Multidisciplinary Care for Fetal Cardiac Tumors

Cardiology 2025

28th Annual Update on Pediatric Congenital Cardiovascular Disease

Jack Rychik, MD and Desiree Fiorentino, MD

Case 1:

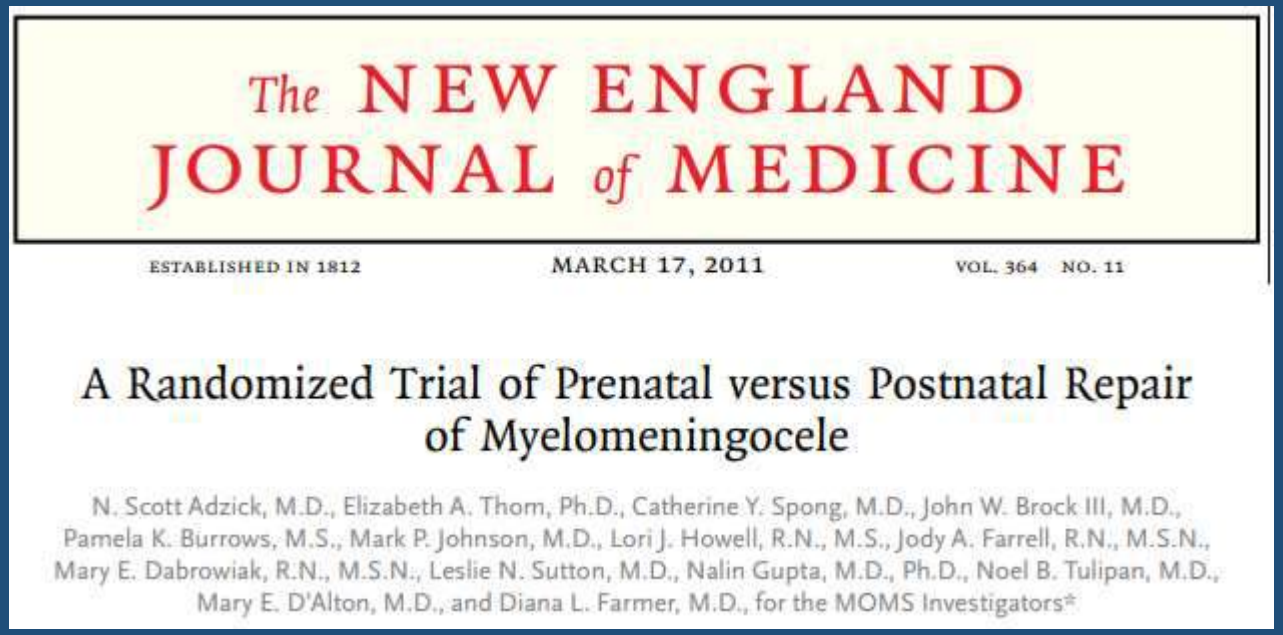
- 31 yo G2P1001 at 25w3d referred for a fetal mediastinal chest mass

- PMH: gestational diabetes on insulin, obesity (BMI 35.4), HTN, hypothyroidism
- PSH: laparoscopic myomectomy
- OB hx: full term vaginal delivery

Imaging:

Management Options:

- Interruption of the pregnancy
- Conservative management
  - Close US follow-up
  - Delivery as indicated
- In utero fetal intervention

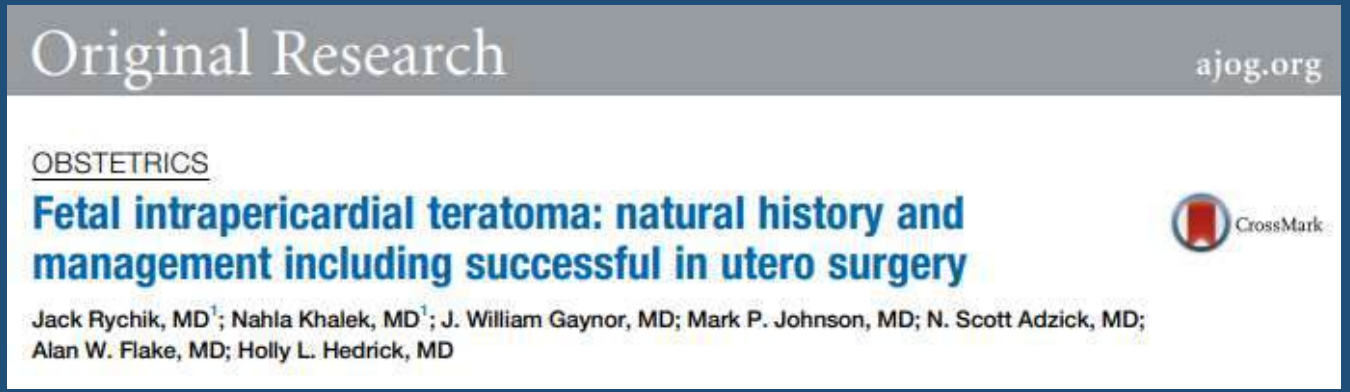


The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 17, 2011 VOL. 364 NO. 11

A Randomized Trial of Prenatal versus Postnatal Repair of Myelomeningocele

N. Scott Adzick, M.D., Elizabeth A. Thom, Ph.D., Catherine Y. Spong, M.D., John W. Brock III, M.D., Pamela K. Burrows, M.S., Mark P. Johnson, M.D., Lori J. Howell, R.N., M.S., Jody A. Farrell, R.N., M.S.N., Mary E. Dabrowiak, R.N., M.S.N., Leslie N. Sutton, M.D., Nalin Gupta, M.D., Ph.D., Noel B. Tulipan, M.D., Mary E. D'Alton, M.D., and Diana L. Farmer, M.D., for the MOMS Investigators*



Original Research ajog.org

OBSTETRICS

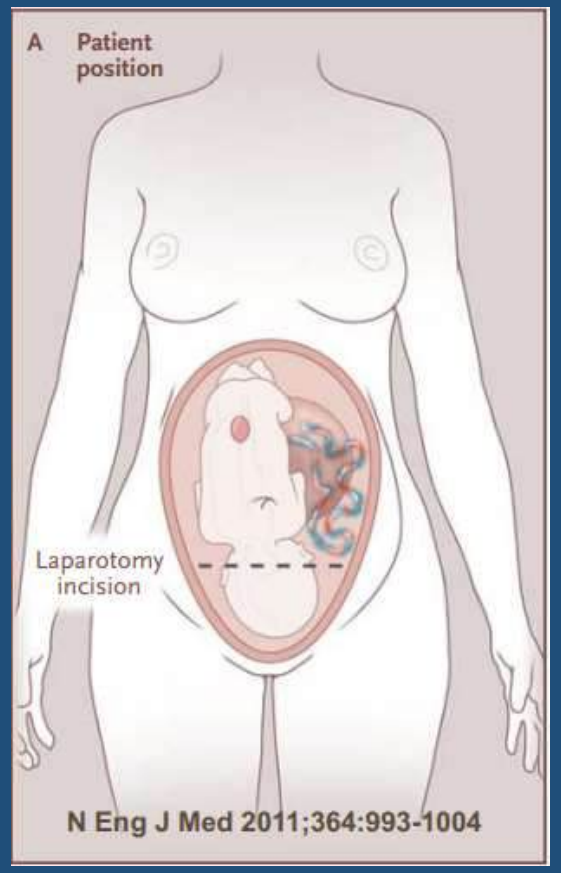
Fetal intrapericardial teratoma: natural history and management including successful in utero surgery

Jack Rychik, MD[1]; Nahla Khalek, MD[1]; J. William Gaynor, MD; Mark P. Johnson, MD; N. Scott Adzick, MD; Alan W. Flake, MD; Holly L. Hedrick, MD

Open Maternal Fetal Surgery:

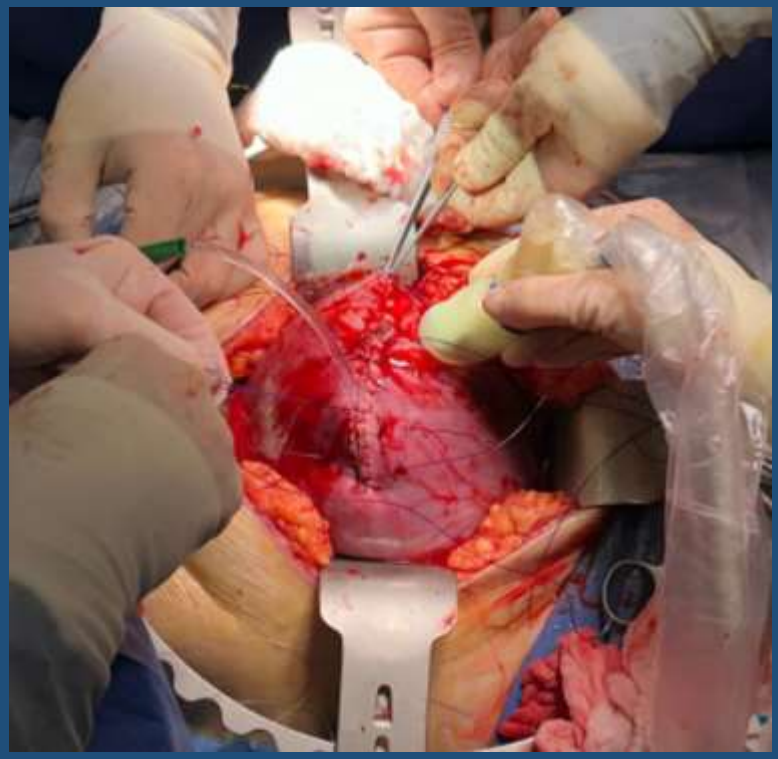
- Candidates:
  - Singleton
  - BMI ≤ 40
  - No medical or obstetric contraindications to surgery
  - No increased risk of preterm birth
  - No additional fetal findings

Operative Procedure:



