuffed endotracheal tube at 2 minutes of life. No heart rate was auscultated, so chest compressions started at 3 minutes of life, and the infant was taken emergently to an adjoining operating room, where the pediatric cardiothoracic surgery team was prepared and ready. Sternotomy was performed, and without delay, direct cardiac massage was initiated. Epinephrine was administered directly into the pulmonary artery. Central cannulation was not possible because the intrapericardial tumor covered the entire anterior heart with the sternum broadly open, so the neck vessels were isolated while direct cardiac massage continued for venous-arterial cardiopulmonary bypass; an 8-F

FIGURE 2 **Teratoma Pathology Results**



(A) Gross specimen of resected tumor. (B) Low-power image revealing cartilage, foregut epithelial glands, and primitive neuroepithelial tissue and tubules (H&E, original magnification ×5). (C) Neuroepithelial cyst with retinal type pigmentation (H&E, original magnification ×8.5). (D) Primitive neuroepithelial tissue (left side), immature liver with extramedullary hematopoiesis (right lower corner), and a single foregut type structure (upper right) (H&E, original magnification ×15).

cannula was placed in the internal jugular vein, and a 6-F cannula was placed in the carotid artery. Cardiac function improved. The teratoma was very large, roughly 3 times the size of the heart, and covered the entire opening of the sternotomy. Intraoperative echocardiogram (Video 1) revealed poor right and left ventricular systolic function. The tumor was debulked and carefully removed from the chest, including around the aorta and right coronary artery. Complete resection was not possible, and approximately 1% to 2% of the tumor around the area of the left coronary artery was left in situ.

During surgery, it was difficult to adequately ventilate the infant despite endotracheal tube adjustments, surfactant (2.5 mL/kg) administration, and increasing ventilator pressure. The peritoneal cavity was opened just below the diaphragm to drain abdominal fluid. Intraoperatively, discussions with cardiothoracic surgery, neonatology, anesthesiology, and cardiology services ensued regarding continuing or discontinuing extracorporeal membrane oxygenation support. The teams deemed the infant at high risk for a devastating intracranial hemorrhage, given the anticoagulation that extracorporeal membrane oxygenation would require, her prematurity, and concern for hypoxic injury during resuscitation, so they opted to wean and decannulate before admission to the neonatal intensive care unit after placing umbilical (5-F double lumen) venous, and arterial (3.5-F single lumen) lines.

The neonate was brought to the neonatal intensive care unit NICU with an open chest and receiving milrinone (maximum dosage 1 μg/kg/min), epinephrine (maximum dosage 0.15 μg/kg/min), dopamine

(maximum dosage 10 μg/kg/min), and calcium gluconate (maximum dosage 30 mg/kg/h) drips with stress dose hydrocortisone (1 mg/kg every 6 h), and with pacing wires. Her birth weight was 1.588 kg, and her estimated dosing weight was 1.2 kg. Initial postoperative echocardiography (Video 2) revealed severely diminished right ventricular function. Her initial postoperative course was complicated by severe hypercarbic respiratory failure and large volume output from the chest tube and mediastinal drain. She received blood product repletions as indicated by serial laboratory determinations and 5% albumin transfusions. In the first 24 hours postoperatively, she received 250 mL/kg of fluids. She was monitored by continuous video electroencephalography for 24 hours, given the prolonged cardiac surgery and her hemodynamic function, and serial head ultrasonography followed; no seizures or hemorrhages were noted. Serial echocardiograms (Videos 3 and 4) revealed improved cardiac function postoperatively.

She was weaned off all vasopressors and cardiac medications by 12 days of life. Her chest tube, mediastinal drain, and pacer wires were removed on postoperative day 17. She was extubated the next day and weaned to room air when she was at 35 weeks 5 days corrected gestational age. She was discharged home with family when she was 37 weeks 3 days corrected and was taking all feedings by mouth, with unremarkable results of a neurologic examination.

The tumor was a 4.9-cm × 4.7-cm × 1.9-cm extragonadal immature teratoma, grade 3 (**Figure 2**). Genetic testing revealed a normal chromosomal microarray and no established clinically significant variants related to her primary concerns on whole exome. However, a heterozygous pathogenic variant was identified in the *ATM* gene; biallelic pathogenic variants in this gene are associated with autosomal recessive ataxia-telangiectasia.

