

In Utero Embolization for Fetal Vein of Galen Malformation

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 [Supplemental content](#)

IMPORTANCE Vein of Galen malformation (VOGM) is the most common congenital cerebrovascular anomaly. Fetuses with VOGM and wide mediolateral falcine sinus diameters are at high risk for mortality, brain injury, and neurodevelopmental delay. In utero embolization may improve survival and outcomes.

OBJECTIVE To report early results from this institutional review board–approved single-group intervention study of in utero embolization for VOGM.

DESIGN, SETTING, AND PARTICIPANTS Single-center, single-group intervention study in the US. First enrollment was on September 30, 2022; the most recent follow-up was on April 10, 2025. Eligible fetuses had VOGM, no major brain injury on fetal magnetic resonance imaging, and falcine sinus width of 7 mm or greater. Fetal embolization was ultrasound guided, using transuterine, transcranial needle access and microcatheterization of the prosencephalic venous varix with detachable coils.

INTERVENTION In utero embolization of fetuses with VOGM.

MAIN OUTCOMES AND MEASURES Neonatal mortality and neurodevelopmental outcomes. Pre- and postembolization fetal magnetic resonance imaging and echocardiography were performed.

RESULTS Seven patients were enrolled; 5 underwent successful embolization. The mean maternal age was 32.4 years (range, 22-36); the mean fetal gestational age was 35 6/7 weeks (range, 33 6/7 to 37 1/7); and the sex ratio was 3:4 (female to male). The mean falcine diameter (10.3 mm) corresponded to 90% expected mortality and 9% likelihood of reaching 6-month milestones with standard postnatal care. Overall mortality was 43%, and 43% were meeting milestones at 6 months. Three embolized patients (aged 8, 18, and 24 months) survived, all without neurodevelopmental delay. Four of the 7 patients underwent additional neonatal embolization. Fetal echocardiography showed a mean 33.4% reduction (range, 16%-46%) in cardiac output. Five of 7 patients (71.4%) had unscheduled deliveries and 3 of these 5 were preterm, at a mean of 3.2 days after intervention.

CONCLUSIONS AND RELEVANCE Early results demonstrate the feasibility of fetal embolization. Any potential reduction in mortality, brain injury, and neurodevelopmental delays must be weighed against an increased risk of unscheduled, preterm delivery.

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Vein of Galen malformation (VOGM) is the most common congenital cerebrovascular anomaly, occurring in more than 1 of every 60 000 live births.¹ The high-flow arteriovenous shunting brain lesion results in severe elevation of cardiac output, often leading to neonatal high-output heart failure with pulmonary hypertension, and severe intracranial venous hypertension resulting in white matter injury, frequently with ischemia related to arterial steal phenomenon. The development of transarterial embolization techniques² and improvement in neonatal intensive care management algorithms³ have resulted in improvement in overall survival and at least the potential for good neurologic outcomes, though morbidity and mortality remain high, both intrinsic and treatment related.⁴ Despite decades of efforts, the overall prognosis for fetuses with this diagnosis remains grim, with a recent meta-analysis showing only about a 35% likelihood of such fetuses surviving infancy without major neurologic compromise.⁵

The falcine venous sinus drains the malformation flow from the site of arteriovenous shunting in the prosencephalic varix of Markowski⁶ to the posterior cranial sinuses and then to the systemic circulation. It was previously demonstrated that the mediolateral width of falcine sinus on fetal magnetic resonance imaging (MRI) robustly predicted the likelihood that a fetus would experience decompensation after birth, requiring intubation and urgent embolization,⁷ and subsequently was shown that fetal sinus width correlated tightly with flow as measured by 4-dimensional flow MRI.⁸ More recently, it has been shown in a cohort of 59 fetal MRI scans that falcine sinus width is a robust prognosticator of the risk of mortality, the risk of brain parenchymal injury on the first postnatal MRI scan, and the risk of neurodevelopmental delay at 1 month, 6 months, and 1 year after birth.⁹ Fetuses with the widest falcine sinuses face grim prognoses, despite management at expert high-volume centers.⁹

To improve outcomes for this high-risk fetal cohort, fetal brain and skull phantoms were used to design a fetal embolization procedure that results in packing of the venous varix sufficiently to markedly diminish flow without occlusion.¹⁰ This resulted in an institutional review board (IRB)- and Food and Drug Administration (FDA)-approved single-group interventional study (ClinicalTrials.gov ID: [NCT04434729](#), Fetal Treatment of Galenic Malformations).¹¹ Fetuses with a diagnosis of VOGM qualified for in utero embolization if falcine sinus width measured 7 mm or greater and there was no preexisting major brain parenchymal injury (>10% of the supratentorial parenchymal volume).

