Early Online

The European Research Journal 2025 Original Article

DOI: https://doi.org/10.18621/eurj.1694766 *Obstetrics and Gynaecology*

Early-onset versus late-onset fetal cerebral ventriculomegaly: Sonographic characteristics and neonatal outcomes

Ruken Dayanan, Ahmet Arif Filiz, Merve Ayas Özkan, Dilara Duygulu Bulan, Hatice Ayhan, Ecem Bakan, Gülşan Karabay, Şevki Çelen

Department of Obstetrics and Gynecology, Division of Perinatology, Ankara Etlik City Hospital, Ankara, Türkiye

ABSTRACT

Objectives: This study aimed to compare the prenatal ultrasound characteristics, pregnancy outcomes, and neonatal prognosis of early- and late-onset fetal ventriculomegaly (VM).

Methods: A retrospective analysis was conducted on 102 pregnant women diagnosed with fetal VM, categorized into early-onset (≤24 weeks) and late-onset (>24 weeks) groups. Maternal characteristics, ventricular dimensions, associated anomalies, pregnancy outcomes, and neonatal parameters were compared between the groups.

Results: Early-onset VM was significantly associated with progressive ventricular enlargement, bilateral involvement, and a higher prevalence of additional anomalies detected via ultrasonography (70.4% vs. 29.2%, P<0.001) and Magnetic resonance imaging (MRI) (35.4% vs. 16.7%, P=0.030). Prenatal ultrasound findings differed significantly between the groups; early-onset VM cases more frequently exhibited bilateral (72.2% vs. 39.6%, P=0.002) and asymmetric (46.3% vs. 31.2%, P=0.037) ventricular enlargement, while late-onset VM was more commonly isolated (70.8% vs. 29.6%, P<0.001) and unilateral (60.4% vs. 27.8%). Live birth rates were lower (55.6% vs. 85.4%, P=0.001), pregnancy termination rates were higher (44.4% vs. 14.6%, P=0.001) and chromosomal abnormalities were higher (16.7% vs. 8.3%, P=0.246) in early-onset cases. Additionally, Apgar scores at 1 and 5 minutes were significantly lower in the early-onset group (P=0.028 and P=0.042, respectively).

Conclusions: Early-onset VM is more frequently associated with ventricular progression and structural anomalies, leading to poorer pregnancy and neonatal outcomes. These findings highlight the importance of close prenatal monitoring, including detailed ultrasound, fetal MRI, and genetic evaluation, to guide clinical management and parental counseling. Future studies with long-term neurodevelopmental follow-up are needed to further refine risk stratification and optimize patient care.

Keywords: Fetal cerebral ventriculomegaly, prenatal ultrasound, fetal MRI, pregnancy outcome, congenital anomalies, isolated ventriculomegaly

Fetal cerebral ventriculomegaly (VM) is one of the central nervous system anomalies characterized by enlargement of the lateral ventricles during prenatal ultrasonography and is among the most common neurological pathologies detected prenatally [1]. The incidence in the general population is

Received: May 8, 2025 **Accepted:** August 15, 2025 **Available Online:** August 21, 2025 **Published:** XX XX, 2025

How to cite this article: Dayanan R, . Early-onset versus late-onset fetal cerebral ventriculomegaly: Sonographic characteristics and neonatal outcomes. Eur Res J. 2025. doi: 10.18621/eurj.1694766

Corresponding author: Ruken Dayanan, MD., Phone: +90 312 797 00 00, E-mail: rukendayanan@gmail.com

Available Online at https://dergipark.org.tr/en/pub/eurj

approximately 1.5-2/1000 pregnancies and is classified as mild, moderate, and severe [2]. A lateral cerebral ventricular atrium diameter of 10 mm or more is accepted as the diagnostic criterion. VM may occur as an isolated finding or may be associated with genetic anomalies, intrauterine infections, congenital central nervous system malformations or vascular events [3]. The prognosis of VM identified in the prenatal period varies depending on the degree of ventricular enlargement, time of onset, and associated anomalies [2].