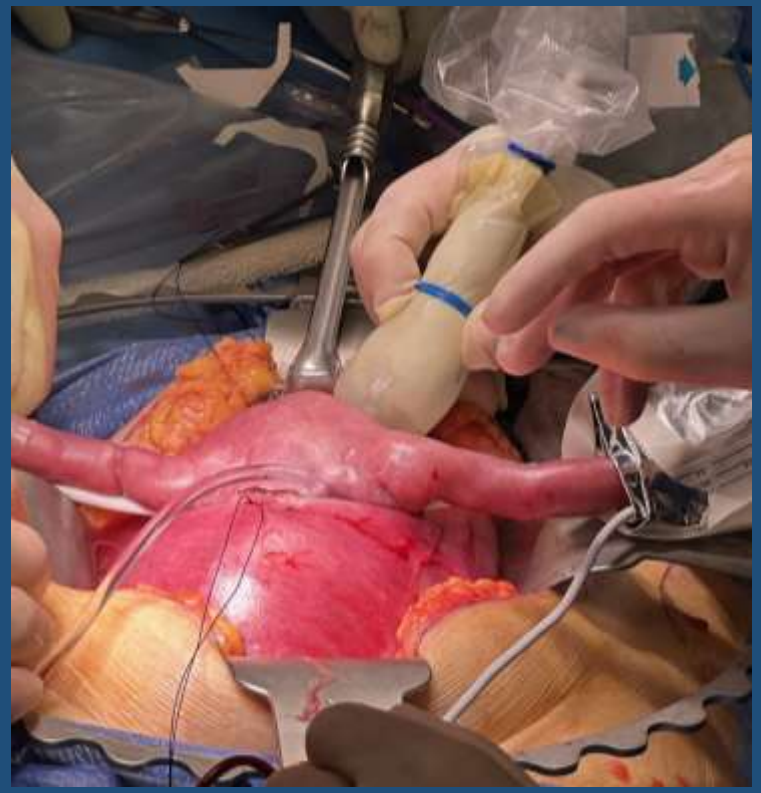
Incision halfway between pubic bone and umbilicus

Intraoperative mapping of the placenta

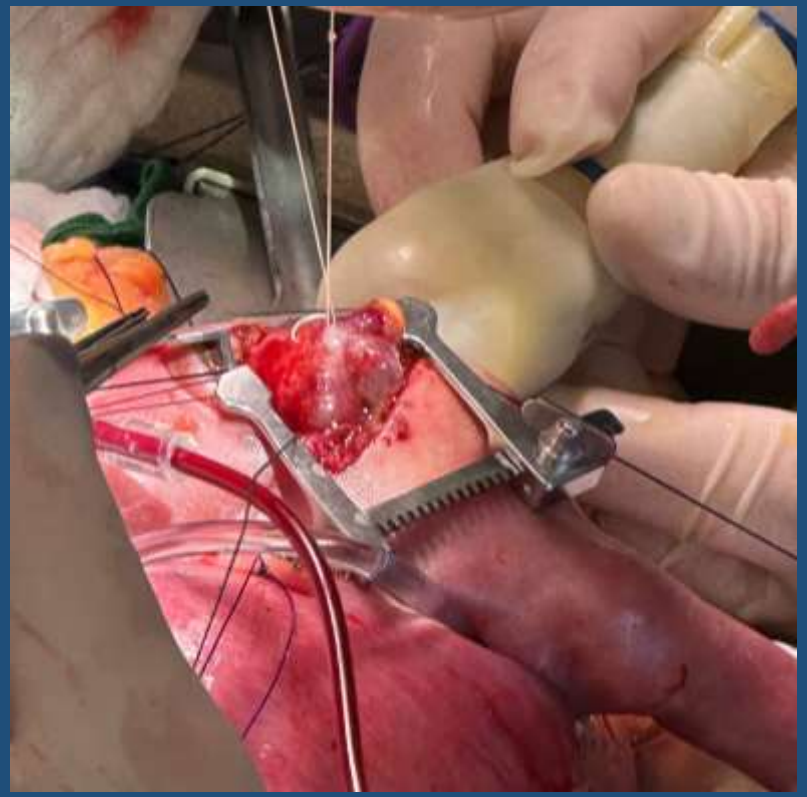


Uterine closure

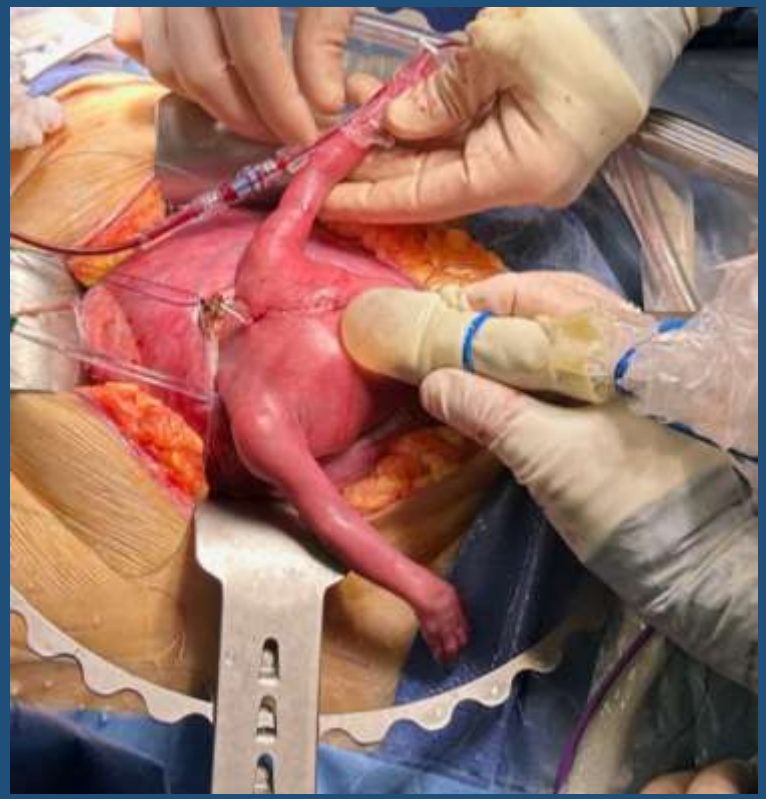
Operative Procedure:



Fetal positioning



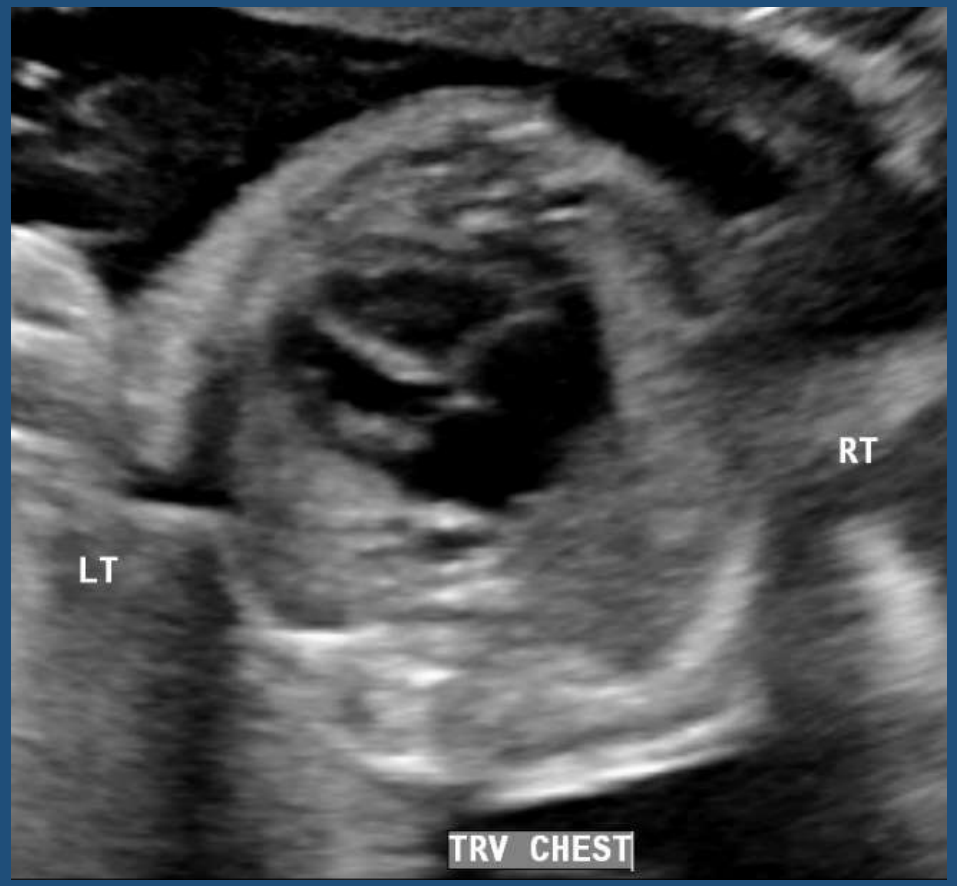
Sternotomy and tumor debulking



Chest closure with vessel loop as a drain

Post Operative Care:

- 4 day hospital admission
- Activity restriction
- Weekly ultrasonographic evaluation
- Weekly to biweekly fetal echocardiography
- Planned cesarean delivery
  - Goal of 37 weeks