The outcome of the first fetus in this single-group interventional study successfully treated with fetal embolization was previously reported,¹² and another group similarly reported a successful fetal embolization based on this protocol.¹³ This study presents the clinical and radiological outcome for the first 7 fetal patients enrolled in the single-group interventional study.

Methods

The protocol to enroll 20 to 25 patients was approved independently by the institutional review boards at Brigham and

Key Points

Question Is in utero embolization of high-risk vein of Galen malformation feasible?

Findings In this single-group intervention study, embolization was completed in 5 of 7 patients. Three of 5 embolized patients survived past the neonatal period, all without neurodevelopmental delay. Postembolization magnetic resonance imaging showed no clinically significant parenchymal injury.

Meaning Early results demonstrate the feasibility of fetal embolization. Any potential reduction in mortality, brain injury, and neurodevelopmental delays must be weighed against an increased risk of unscheduled, preterm delivery.

Women's Hospital (Mass General Brigham) and Boston Children's Hospital as well as the FDA. This initial report on the first 7 enrolled patients describes feasibility. The protocol is available in [Supplement 1](#). Per protocol, with written informed consent, fetal intervention could be performed any time from fetal diagnosis to term. For the enrolled cohort, the mean gestational age at the time of attempted fetal surgery was 35 6/7 weeks (range, 33 6/7 to 37 1/7). Fetal MRI and echocardiography (including calculation of combined cardiac output) were performed before and after embolization.

The procedure was performed using maternal spinal anesthesia (for maternal comfort and to lower the risk of maternal movement, which could add significant risk), with the fetus receiving an intramuscular injection of fentanyl, vecuronium, and atropine, after being positioned by external manipulation on the part of the fetal surgeon. Fetal embolization was performed under ultrasound guidance using transuterine, fetal transcranial needle access (18-gauge EchoTip Chiba biopsy needle, 15 cm, Cook Medical), with coaxial microcatheterization of the falcine sinus and the prosencephalic venous varix using a neurointerventional microcatheter-microwire pair (Headway 21, MicroVention and Asahi Chikai black 18 soft tip, Asahi Intecc USA). Detachable platinum coils were used for embolization (Target XXL, 50-cm length, Stryker Neurovascular), with a target packing density of 20%. Additional procedural details are provided in [Supplement 1](#) and See et al¹¹ and Orbach et al.¹²

All patients were admitted for postoperative overnight observation with continuous fetal monitoring, with postprocedural fetal MRI and echocardiography performed the next day. The length of postprocedural observation, management of the balance of the pregnancy, and the timing and mode of delivery were at the discretion of the maternal-fetal medicine specialist (barring an obstetric indication, we do not advocate cesarean delivery for patients with VOGM by virtue of the presence of the malformation, independent of whether fetal intervention is a consideration). At the prerogative of the maternal-fetal medicine specialist, urgent delivery could be performed at any time during the procedure or after the procedure if warranted. Similarly, the decision whether to use tocolytic pharmacotherapy before, during, or after the intervention was at the discretion of the maternal-fetal medicine

Table 1. Maternal and Fetal Baseline Characteristics

Patient	Maternal age range, y	G/P (TPAL), No.	Maternal BMI	Gestation age, wk	
				At diagnosis	At surgery
1	21-24	2 (1002)	48.2	33 5/7	35 6/7
2	35-37	4 (2103)	29.9	32 0/7	34 2/7
3	31-34	3 (2002)	26.5	35 5/7	36 1/7
4	31-34	7 (2042)	27.5	35 0/7	37 0/7
5	35-37	4 (3003)	31.7	33 0/7	33 6/7
6	31-34	2 (1001)	26.1	35 3/7	36 4/7
7	35-37	5 (2002)	29.8	36 3/7	37 1/7

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); G/P (TPAL): gestation/parturition (term, preterm, abortus, living).

specialist, in keeping with the gestational age and other relevant factors, with the goal of maximizing maternal and fetal safety.