Because of the incomplete resection and this infant's complicated postnatal course, she is being followed up by hematology-oncology, cardiology, and high-risk infant follow-up teams. She is receiving serial α-fetoprotein laboratory testing, and the trend is reassuring. Her echocardiograms reveal normal cardiac function. Her neurodevelopmental testing results are normal, and she is growing well. Her clinical course is outlined in **Table 1**.

QUESTION 1: HOW IS A FETAL CARDIAC MASS DIAGNOSED AND WHAT IS THE DIFFERENTIAL DIAGNOSIS?

A fetal cardiac mass may be diagnosed on routine obstetrical anatomical ultrasonography, which includes 4-chamber, left ventricle outflow tract, and right ventricle outflow tract views. An abnormality would prompt formal fetal echocardiography, ideally performed at 20 to 22 weeks of gestation.[1]

Fetal primary cardiac tumors include benign rhabdomyomas (most common), teratomas, fibromas, hemangiomas, and myxomas as well as rare malignant rhabdomyosarcomas and fibrosarcomas.[2] These are often detected on fetal ultrasonography or echocardiography and can cause complications including arrhythmias, hydrops fetalis, ventricular outflow or inflow obstruction, cardiac failure, and sudden death. Cardiac rhabdomyomas make up 60% of primary fetal cardiac masses. They can be located anywhere in the heart but typically involve the left ventricle, right ventricle, and ventricular septum; often exist as multiples; and over time usually spontaneously regress. Fibromas are usually heterogeneous masses in the left ventricular or septal myocardium. Teratomas are often symptomatic, with significant pericardial effusions, and can lead to hydrops fetalis caused by mediastinal invasion.

QUESTION 2: WHAT FETAL INTERVENTIONS EXIST FOR A CARDIAC MASS?

In a retrospective case series, >92.7% of fetuses with cardiac teratomas had pericardial effusion, and 72.3% had hydrops.[3] In the presence of pericardial effusion, in utero pericardiocentesis may relieve the tamponade and delay the progression to hydrops. The effusion is likely to recur, so in place of serial pericardial taps, fetal pericardioamniotic shunts can be placed. A pericardioamniotic shunt could allow time to coordinate more invasive options as needed. If there is hydrops with pleural effusion, a percutaneous thoracoamniotic shunt is an option that has led to clinical improvement.[4] In rare instances for severe progressive hydrops, open fetal surgery has been done to resect cardiac masses.[5] Another possible option, which has been pursued for cystic lung lesions causing fetal hydrops, is laser ablation of the systemic arterial blood supply.[6] The decision to pursue fetal interventions (single or staged) versus move toward birth for postnatal resection can be difficult. A proposed clinical pathway is outlined in **Figure 3**.

QUESTION 3: WHAT ARE FETAL INDICATIONS FOR (PRETERM) DELIVERY IN THE SETTING OF A FETAL CARDIAC MASS?

Choosing between prenatal or neonatal interventions in the setting of a fetal cardiac mass causing hydrops can be a difficult decision. Estimated fetal weight and gestational age are important factors. Later in

TABLE 1 Clinical Course Summary

Day of Life	Major Procedures and Interventions	Major Medication Changes	Imaging Findings
1	Cesarean birth Endotracheal intubation Cardiothoracic surgery for tumor resection Venous-arterial cardiopulmonary bypass initiated and weaned off Mediastinal drain placement Chest tube placement	Initiation of epinephrine, dopamine, milrinone, calcium gluconate drips	Intraoperative echocardiogram revealed large mass, moderate left ventricular systolic dysfunction, and severe right ventricular systolic dysfunction Head ultrasound unremarkable; no germinal matrix or parenchymal hemorrhages
2		Chest tube and mediastinal drain output replaced with normal saline and albumin repletions Multiple blood product transfusions	Echocardiogram revealed mild to moderately decreased left ventricular systolic function and moderate to severely decreased right ventricular systolic function Head ultrasound without intracranial hemorrhage
3	EEG removed after 48 hours, no seizures detected	Epinephrine weaned off and norepinephrine up-titrated.	Echocardiogram revealed moderately depressed RV and LV systolic function Small pericardial effusion, stable
4		Norepinephrine and dopamine weaned off	
6			Echocardiogram revealed mildly depressed RV systolic function, low normal LV systolic function, improved from prior
8	Chest wall closure at bedside		
11	Trophic enteral feeds initiated	Calcium drip wean started	Echocardiogram with normal biventricular size and function
12		Milrinone weaned off, calcium drip weaned off	Head ultrasound without intracranial hemorrhage
18	Chest tube removed Mediastinal drain removed Pacing wires removed		
19	Extubated		
48	Respiratory support weaned off to room air		Head ultrasound with normal findings
60	Discharged home		