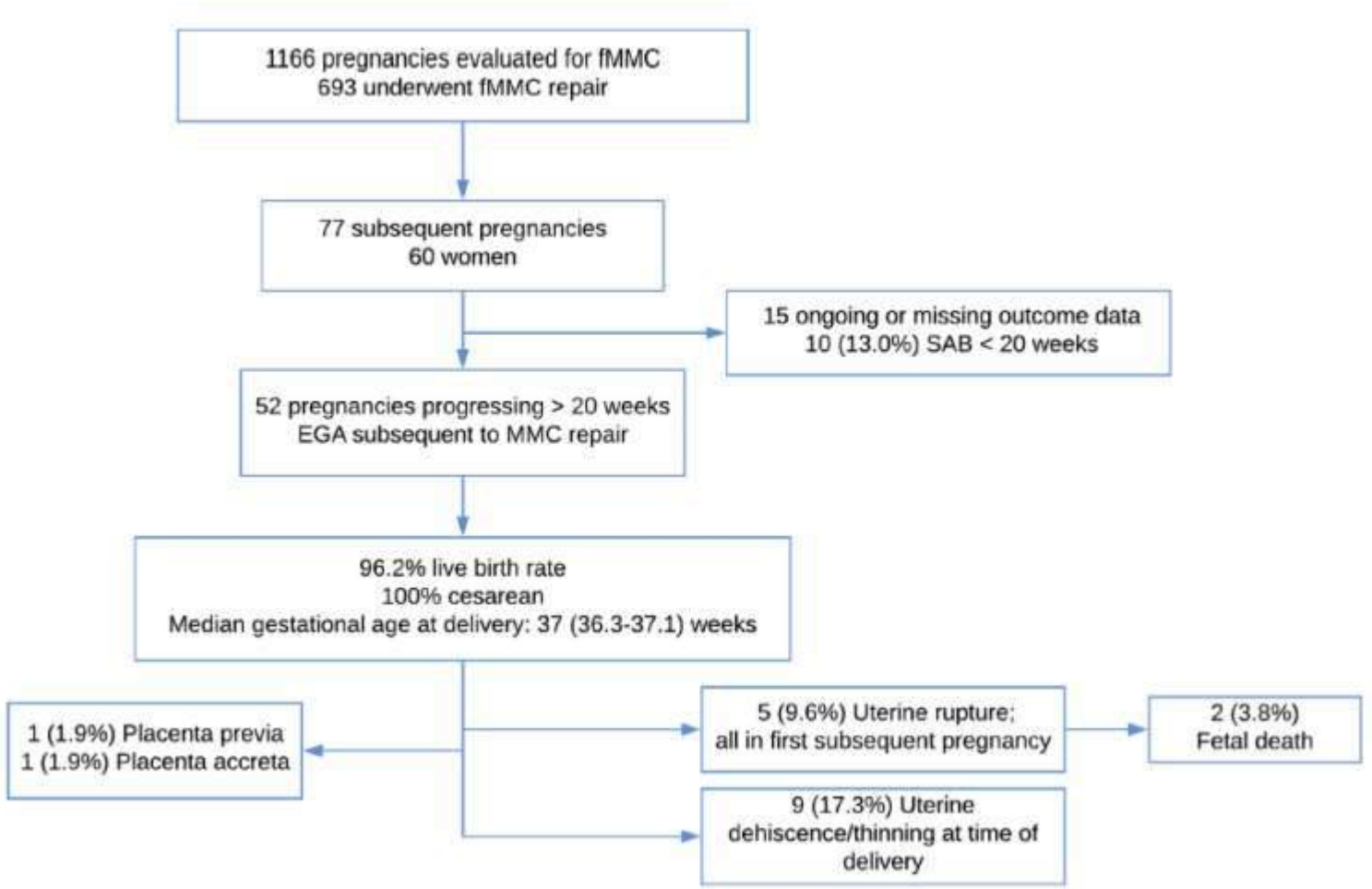
28 weeks and 1 day GA

Risks of Fetal Surgery

- Maternal:
  - Bleeding
  - Infection
  - Membrane separation
  - Preterm delivery
  - Complications of anesthesia
  - Pulmonary edema
  - Uterine rupture
  - Need for cesarean delivery
  - Impact on future child-bearing
- Fetal:
  - Surgical Injury
  - Prematurity
  - Need for blood transfusion
  - Drug effects
  - Unsuccessful procedure

MOMS, 2011; Moldenhauer, 2015

Subsequent Pregnancies:



RESEARCH www.AJOG.org

OBSTETRICS

Reproductive outcomes in subsequent pregnancies after a pregnancy complicated by open maternal-fetal surgery (1996–2007)

R. Douglas Wilson, MD; Kerrie Lemerand, BSN; Mark P. Johnson, MD; Alan W. Flake, MD; Michael Bebbington, MD; Holly L. Hedrick, MD; N. Scott Adzick, MD

Original Research ajog.org

OBSTETRICS

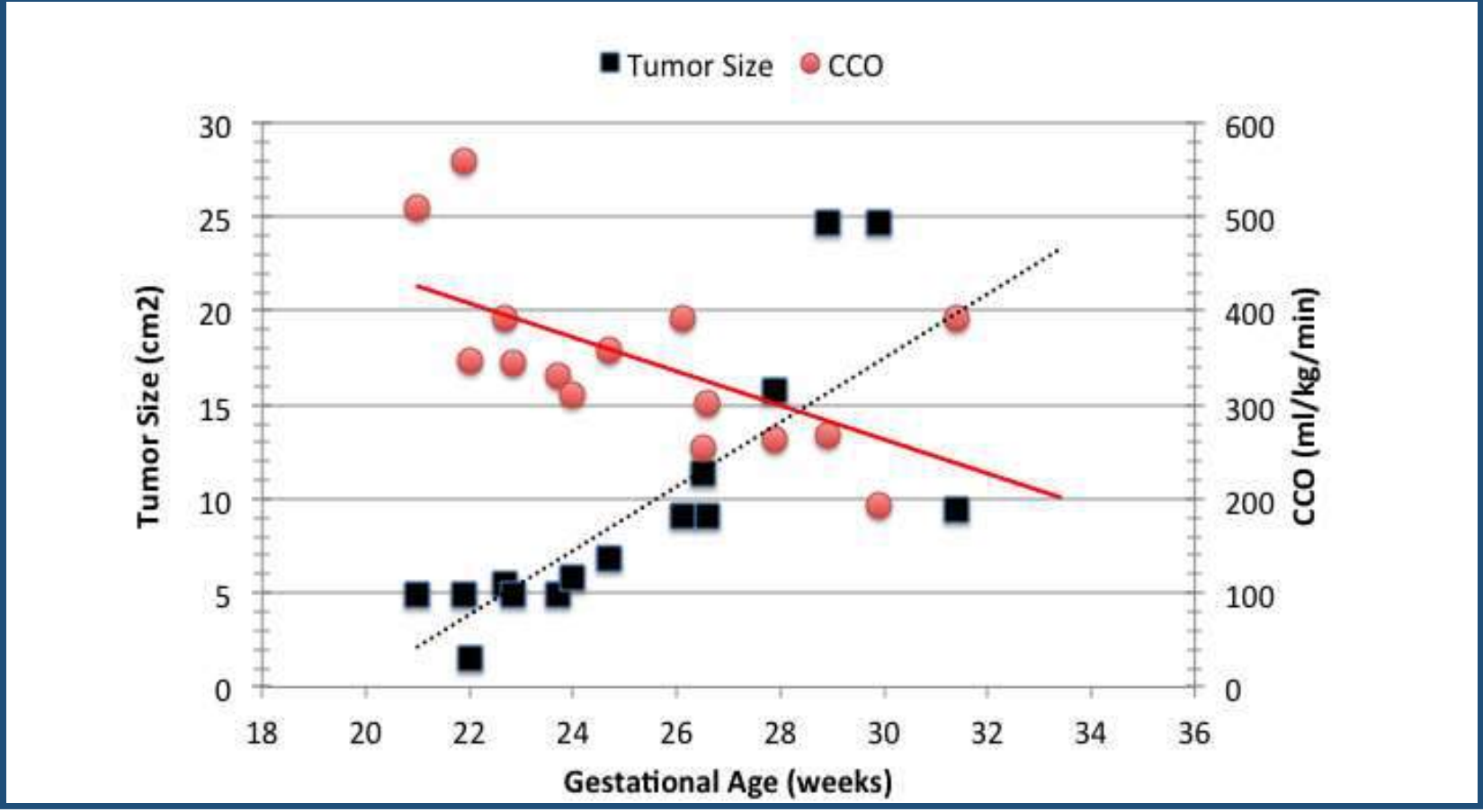
Subsequent pregnancy outcomes after open maternal-fetal surgery for myelomeningocele

William H. Goodnight, MD, MSCR; Ozan Bahtiyar, MD; Kelly A. Bennett, MD; Stephen P. Emery, MD; J. B. Lillegard, MD, PhD; Allan Fisher, MD; Ruth Goldstein, MD; Jillian Jatres, MS; Foong-Yen Lim, MD; Laurence McCullough, PhD; Ueli Moehrlen, MD; Julie S. Moldenhauer, MD; Anita J. Moon-Grady, MD; Rodrigo Ruano, MD, PhD; Daniel W. Skupski, MD; Elizabeth Thom, PhD; Marjorie C. Treadwell, MD; KuoJen Tsao, MD; Amy J. Wagner, MD; Lindsay N. Waqar, MPH; Michael Zaretsky, MD; for the fMMC Consortium sponsored by NAFTNet