Clinical parameters of the neonatal course were reported including intubation or resuscitation in the delivery room or the neonatal intensive care unit (NICU) for high-output cardiac failure resulting in respiratory failure, presence or absence of seizures, neurologic examination, and status at discharge from the NICU, as well as meeting neurodevelopmental milestones, including age-appropriate motor, tone, reflex, sensory, and behavioral assessment by the primary pediatricians, and outpatient medications.

Postnatal brain MRI was completed and evaluated for parenchymal injury. Postnatal cardiac ultrasound data were evaluated for presence of anatomic abnormalities, right and left ventricular dysfunction, and suprasystemic right heart pressures. B-type natriuretic peptide levels were followed as a laboratory marker of overall cardiac health. Neonatal embolizations were recorded, as were any neonatal deaths, along with their proximal cause. Current participant age was reported along with neurodevelopmental outcomes (including age-appropriate motor, tone, reflex, sensory, and behavioral assessment), as assessed in person by the primary pediatrician and by video follow-up consultation with the treating pediatric cerebrovascular team.

Results

Seven patients were enrolled with intention to treat. **Table 1** provides baseline data on the 7 patients in the study cohort and **Table 2** summarizes surgical details and outcomes.

Per protocol, all patients had a fetal MRI diagnostic of VOGM, with less than 10% parenchymal injury at baseline and a falcine sinus width greater than or equal to 7 mm. Fetal embolization was technically successful in 5 of 7 patients. Transcranial access was not achieved for patient 1 and patient 4 and as such, embolization was not performed.

For patient 1, morbidly obese maternal body habitus led to aortocaval compression and hemodynamic instability, with maternal hypotension that was unresolved with repositioning and standard resuscitation maneuvers, resulting in fetal bradycardia before cranial puncture leading to emergent cesarean delivery. For patient 4, despite repeated efforts using a manual rotational drilling-type technique under ultrasound guidance, the needle tip did not successfully traverse

the skull and embolization could not be performed. During the postoperative period, delivery was induced due to nonreassuring fetal tracings.

The cohort of 7 enrolled fetal patients had a mean falcine diameter of 10.3 mm, conferring an expected 90% mortality and only 9% likelihood of reaching milestones at 6 months under conventional postnatal management.⁹ The 7 enrolled patients had a 43% mortality and 43% met milestones at 6 months of age. The 3 surviving patients who underwent fetal embolization were ages 8 months, 18 months, and 24 months as of April 10, 2025, all without neurodevelopmental delay.

Four of the 7 enrolled patients underwent neonatal embolization, including both patients in whom fetal embolization could not be performed and 2 of 5 patients in whom fetal embolization was successfully achieved.

Presurgical and Postsurgical Fetal Brain MRI

The 5 patients who underwent successful fetal embolization were patients 2, 3, 5, 6, and 7. Comparison of fetal brain MRI before and after embolization (postoperative MRI was always within 24 hours of the procedure) showed no appreciable deleterious effect intra-axially or extra-axially in patients 3 and 7 (**Figure 1**). Patient 2 showed a focus of nonrestricting T2 hyperintensity postoperatively, which resolved on subsequent imaging (**Figure 2A**); this patient was more fully described in our initial case report on the first successful fetal embolization in the trial.¹² Patient 5 postoperatively showed small subdural hematomas bilaterally (**Figure 2B**). Patient 6 showed a small focus of left medial parietal restricted diffusion and a focus of restricted diffusion in the right caudate head (**Figure 2C**). Six days separated the preoperative and postoperative fetal MRI in patient 6, and both parenchymal findings are common in fetuses with high-risk VOGM, so whether these relate to the fetal intervention is indeterminate. Fetal MRI findings are listed in **Table 2**.

Fetal Echocardiography: Preoperative and Postoperative Combined Cardiac Output

Table 2 shows the preembolization combined cardiac output and postembolization percentage change for each fetus. For the 5 successfully embolized fetuses, there was a mean reduction in combined cardiac output of 33.4% (range, 16%-46%).