EEG = electroencephalogram; LV = left ventricle; RV = right ventricle.

gestation with assured lung maturity, most would opt for birth and neonatal management. Earlier in gestation with immature lungs and likely postnatal pulmonary compromise, prenatal interventions (pericardiocentesis, thoracentesis, pericardioamniotic shunt, open fetal surgery) are favored in the setting of hydrops and have been shown to improve outcomes.[7] However, prenatal interventions carry risk and may serve only as temporizing measures. Tumor size and rate of growth must also be considered; the development of hydrops has been shown to correlate with tumor size.[8] Rapid tumor growth, worsening heart failure or hydrops despite prenatal management, and poor biophysical profile are indicators that delivery and postnatal management may be preferred.

QUESTION 4: WHAT ARE POSTNATAL TREATMENT OPTIONS FOR CARDIAC TERATOMAS?

Surgical resection is the curative treatment of choice. There is a low risk of recurrence. In a hemodynamically unstable hydropic infant, pericardiocentesis, thoracentesis, and/or paracentesis may be indicated emergently after birth for stabilization and to improve ventilation before surgery.

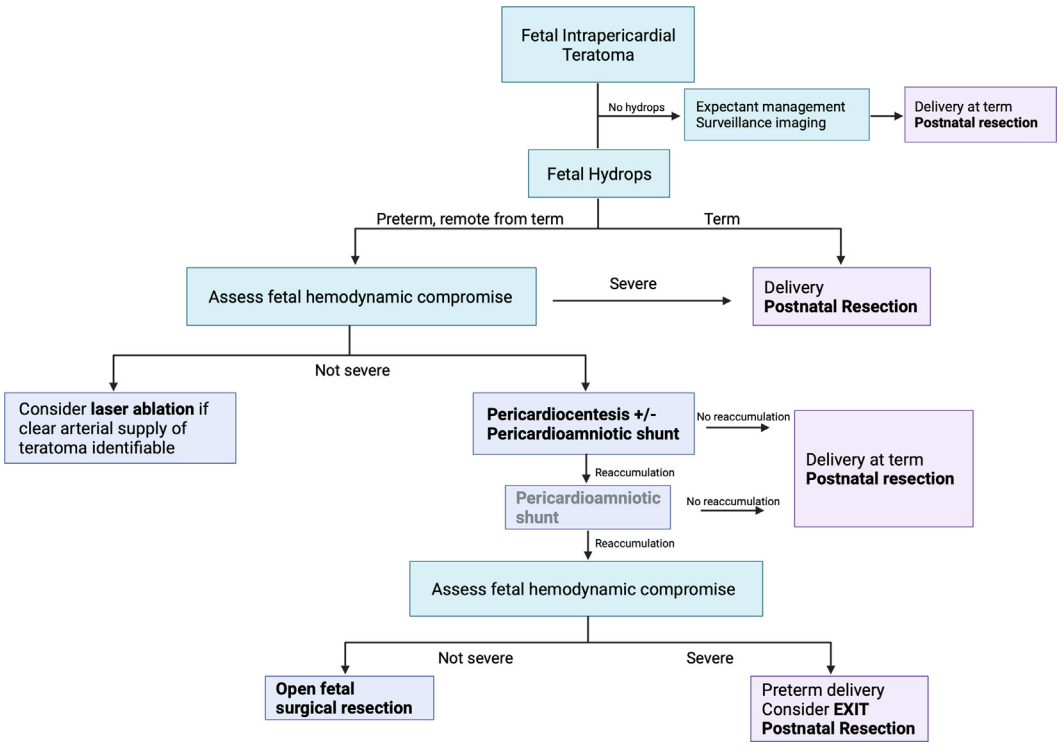
QUESTION 5: WHAT IS THE PROGNOSIS OF A PERICARDIAC TERATOMA?