Cardiology Perspectives

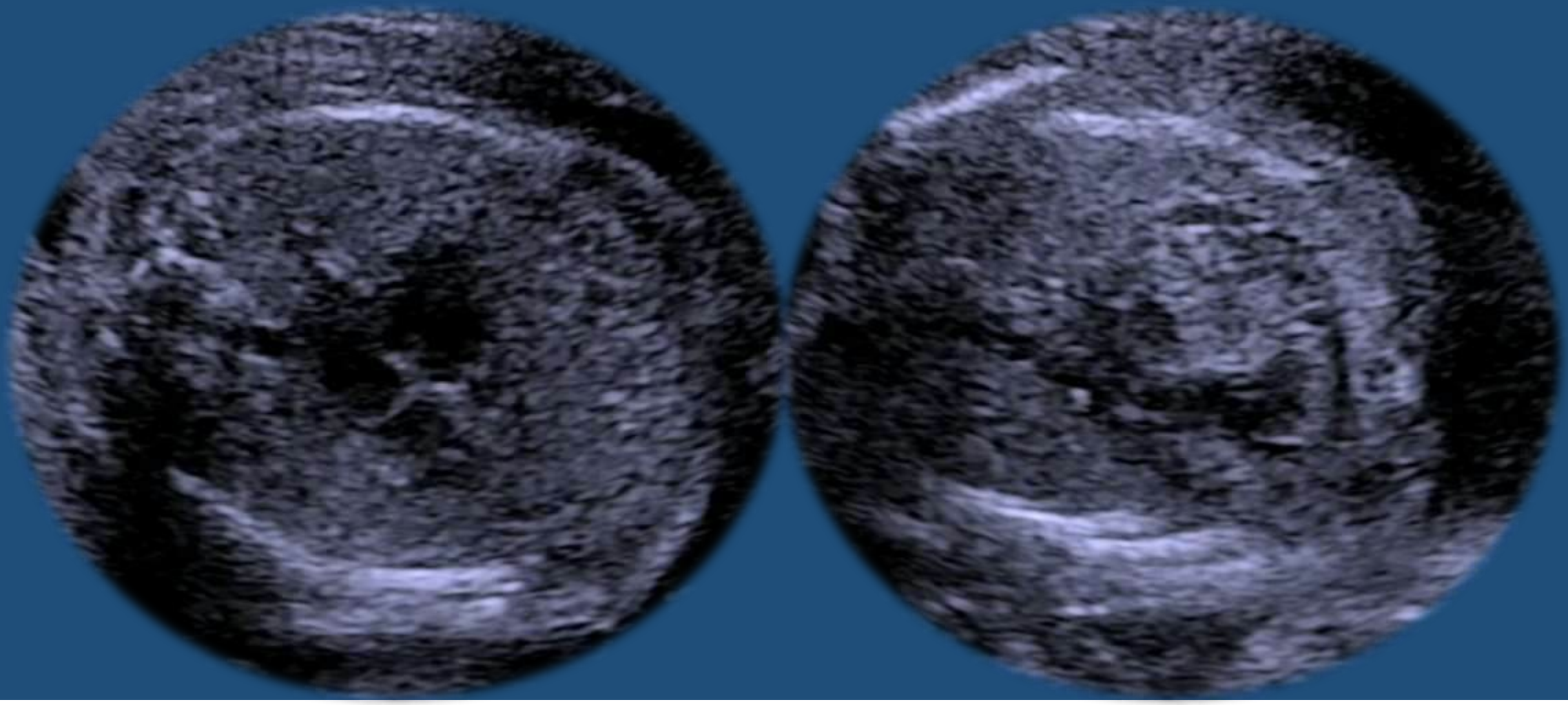
Pericardial Teratoma

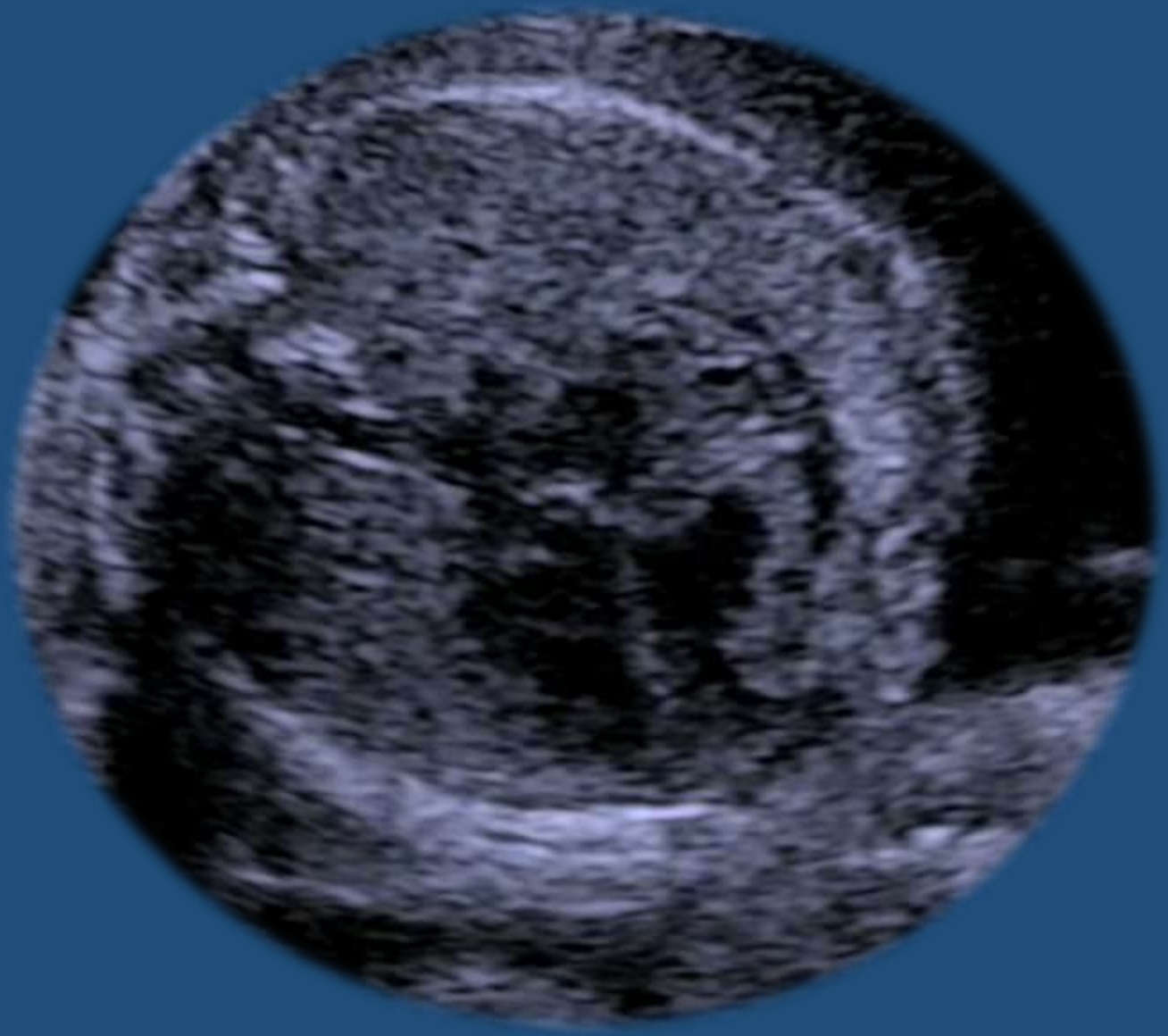
Relationship Between Tumor Growth and Combined Cardiac Output