Postnatal Brain MRI

The 2 patients who did not undergo fetal embolization, patients 1 and 4, both showed new parenchymal findings on their

Table 2. Anatomy, Physiology, Surgical Details, and Clinical Follow-Up

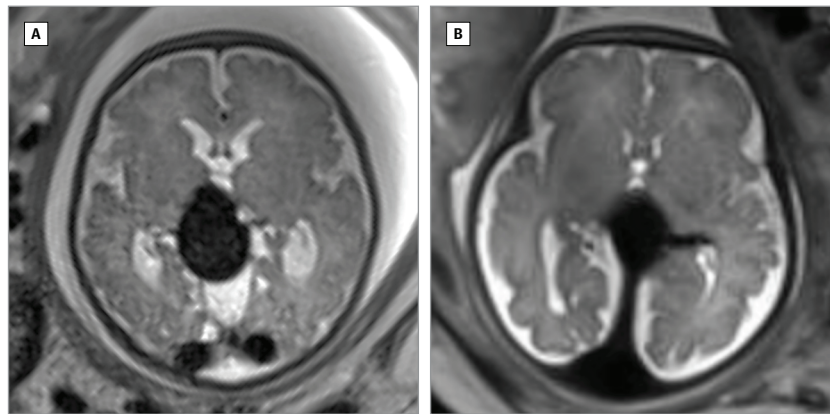
Patient	Packing density, % ^a	Diameter, mm		Varix AP/ML/CC		Combined cardiac output, mL/min		Postembolization abnormalities on fetal MRI	Neonatal embolization	Current clinical status (age at last follow-up, mo)
		Before embolization	After embolization	Before embolization	After embolization	Before embolization	After embolization			
1 ^b	NA	9	NA	28/22/32	NA	2270	NA	NA	Yes	Neurodevelopmental delay (29 mo)
2	12.9	12	8	24/35/33	26/32/27	2347	41	Region of left parieto-occipital edema	No	Neurodevelopmental intact (23 mo)
3	7.2	9	7	29/18/21	27/23/22	4341	46	None	No	Neurodevelopmental intact (15 mo)
4 ^b	NA	7	NA	14/22/20	NA	2717	NA	NA	Yes	Deceased, comfort care due to postnatal infarcts
5	20	12	11	27/25/21	26/25/18	2948	46	Small subdural hematoma without mass effect	No	Deceased, high output heart failure
6	18	14	10	31/27/22	32/27/23	2137	16	Small foci of diffusion restriction in the right caudate head and left parietal lobe, the latter with punctate blood products	Yes	Deceased, gram-negative sepsis
7	21	9	8	18/17/15	19/18/15	2458	21	None	Yes	Neurodevelopmental intact (8 mo)

Abbreviations: AP, anteroposterior axis; CC, craniocaudal axis; ML, mediolateral axis; MRI, magnetic resonance imaging; NA, not applicable (no packing density, change in MRI measurements, or change in cardiac output is reported for the 2 patients in whom fetal embolization was not performed).

^a Packing density refers to the fraction of the proencephalic varix volume filled with detached coils. As detailed in the protocol, target packing density was 20%, but embolization was stopped when malformation flow was seen to markedly diminish on color Doppler.

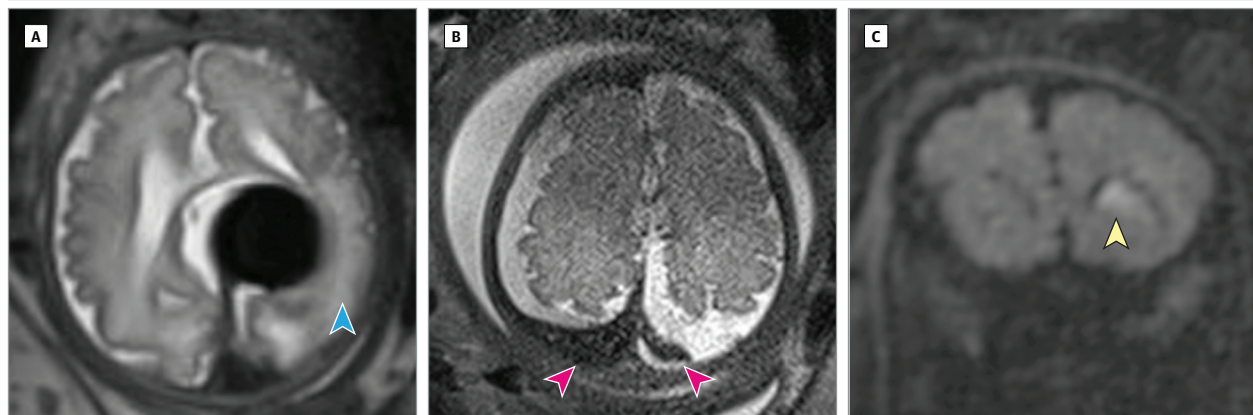
^b Rows indicate patients in whom fetal embolization could not be performed.