Fetal VM cases are divided into two categories as early-onset and late-onset in the prenatal period. Early-onset VM refers to cases detected before 24 weeks of gestation, while late-onset VM refers to cases detected after 24 weeks [2]. In the literature, it is reported that there are significant differences between early and late onset VM cases in terms of clinical course, prenatal follow-up, and postnatal outcomes. Early-onset cases have a higher incidence of genetic abnormalities and associated structural anomalies, and more unfavorable outcomes in terms of neurodevelopmental prognosis. In contrast, late-onset VM cases are reported to have a milder course and may spontaneously regress in some cases [4]. However, it is also known that severe neurodevelopmental effects may occur in the postnatal period in cases with progressive ventricular enlargement [1].

The long-term prognosis of fetal VM in the postnatal period depends on the degree of ventricular enlargement, associated neurologic abnormalities and whether the ventricular enlargement is progressive [5]. Most cases of mild VM have a favorable neurodevelopmental prognosis, whereas severe VM is associated with a higher risk of neurodevelopmental problems such as cerebral palsy, motor and cognitive retardation. Therefore, cases of fetal VM should be carefully followed up both prenatally and postnatally [6]. Although early- and late-onset fetal VM differ in clinical course and prognosis, comparative data remain limited. Existing studies often have small sample sizes, inconsistent definitions, and lack detailed evaluation of ventricular dynamics. This study addresses these gaps by systematically comparing early- and late-onset VM in a single well-defined cohort, integrating ultrasound, Magnetic resonance imaging (MRI), and neonatal outcomes to inform prenatal counseling and management. This study aims to compare the prenatal sonographic spectrum and neonatal outcomes of early and late onset fetal cerebral VM cases. Identifying differences between early and late onset cases will contribute to improving prenatal counseling processes and optimizing clinical management strategies.

METHODS

This retrospective cohort study included pregnant women admitted to the Perinatology Clinic of Ankara Etlik City Hospital between December 2022 and December 2024 and diagnosed with fetal VM. Diagnosis and follow-up information were obtained retrospectively from the hospital information management system and prenatal and neonatal outcomes were evaluated. The diagnosis of fetal VM was based on prenatal ultrasonography with a lateral ventricular atrial diameter ≥10 mm. All ultrasound examinations had been performed as part of routine prenatal care using a Voluson E10 system (GE Healthcare, Chicago, IL, USA) equipped with a 2-5 MHz convex transducer. Measurements were obtained transabdominally at the level of the lateral ventricular atrium in a standard coronal plane. The inclusion criteria for the study were singleton pregnancies diagnosed with VM based on an atrial width of 10 mm or greater, and with at least one follow-up ultrasound examination available in the records. Pregnancies were excluded if they were multiple gestations, lacked follow-up data, or were complicated by major maternal systemic diseases such as pregestational diabetes or chronic hypertension. The diagnosed cases were classified as early or late onset VM according to gestational week. Prenatal findings, neonatal outcomes and perinatal morbidity and mortality rates were compared between the groups.

A total of 102 pregnant women were included in the study. Patients were divided into two groups according to the gestational week at which fetal VM was diagnosed. The early onset group (n=54) consisted of patients diagnosed before 24 weeks of gestation, and the late onset group (n=48) consisted of patients diagnosed after 24 weeks of gestation.

Within the scope of detailed ultrasound evaluation, whether VM was symmetric or asymmetric, whether it showed unilateral or bilateral enlargement, and dynamic changes in ventricular width were recorded. Asymmetry was defined as a ≥2 mm difference in width between the lateral ventricles. Unilateral VM was defined as ≥10 mm diameter of only one lateral

ventricle, whereas bilateral VM was defined as ≥10 mm diameter of both lateral ventricles.

It was also monitored whether the VM was transient or permanent (progressive). Transient VM was defined as a decrease in ventricular width to <10 mm during follow-up. In contrast, persistence of ventricular width ≥10 mm on multiple ultrasound assessments during follow-up was classified as persistent VM. A change of ≤2 mm in ventricular diameter compared with the initial measurement indicates stability, an increase of >2 mm indicates progression, and a decrease in ventricular diameter to <10 mm is considered spontaneous regression. Isolated VM (IVM) was defined as a special category and diagnosed in the absence of associated structural anomalies, chromosomal abnormalities or intrauterine infections. Cases with associated anomalies are classified as non-isolated VM (non-IVM).