Rychik et al. Am J Obstet Gynecol 2016

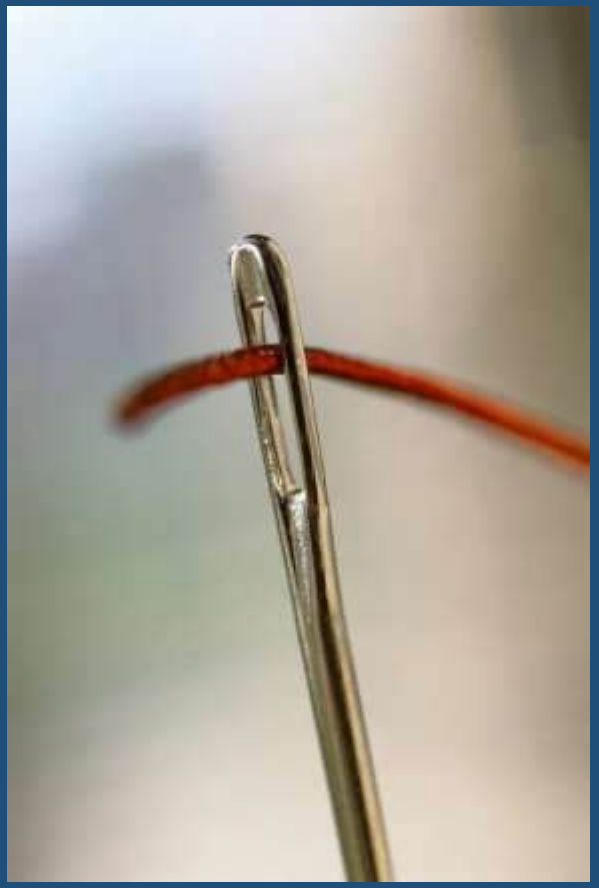
Recent case referred for review…

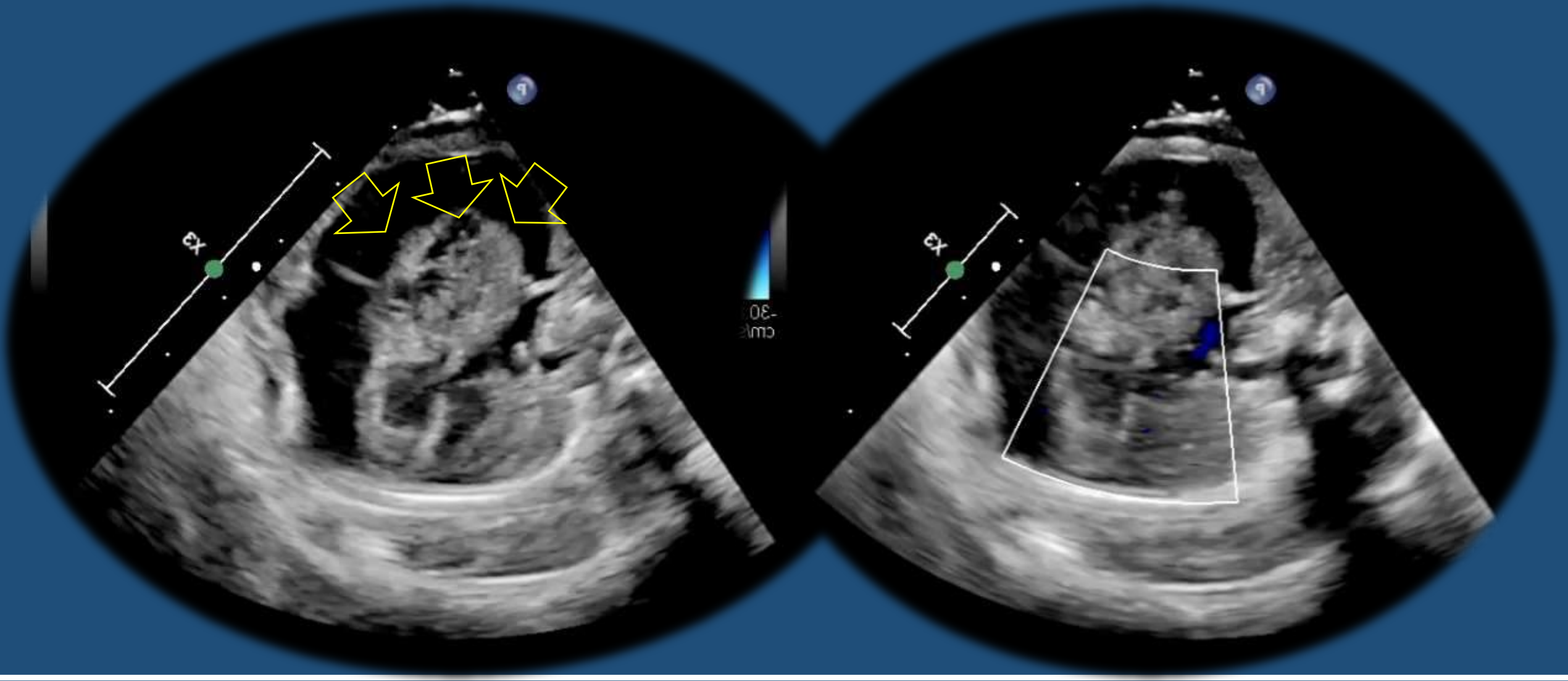




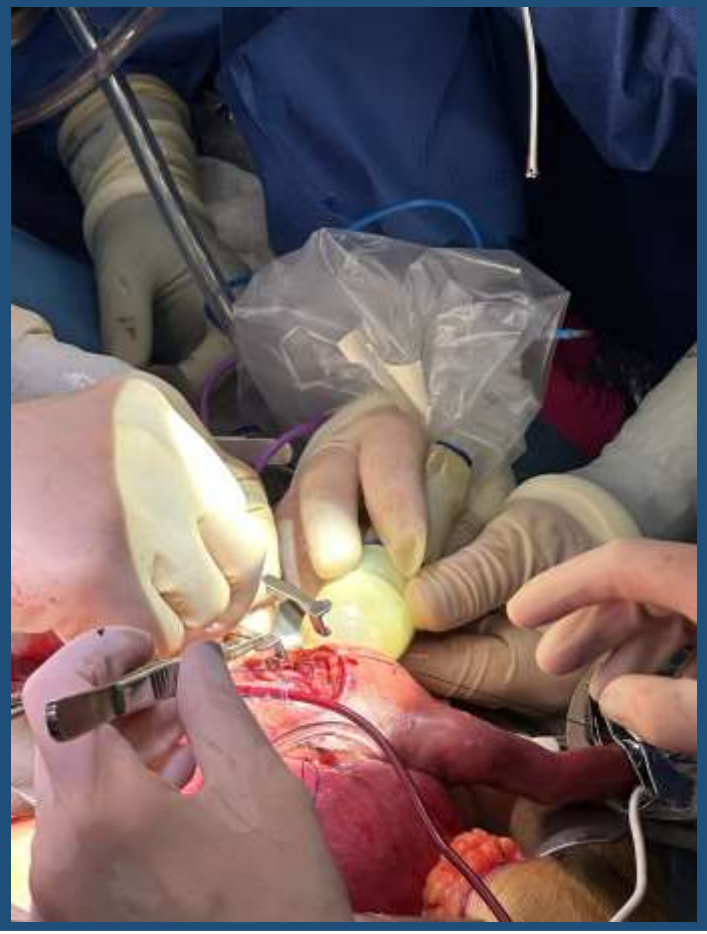
Candidacy Criteria for Fetal Surgical Resection of Pericardial Teratoma

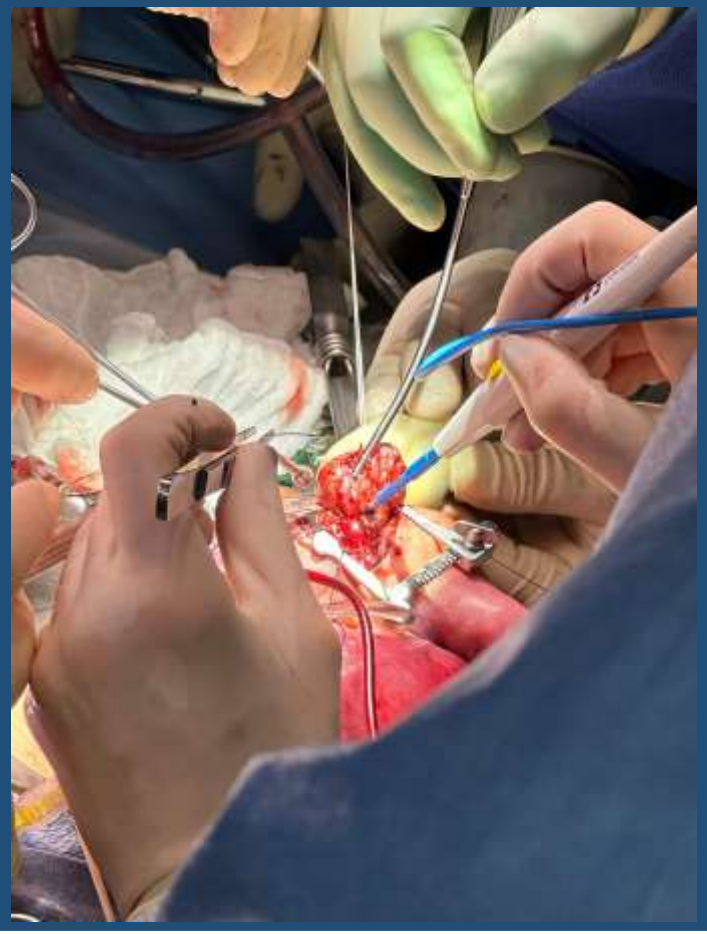
- Confidence that tumor is a pericardial teratoma
  - Originates from typical region of "right atrial – aortic origin" fold
  - Extra-cardiac and not intra-cardiac
- Evidence for progressive rapid growth
- Evidence for diminution in combined cardiac output (approaching <400 cc/k/min)
- Evidence for impending tamponade (compressed RV, abnormal DV, abnormal UV flow patterns)
- **Besides a pericardial effusion, no other evidence for hydrops fetalis**



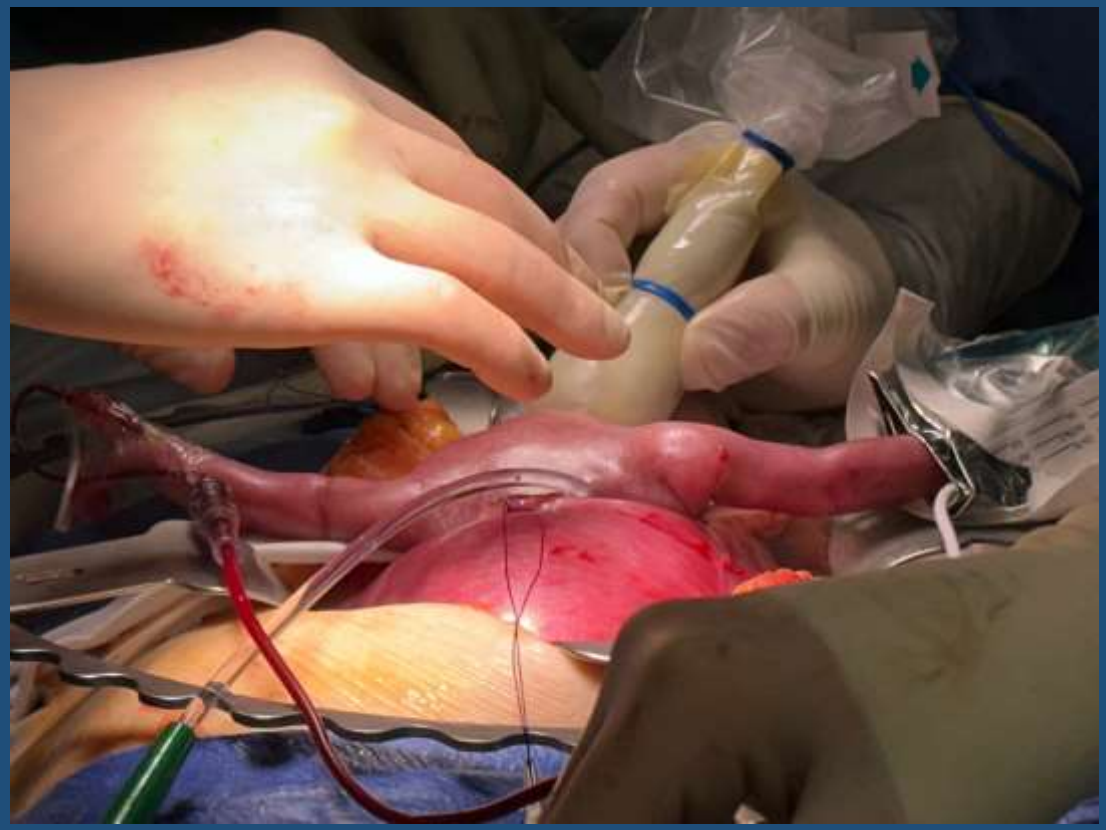


Fetal surgical resection of pericardial teratoma





Fetal surgical resection of pericardial teratoma

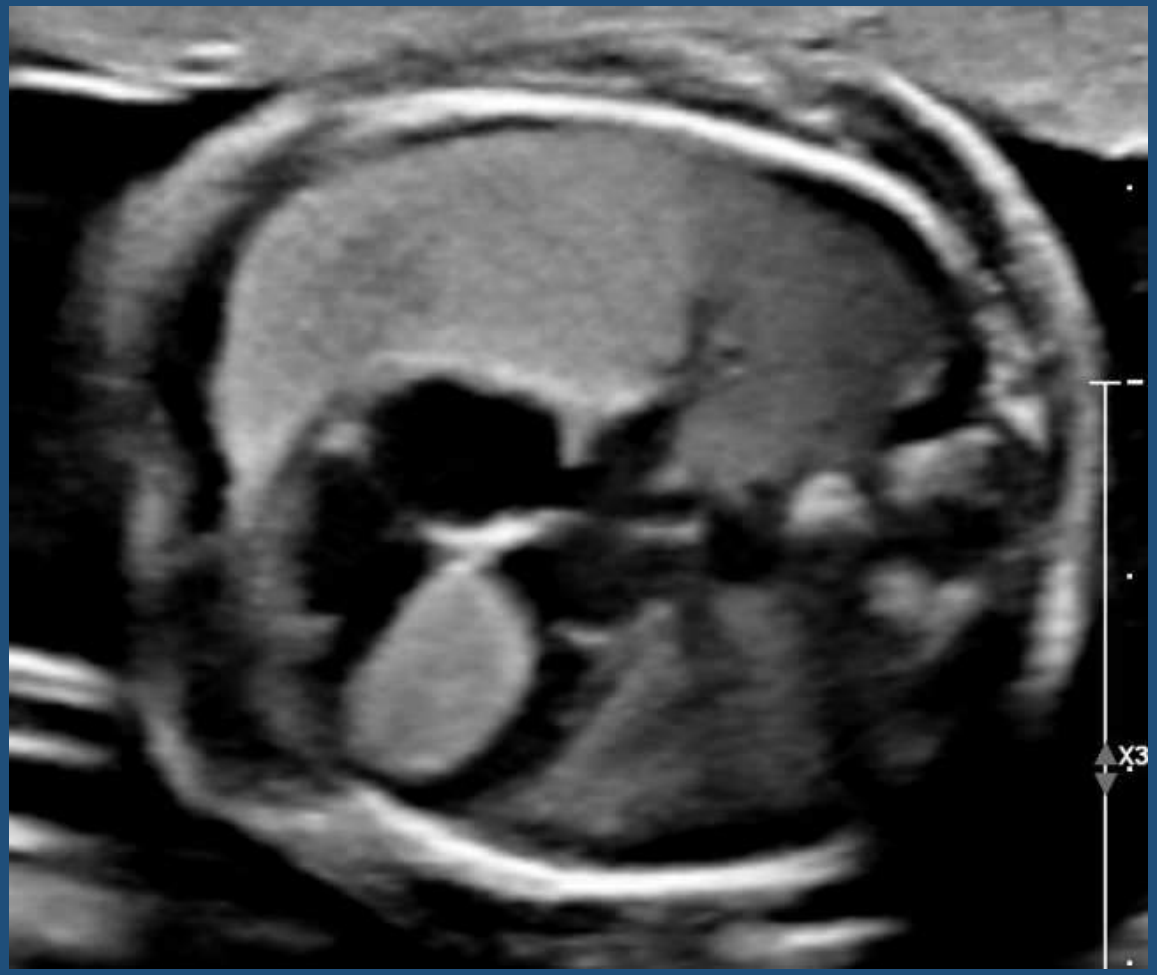


Case 2:

- 36 year old G3P2002 at 22 weeks referred for intracardiac mass

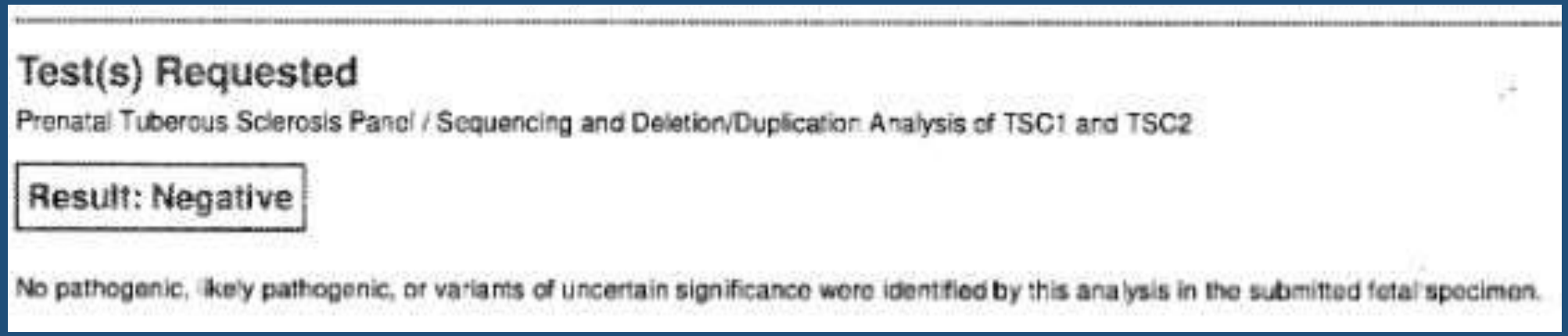
- Obstetric history: two full term vaginal deliveries
- PMH: unremarkable
- PSH: extraction of wisdom teeth and bilateral ACL repairs
- Family Hx: unremarkable

Imaging:



Further Evaluation:

- Amniocentesis:
  - FISH: normal male
  - Karyotype: 46, XY



Test(s) Requested

Prenatal Tuberous Sclerosis Panel / Sequencing and Deletion/Duplication Analysis of TSC1 and TSC2

Result: Negative

No pathogenic, likely pathogenic, or variants of uncertain significance were identified by this analysis in the submitted fetal specimen.

Follow-Up:

- By 29 weeks there was continuous interval growth and decreased LV component of combined cardiac output
- Fetal cardiac MRI: findings suggestive of rhabdomyoma
- Proceeded with Sirolimus administration

CORRESPONDENCE

Maternal Sirolimus Therapy for Fetal Cardiac Rhabdomyomas

Published May 9, 2018 | N Engl J Med 2018;378:1844-1845 | DOI: 10.1056/NEJMc1800352 | VOL. 378 NO. 19

Management:

- Maternal admission for sirolimus administration and titration
- Maternal monitoring:
  - Baseline labs: CBC, CMP, coagulation profile, cholesterol panel
  - Weekly triglycerides, liver function tests, lymphocyte counts
  - Sirolimus trough on day 3 to achieve concentration 10-15 ng/ml
  - CBC, CMP, coagulation profile and cholesterol panel at 2 and 6 wks pp
- Fetal monitoring:
  - Daily echo until improvement of cardiac status
  - Biweekly growth evaluation
- Neonatal monitoring:
  - Cord blood Sirolimus level (+ level at 24, 48, and 72 hours old)

Adverse Events associated with Sirolimus:

Zhang Z, Li Y, Zhang G, et al. Safety Evaluation of Oral Sirolimus in the Treatment of Childhood Diseases: A Systematic Review. *Children (Basel)*. 2022;9(9):1295. Published 2022 Aug 26. doi:10.3390/children9091295

CARDIOLOGY 2025

Table 4. Summary of adverse events.

	Sirolimus (Total Patients n = 575)	
	n [a]	%
Patients with at least 1 adverse event		
Oral mucositis	118	20.52
Acne	25	4.35
Pneumonia	26	4.52
Upper respiratory tract infection	94	16.35
Lymph node infection	5	0.87
Otitis media	2	0.35
Other infection	12	2.09
Fever	6	1.04
Gastrointestinal reaction	53	9.22
♦ Nausea and vomiting	30	5.22
♦ Diarrhea	13	2.26
Anorexia	6	1.04
Cellulitis	1	0.17
Rash	10	1.74
Eczema	17	2.96
Pain	35	6.09
♦ Headache	17	2.96
♦ Muscle pain	1	0.17
Dizziness	1	0.17
Hypertension	4	0.70
Edema	4	0.70
Hemorrhagic disease	4	0.70
Fatigue	4	0.70
Alopecia	5	0.87
Hyperhidrosis	3	0.52
Polyuria	1	0.17
Wound healing delay	4	0.70
Red eye	1	0.17
Behavioral change	3	0.52
Injury due to accident	4	0.70
Laboratory		
Dyslipidemia	36	6.26
♦ Hypercholesterolemia	17	2.96
♦ Hyperlipidemia	23	4.00
♦ Elevated LDL	7	1.22
Anemia	6	1.04
Neutropenia	15	2.61
Lymphocytopenia	8	1.39
Thrombocytosis	25	4.35
Increases in liver enzymes	53	9.22
♦ spartate aminotransferase raised	3	0.52
♦ Alanine aminotransferase raised	2	0.35

TABLE 4 Maternal mTOR inhibitor therapy for fetal rhabdomyomas and LM.

No	Study	Case/no	mTOR/ GA at initiation[b]	Initial mediation effect/week[c]	Duration of treatment[b]	mTORs caseation prior delivery/ week	GA at delivery/ mode of delivery[b]	Size reduction?	Dose[a]	Maternal complications[d]	Neonatal complication
1	Barnes BT et al. 2018	CR (1)	SRL/30	~2	6	Not mentioned	36/CD	Yes	12 mg/first 48 h additional 22 mg, then 12 ± 2 mg/ day	↑TG at 31 5/7 weeks	No
2	Vachon-Marceau C et al. 2018	CR (1)	SRL/31 +4	~1	~1.5	3	39/-	Yes	Loading dose: 15 mg/day, then 5–8 mg/day	-	No
3	Park H et al. 2019	CR (1)	SRL/23	~3	6	No caseation	39/-	Yes	Loading dose: 12 mg/day	-	No
4	Pluym I et al. 2019	CR (1)	SRL/28	~2	8	1	36+6/VD	Yes	Loading dose: 10 mg/day, then 6–10 mg/day	Preeclampsia	Fetus (intrauterine growth restriction)
5	Ebrahimi-Fakhari D et al. 2021	CR (3)	SRL/35+2	-	~3	No caseation in case 1, and 2	39+1/-	Yes	Case 1: 1–3 mg/day	No	Case 1: Length in 43th percentile
			SRL/33+3			Case 3: Discontinued just before delivery	36+6/-		Case 2: 3 mg/day		Case 2: Head and length in 3th percentile/weight in 58th percentile
			34				38+6/-		Case 3: 4—6 mg/day		Case 3: Fetus (14 days after treatment AC was 6th percentile)
6	Carvalherio S et al. 2021	CR (1)	EVR/-	-	-	-	39/CD	Yes	Loading dose: 10 mg/day	No	No
7	Dagge A et al. 2021	CR (1)	EVR/27	~1	~12	No caseation	39/CD	Yes	Initial dose: 4 mg/day	-	Estimated fetal weight (EFW) on the 9th centile
8	Maasz A et al. 2023	CR (1)	EVR/-	-	5	-	Term/CD	Yes	Loading dose: 10 mg/day	-	No
9	Will CJ et al. 2023	CR (1)	SRL/27	-	11	1	39/-	Yes	Starting with 4 mg/day	Hypercholesterinemia, anemia, small vesicles on tongue	No
10	Livingston J et al. 2020	Cervical LM (1)	SRL/30 +4	-	~7	48 h	37cesearean/ EXIT delivery	Yes	Loading dose: 15 mg/day, then 5 mg/day, after 1 week, 4 mg BID	No	No
11	Seront E et al. 2022	Cervical LM (1)	SRL/22	~1 +2	15	2	39/CD	Yes	Loading dose: 6 mg/day for 3 days, then 2 mg/day	Mucositis	No