Figure 1. Postoperative Fetal Magnetic Resonance Imaging in 2 Patients Showing No Procedural Morbidity



Fetal brain magnetic resonance imaging after embolization for patient 3 (A) and patient 7 (B) showed no appreciable changes compared with preoperative imaging.

Figure 2. Postoperative Fetal Magnetic Resonance Imaging in 3 Patients Showing Minor Procedural Morbidity



A, Imaging for patient 2 showed a region of nonrestricting T2 hyperintensity (blue arrowhead). B, Patient 5 showed small subdural hematomas bilaterally (pink arrowheads show the dark layering blood). C, Patient 6

showed a small focus of left medial parietal restricted diffusion and a focus of restricted diffusion in the right caudate head (yellow arrowhead).

first postnatal MRI scan. Patient 1, who underwent urgent cesarean delivery, showed small foci of restricted diffusion in the left occipital lobe and moderate bilateral parietal and posterior fossa subdural hematomas. Patient 4 showed a nearly holohemispheric left-sided infarct with progressive extension to the right hemisphere on subsequent imaging.

Of the fetal patients who underwent successful fetal embolization, patients 2, 3, 6, and 7 showed no new parenchymal brain findings on postnatal MRI. Patient 5 showed a small focus of hemorrhage in the right occipital lobe and growth of the subdural hematomas compared with the fetal scan.

The 3 survivors who underwent successful fetal embolization did not show signs of parenchymal injury on follow-up brain MRI (Figure 3).

Mortality and Neurodevelopmental Outcomes

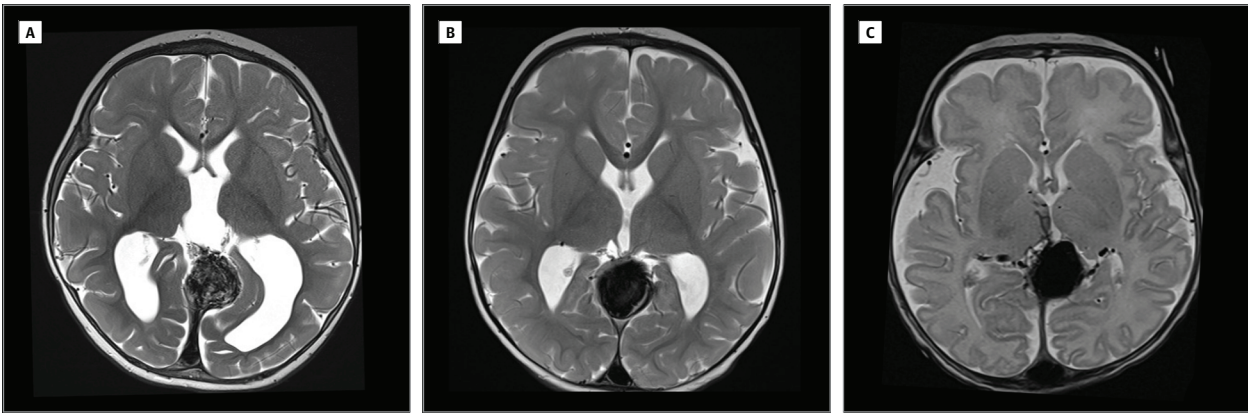
The postnatal course of the 2 patients who did not undergo successful fetal embolization was consistent with the expected evolution of aggressive VOGM. Patient 1 underwent multiple rounds of postnatal embolization, developed intracranial hemorrhage and seizures, was in our NICU and a NICU closer to home for several months, and is alive. Despite the large post-

natal infarct, patient 4 underwent one round of postnatal embolization. However, despite significant improvement in cardiac function, subsequent imaging demonstrated extension of infarct to the right hemisphere, and the family opted for palliative redirection of care.

Of the 5 patients who did undergo successful fetal embolization, patients 5 and 6 did not survive. Patient 5 showed immediate postnatal severe high-output heart failure related to the VOGM and was not stable enough to undergo postnatal embolization due to rapid decline in cardiac function. Patient 6 underwent one round of postnatal embolization on postnatal day 3, with significant improvement in cardiac function. On postnatal day 6, the neonate developed a lacy body rash and hypotension without ventricular dysfunction on echocardiography, consistent with low peripheral vascular resistance, and was found to have gram-negative bacteremia, matched to *Escherichia coli* cultured from the patient's urine. Despite treatment with broad-spectrum antibiotic, the patient did not survive. Autopsy with histology was performed, showing no evidence of infection in the brain or implanted coils.