Teratomas are tumors of embryonic origin composed of 3 germinal layers and are histologically complex. They generally present right-sided in the pericardium, often connected to 1 of the great vessels, during the second or third decade.[9] Once resected, mature teratomas usually do not require further treatment.[10] However, intramyocardial lesions can lead to heart failure and sudden death. Pericardial teratomas in the intraventricular location can cause arrythmia.

CONCLUSIONS

Although the postnatal prognosis of infants born with cardiac teratomas is promising with curative surgical resection, prenatal management is challenging

FIGURE 3 Approach to Fetal Intrapericardial Tumors



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because of the high incidence of pericardial effusions and progression to fetal hydrops. In utero demise can occur. As a result, many pregnancies complicated by fetal teratomas require invasive temporizing procedures or preterm birth for postnatal resection. In this case, preterm birth and postnatal resection was favored over temporizing procedures (pericardiocentesis, pericardioamniotic shunt) or open fetal surgical resection, given the rapid progression of the fetal mass, pericardial effusion, and fetal hydrops as well as reversal of flow through the ductus venosus signifying severe fetal hemodynamic compromise. Postnatal surgical resection, hemodynamic management, and respiratory management in a small preterm neonate with immature lungs requires multidisciplinary coordination and expertise.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

Dr Desmond is supported by supported by the National Library of Medicine of the National Institutes of Health under Award Number T15LM013976. Dr Afshar is supported by National Institute of Health K12 HD000849 by the Eunice Kennedy Shriver National Institute of Child Health & Human Development and American College of Obstetricians and Gynecologists, as part of the Reproductive Scientist Development Program and the Burroughs Wellcome Fund, and has served as a consultant to Mirvie and has investigator-initiated research with Natera. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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REFERENCES

1. Donofrio MT, Moon-Grady AJ, Hornberger LK, et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation*. 2014;192:2183-2242.

2. Yuan SM. Fetal primary cardiac tumors during perinatal period. *Pediatr Neonatol*. 2017;58(3):205-210.

3. Devlieger R, Hindryckx T, Van Mieghem T, et al. Therapy for foetal pericardial tumours: survival following in utero shunting, and literature review. *Fetal Diagn Ther*. 2009;25(4):407-412.

4. Grebille AG, Mitanchez D, Benachi A, et al. Pericardial teratoma complicated by hydrops: successful fetal therapy by thoracoamniotic shunting. *Prenat Diagn*. 2003;23(9):735-739.

5. Sydorak RM, Kelly T, Feldstein VA, et al. Prenatal resection of a fetal pericardial teratoma. *Fetal Diagn Ther*. 2002;17(5):281-285.

6. Cruz-Martinez R, Martinez-Rodriguez M, Bermudez-Rojas M, et al. Fetal laser ablation of feeding artery of cystic lung lesions with systemic arterial blood supply. *Ultrasound Obstet Gynecol*. 2017;49(6):744-750.

7. Nassr AA, Shazly SA, Morris SA, et al. Prenatal management of fetal intrapericardial teratoma: a systematic review. *Prenat Diagn*. 2017;37(9):849-863.

8. Rychik J, Khalek N, Gaynor JW, et al. Fetal intrapericardial teratoma: natural history and management including successful in utero surgery. *Am J Obstet Gynecol*. 2016;215(6):780e1-780e7.

9. Cohen R, Mirrer B, Loarte P, Navarro V. Intrapericardial mature cystic teratoma in an adult: case presentation. *Clin Cardiol*. 2013;36(1):6-9.

10. Gonzalez M, Krueger T, Schaefer SC, Ris HB, Perentes JY. Asymptomatic intrapericardial mature teratoma. *Ann Thorac Surg*. 2010;89(6):e46-e47.

KEY WORDS congenital heart defect, hemodynamics, pericardial effusion, pregnancy, teratoma

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