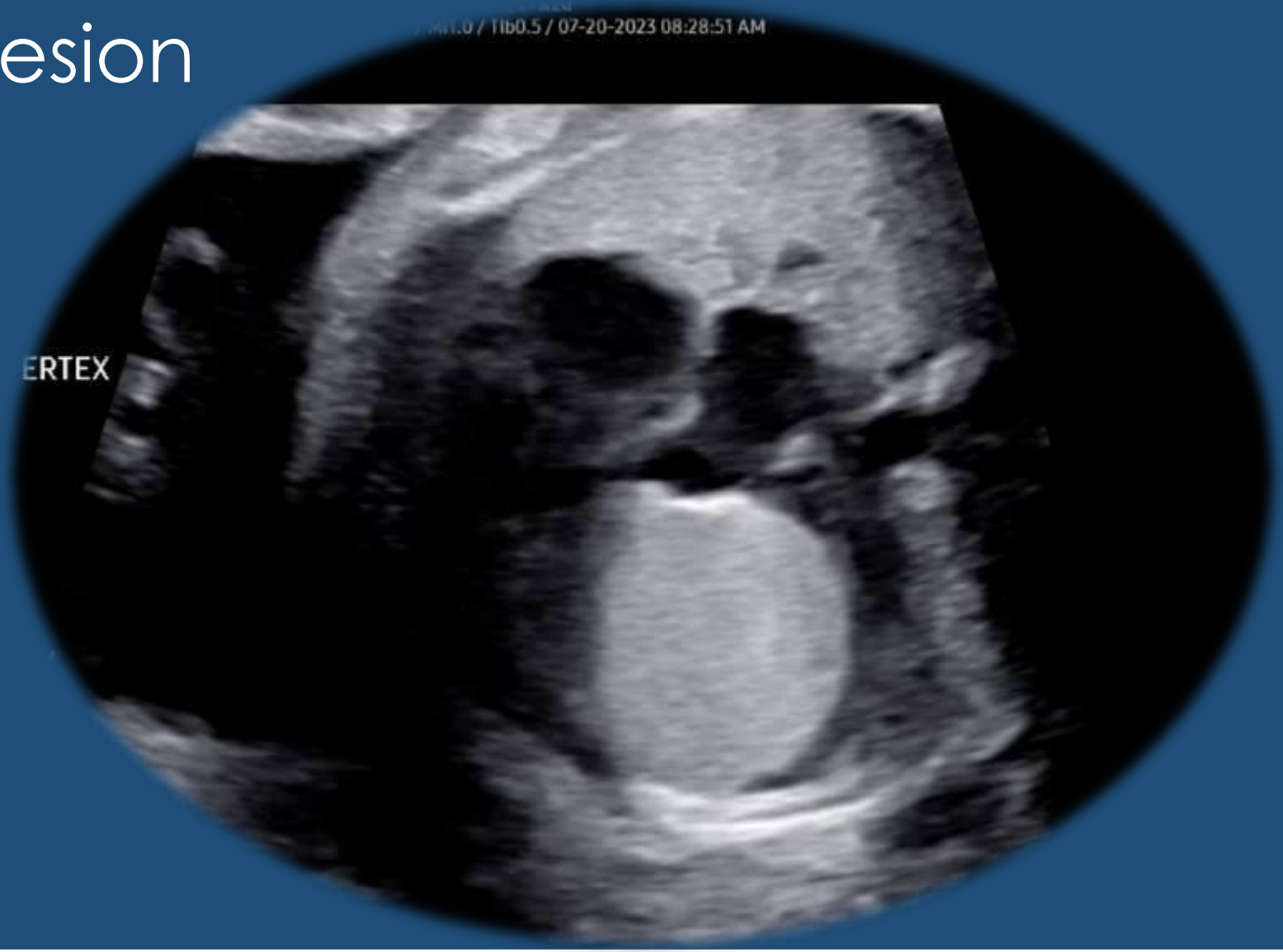
Qaderi S, Javinani A, Blumenfeld YJ, et al. Mammalian target of rapamycin inhibitors: A new-possible approach for in-utero medication therapy. *Prenat Diagn*. 2024;44(1):88-98. doi:10.1002/pd.6492

Surveillance:

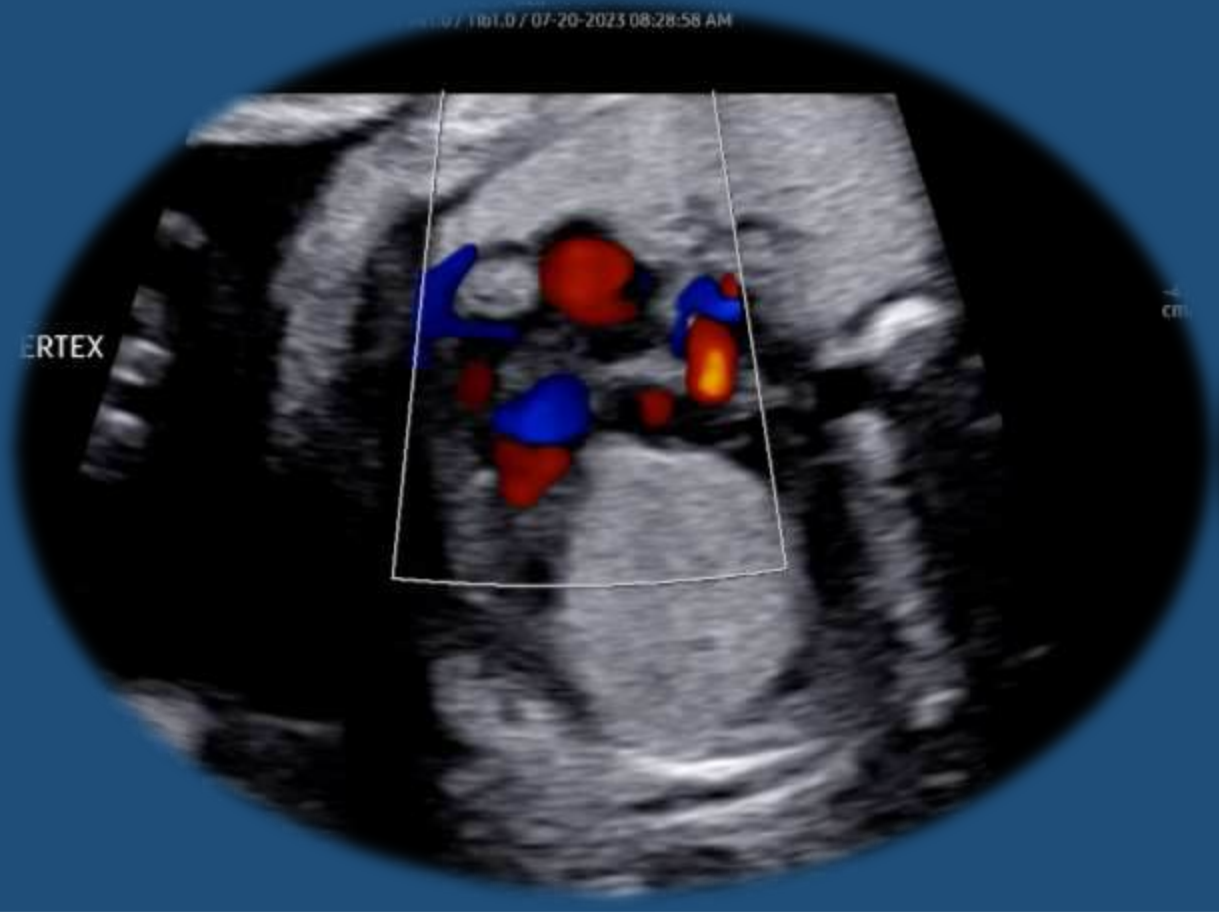
- 31w6d: Smaller, more heterogenous tumor compared to prior studies
- 32w2d: Improvement in size and function of left ventricle
- 34w2d: decision made to start maternal digoxin
- 35w2d: maternal thrombocytopenia→ sirolimus dose decreased
- 38w1d: vaginal delivery

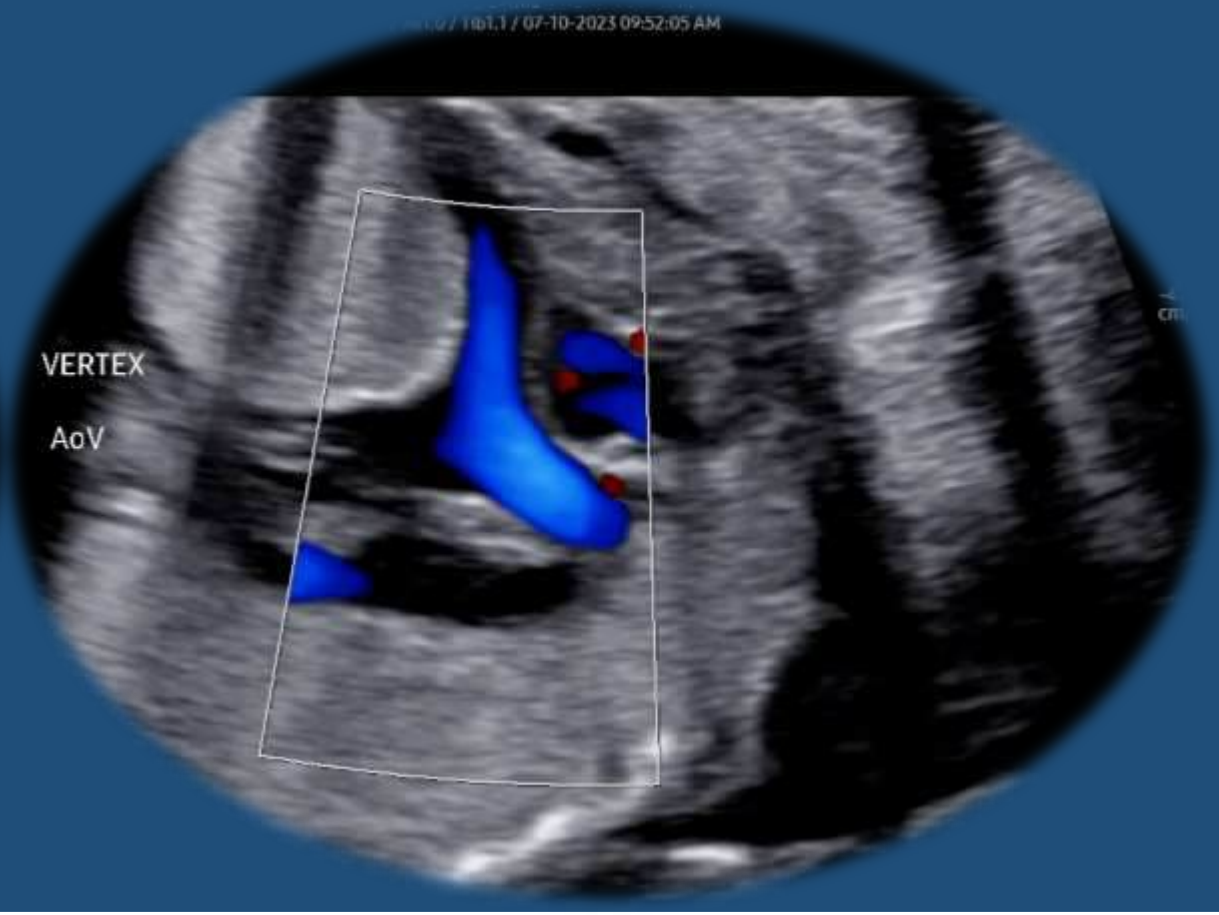
Cardiology Perspectives

Solitary lesion



Space Occupying Within the LV!





Fetal cardiac MRI

Results

Study Result

Narrative & Impression

HISTORY: Fetus with large LV mass. Asked to characterize mass to help differentiate between a rhabdomyoma and fibroma.

TECHNIQUE: Static true-FISP, HASTE, SSFP cine, T1 weighted double inversion dark blood with and without fat saturation, T2 weighted double inversion dark blood, phase encoded velocity mapping. Smart-sync fetal ultrasound gating used for cine imaging.