Of the 5 patients who did undergo successful fetal embolization, patients 2, 3, and 7 are alive, aged 8 months, 18 months,

Figure 3. Magnetic Resonance Imaging in Infancy in the 3 Surviving Patients With Successful Fetal Surgery Showing No Parenchymal Injury



Of the 5 fetal patients who underwent successful fetal embolization, the 3 survivors do not show parenchymal injury on brain magnetic resonance imaging. Images are of patient 2 at 14 months of age (A), patient 3 at 13 months of age (B), and patient 7 at 3 weeks of age (C).

Table 3. Obstetric Outcomes

Patient	Intervention to delivery interval, d	Gestational age at delivery, wk	Scheduled or unscheduled delivery	Mode of delivery	Delivery notes
1	0	35 4/7	Unscheduled	Cesarean	Fetal bradycardia during intervention
2	2	34 4/7	Unscheduled	Vaginal	Periprocudural PROM
3	6	37 0/7	Scheduled	Vaginal	Induction of labor
4	0	37 0/7	Unscheduled	Vaginal	Periprocudural contractions followed by labor
5	7	34 6/7	Unscheduled	Cesarean	Delayed PPRM, intrapartum concern for placental abruption
6	7	37 5/7	Unscheduled	Vaginal	Chorion-amnion separation followed by ROM and labor
7	8	38 0/7	Scheduled	Cesarean	2 Prior cesarean deliveries

Abbreviations: PROM, Premature rupture of membranes; PPRM, preterm premature rupture of membranes; ROM, rupture of membranes.

and 24 months, respectively. All were neurodevelopmentally intact as of April 10, 2025.

Obstetric Outcomes

Of these 7 patients, 5 (71.4%) ultimately had unscheduled deliveries due to circumstances related to fetal intervention, as shown in Table 3.

Three of these 5 deliveries were preterm. Patient 1 was described above. The remaining 2 preterm deliveries occurred in the setting of preterm premature rupture of membranes (PPROM); one had immediate periprocudural PPRM, while the other presented with PPRM 7 days after fetal intervention and subsequent bleeding and nonreassuring fetal heart status resulting in emergency cesarean delivery. Of the 2 patients with unscheduled term deliveries, one had immediate periprocudural contractions and ultimately progressed in labor. The other was diagnosed with partial chorion-amnion separation newly visualized 6 days after fetal intervention, and shortly thereafter had spontaneous ROM followed by labor. In this small cohort, the mean time between attempted fetal intervention and unscheduled delivery was 3.2 days (range, 0-8 days).

Discussion

This study reports the clinical and radiological outcomes for the first 7 patients enrolled in a single-group interventional study of fetal embolization of high-risk VOGM. Five of the patients underwent successful fetal embolization, while in 2, fetal transcranial access was not achieved and embolization was not performed. The mean falcine diameter of the 7 enrolled patients conferred a 90% expected mortality and 9% likelihood of reaching 6-month milestones with standard postnatal care. Overall mortality in the cohort was 43%, and 43% were meeting milestones at 6 months. These early results demonstrate the feasibility of this in utero approach. Further studies are needed to assess outcomes, including mortality and neurodevelopmental morbidity, with comparison with current standard-of-care postnatal management at expert centers.

Important lessons were learned from 2 fetal patients in whom embolization could not be performed. For patient 1, high maternal body mass index was an exclusion criterion for the

intervention. After ascertaining under ultrasound that the fetal target was in fact within reach, an IRB exemption was obtained, allowing the procedure to proceed despite the patient's BMI. However, the patient's body habitus resulted in hemodynamic instability, with maternal aortocaval compression with positioning leading to maternal hypotension and fetal bradycardia, in turn leading to an emergent cesarean delivery before fetal embolization could be performed.

For patient 4, transcranial needle access was not achieved. In fact, one of the most technically challenging aspects of the fetal intervention is crossing the skull with a needle using manual drilling. There is often a narrow sonographic window for optimal visualization of the fetal torcular (the intracranial target for the needle tip), along with the falcine sinus and Markowski varix. It is frequently the case that this window does not align with the fetal occiput facing the mother's anterior abdominal wall at an angle that allows the surgeon nearly perpendicular access to the fetal skull. Angles of approach off the perpendicular tend to result in the needle sliding in the scalp along the skull periosteum with drilling, rather than penetrating the skull. There is thus a learning curve of several attempts for successfully achieving transcranial access. This study has had 2 fetal surgeons as operators, and the learning curve phenomenon was replicated for both.

The second major observation to emerge from this study was that fetal intervention for VOGM has been associated with significant rates of unscheduled delivery, with the majority preterm. Notably, these pregnancy complications have not been seen with such frequency following other needle-based fetal interventions, such as those for congenital heart disease. While there are multiple differences between these interventions, two stand out as potentially relevant: gestational age at the time of intervention (mean 26 weeks' gestational age for cardiac interventions vs approximately 36 weeks for VOGM) and location of uterine entry (upper uterine segment for cardiac interventions vs lower uterine segment for VOGM); nevertheless, the exact etiology of the resulting early delivery after VOGM embolization remains unknown.

It may be possible to continue with in utero embolization at the current range of gestational ages or to consider restricting the gestational age window to fetuses at or after 37 weeks, to be followed by scheduled delivery within 1 to 2 days. Although fetal embolization earlier in gestation is a theoretical possibility as well, the diagnosis is rarely made earlier than about 30 weeks (see Table 1 for the gestational age at diagnosis in this study cohort).

This single-group intervention study was initiated based on large mediolateral widths of the fetal falcine sinus (≥ 7 mm) serving as a marker for very high likelihood of neonatal decompensation, based on an earlier study.⁷ However, because large falcine sinus values are present in only a minority of fetuses with VOGM, most newborns with VOGM who decompensate and who require neonatal embolization do not, in fact, have these large falcine sinus values. Thus, measurements of 4, 5, and 6 mm are far more common among embolized newborns, and such patients make up the bulk of the undifferentiated patients of prior publications

within the neurointerventional and neurosurgical literature on clinical outcomes. After systematically analyzing clinical outcomes as a function of falcine sinus in a retrospective cohort of 59 fetal MRI scans, it became clear that the wide-falcine sinus fetal cohort, ie, the patients of this interventional study, face grim prognoses with standard-of-care postnatal embolization, in terms of mortality, likelihood of brain parenchymal injury, and poor neurodevelopmental outcome.⁹ The difficult postnatal course of the 2 enrolled patients who did not undergo successful fetal embolization, patients 1 and 4, are exemplars of the typical evolution with postnatal management. The prognostic power of the fetal falcine sinus width (with a mean diameter of 10.3 mm) provided a rigorous intrainstitutional control for this cohort of enrolled fetuses, conferring an expected 90% mortality and only 9% likelihood of reaching milestones at 1 and 6 months under conventional postnatal management.⁹

Limitations

This study has several limitations. First, the sample size was small, reflecting the rarity of high-risk fetal VOGMs and the highly specialized nature of the intervention. Moreover, given this rarity and the known poor prognosis of the qualifying fetal cohort, the study did not involve a randomized control group that received standard neonatal care, and historical outcomes were used as the comparator. Second, the follow-up period, while extending beyond the neonatal stage, remains relatively short for assessing long-term neurodevelopmental outcomes. Moreover, given the geographical dispersion of the enrolled patients, neurodevelopmental follow-up was of necessity in partnership with the patients' local primary pediatrician, thus potentially introducing lack of uniformity. Third, all procedures were performed at a single, high-volume tertiary care center by experienced fetal surgeons and pediatric neurointerventionalists, and the generalization to other centers is unknown. In particular, the fact that 4 of 7 enrolled patients underwent neonatal embolization, including 2 of 5 in whom fetal embolization was achieved, demonstrates that fetal intervention is not a cure-all procedure. Careful postnatal management by a multidisciplinary team experienced in managing VOGM in neonates is still necessary. Fourth, the technical learning curve associated with the fetal procedure and the risk of procedure-related preterm delivery underscore the need for further technique refinement and broader multicenter validation.

Nevertheless, there is preliminary evidence to support feasibility of this approach. To our knowledge, this is the first systematic effort to treat any congenital cerebrovascular condition through a fetal surgical approach by changing the dynamics of fetal brain blood flow.

Conclusions

Early results demonstrate the feasibility of fetal embolization. Any potential reduction in mortality, brain injury, and neurodevelopmental delays must be weighed against an increased risk of unscheduled, preterm delivery.

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Other—data acquisition: Wilkins-Haug.

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