FINDINGS:

A large LV mass is identified, measuring 2.3x2.0x2.0 cm. The mass occupies the bulk of a dilated LV cavity. LV ejection appears severely decreased by 4-chamber view and moderately decreased by 2-chamber view.

On T2-weighted imaging, the mass is fairly homogeneous and significantly hyperintense to myocardium with an intensity ratio of around 2:1. On T1weighted dark blood images, the mass is isointense to muscle.

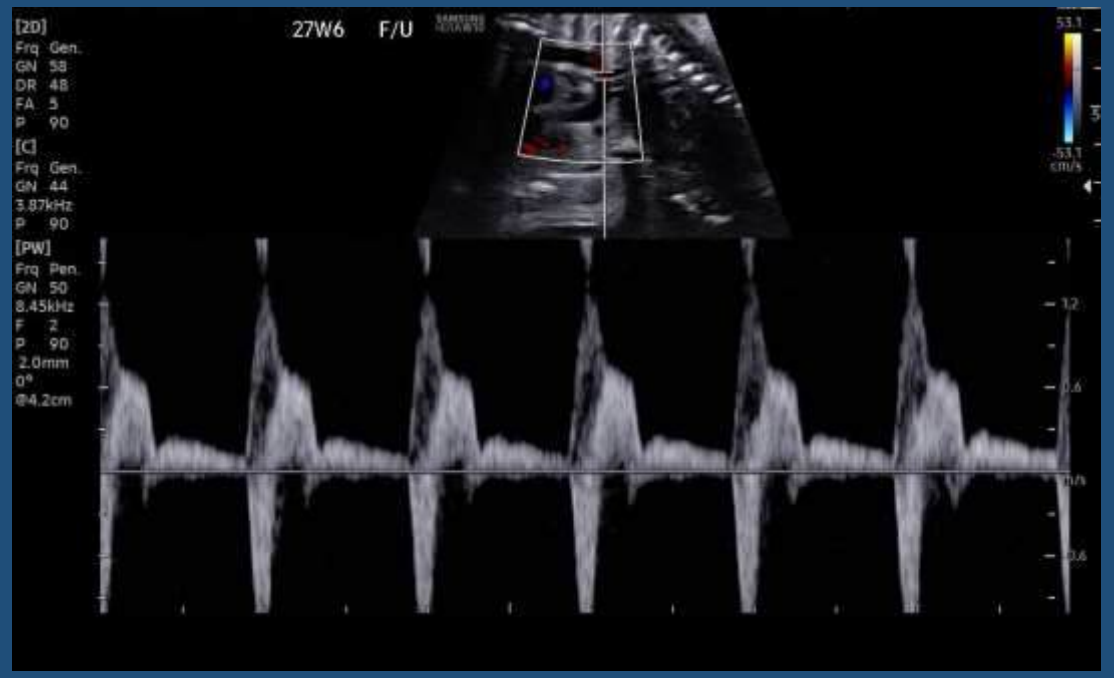
On in-plane velocity mapping, there is the suggestion of antegrade flow in the arch, but this was not definitive due to resolution limitations and movement.

IMPRESSION:

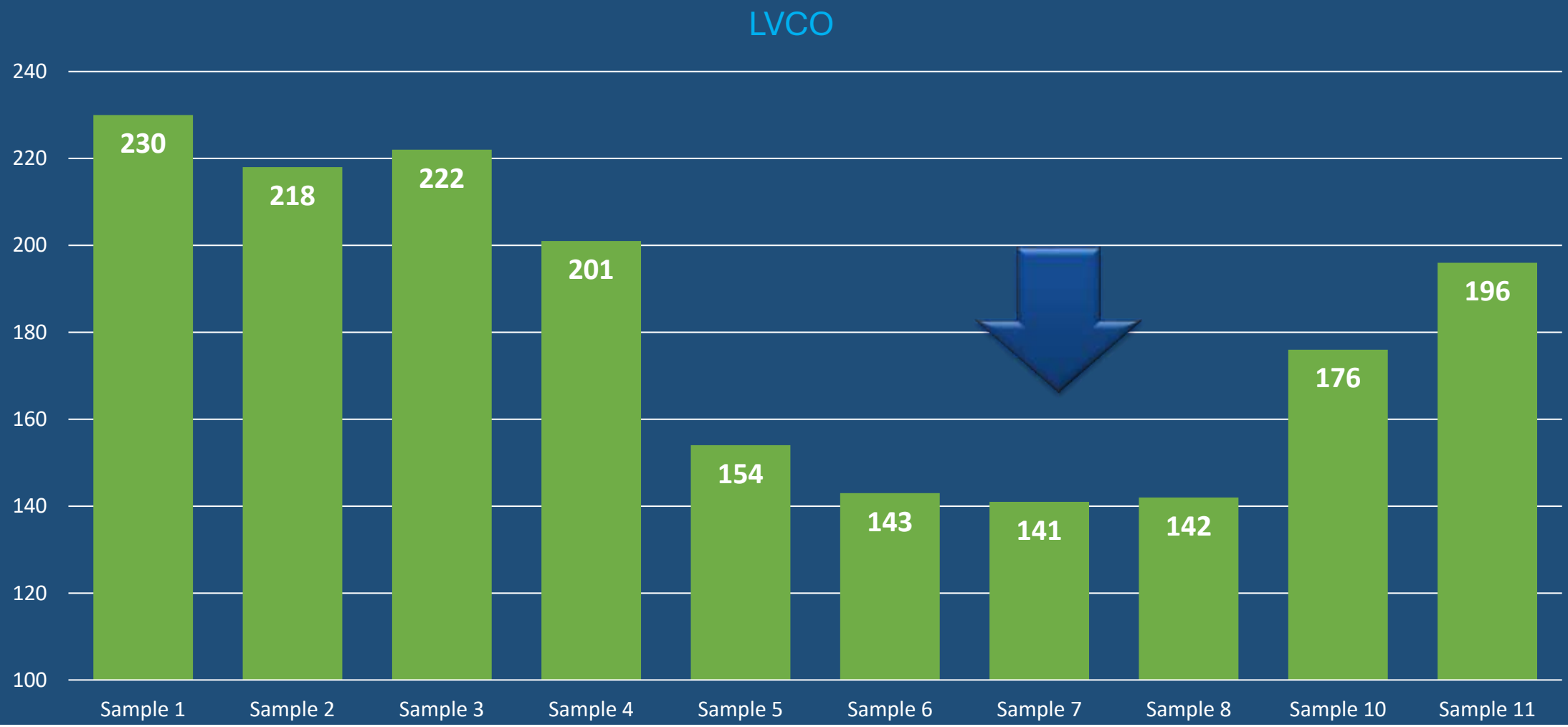
Large LV mass which is isointense to myocardium on T1 and hyperintense on T2.
This is more suggestive of a rhabdomyoma than a fibroma.
Moderately to severely decreased LV ejection.

This was a fetal cardiac MRI focusing on the cardiovascular system. Pathology outside this organ system may not have been fully evaluated and may not be delineated here. As such, if pathology is suggested clinically, other testing should to be performed.

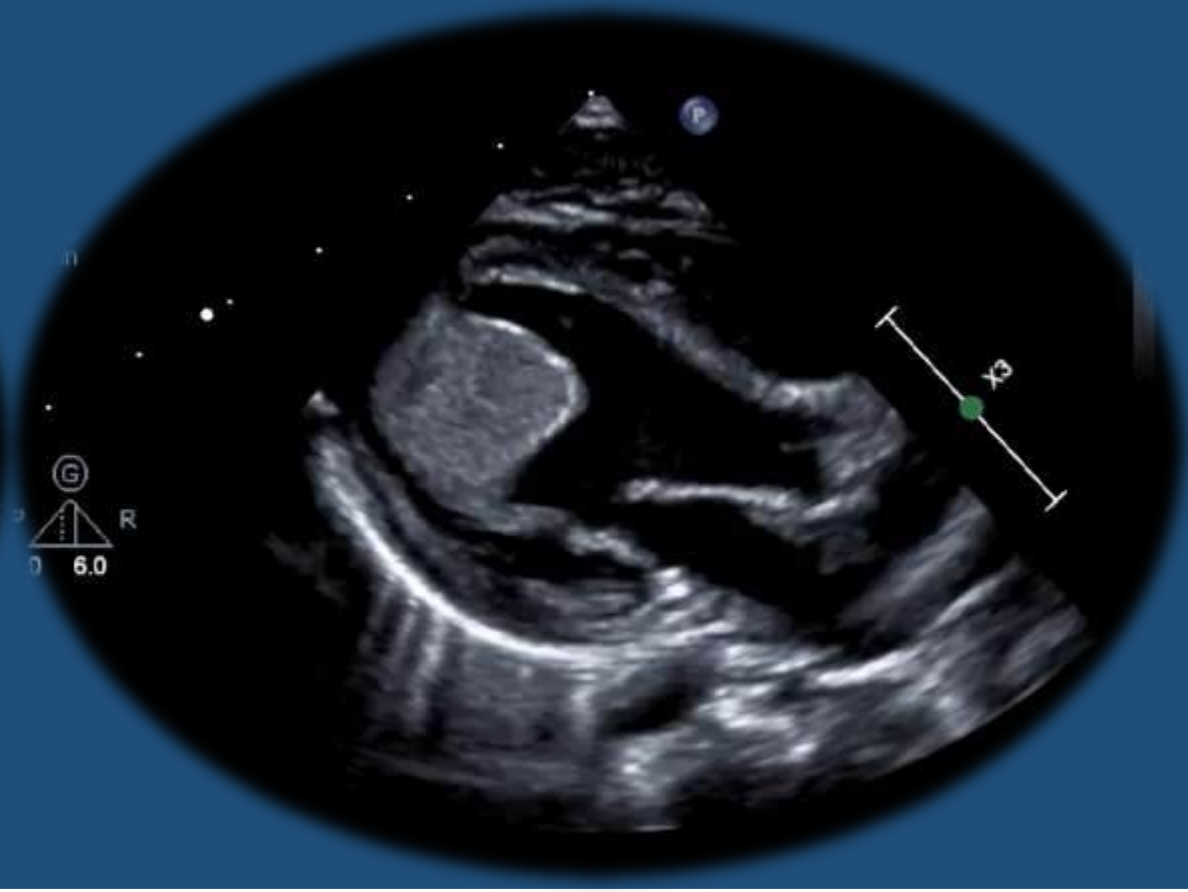
What about magnitude of impact?



Serial LV Cardiac Output Measures



Newborn Postnatal ECHOS



Questions?