In the prenatal period, the isolated VM, presence of additional structural anomalies, bilateral or unilateral enlargement, ventricular enlargement dynamics (progression, regression, or stability) and TORCH test results were analyzed. In the neonatal period, pregnancy outcomes, birth week, birth weight, Apgar scores, need for neonatal intensive care, perinatal morbidity and mortality rates were evaluated. Composite adverse perinatal outcomes (CAPOs) include the presence of at least one of the following adverse outcomes: transient tachypnea of the newborn, respiratory distress syndrome, need for continuous positive airway pressure, need for mechanical ventilation, need for phototherapy, neonatal hypoglycemia, intraventricular hemorrhage, necrotizing enterocolitis, neonatal sepsis, 5th minute APGAR score <7, neonatal intensive care unit (NICU) admission, placental abruption, and preterm birth.

This study was conducted in compliance with the Declaration of Helsinki and was approved by the Ankara Etlik City Hospital Scientific Research Evaluation and Ethics Committee (decision number: AEŞH-BADEK-2025-0259). In this study, due to its retrospective nature, informed consent was waived with the approval of the Ethics Committee. All data were anonymized, and participant confidentiality was strictly maintained.

Statistical Analysis

Statistical analysis was performed using IBM Corporation SPSS version 22.0 (IBM Corporation, Armonk, NY, USA). The Kolmogorov-Smirnov test was used to analyze conformity to normal distribution. Descriptive statistics of continuous variables are shown as "mean ± standard deviation" for those with a normal distribution. and as “median (interquartile range)” for those that do not. Continuous variables that were and were not normally distributed were compared using the Mann-Whitney U test. Normally distributed data were compared using the independent sample t-test. Statistical significance for the tests was defined as a P-value of less than 0.05.

RESULTS

A total of 102 pregnant women were included in the study, and the cases were divided into two groups as early onset (≤24 weeks) and late onset (>24 weeks) according to the gestational week at which fetal VM was detected. There was no significant difference between the groups in terms of maternal age and body mass index (BMI), but the number of gravida was higher in the early-onset group (P=0.036). TORCH test results were similar, but the rate of additional anomaly detection by MRI was significantly higher in the early-onset group (35.4% vs. 16.7 %, P=0.030). The diagnosis was made at a median of 21 weeks in the early-onset group and 28 weeks in the late-onset group, and this difference was statistically significant (P<0.001). There was no significant difference between the groups in terms of ventricular width (P=0.443). Cytogenetic testing was performed in 53.7% of the early-onset group and 29.2% of the late-onset group, with a statistically significant difference between the groups (P=0.021). Regarding chromosomal abnormalities, 16.7% of cases in the early-onset group tested positive, compared to 8.3% in the late-onset group. However, this difference was not statistically significant (P=0.246) (Table 1).

The perinatal ultrasound characteristics of VM differed significantly between the early-onset and late-onset groups. The incidence of isolated VM was significantly higher in the late-onset group compared to the early-onset group (70.8% vs. 29.6%, P<0.001). Conversely, non-isolated VM was more prevalent in the early-onset group (70.4% vs. 29.2%). Laterality also demonstrated a significant difference between the

Table 1. Characteristics of the study population

	Early-onset group (n=54)	Late-onset group (n=48)	P value
Maternal age (year)			0.178[a]
<35	6 (11.1%)	10 (20.8%)	
>35	48 (88.9%)	38 (79.2%)	
BMI (kg/m$^{2)}$	31.4±17.2	29.8±6.3	0.528[b]
Gravida	2 (3)	2 (2)	**0.036[c]**
Parity	1 (2)	1 (1)	0.058[c]
Nulliparous	17 (31.5%)	24 (50%)	0.057[a]
In vitro fertilization	0 (0%)	0 (0%)	NA
Gestational age at initial diagnosis (weeks)	21 (3)	28 (5)	**<0.001[c]**
Ventricular size (mm)	13.6±6.1	12.9±4.1	0.443[b]
Additional abnormalities on MRI	17 (35.4%)	9 (16.7%)	**0.030[a]**
Cytogenetic testing			**0.021[a]**
Absent	25 (46.3%)	34 (70.8%)	
Present	29 (53.7%)	14 (29.2%)	
Chromosomal abnormalities			0.246[d]
Negative	45 (83.3%)	44 (91.7)	
Positive	9 (16.7%)	4 (8.3)	
TORCH			0.552[a]
Negative	52 (96.3%)	45 (93.8%)	
Positive	2 (3.7%)	3 (6.3%)	

Data are shown as mean±standard deviation or median (interquartile range) or n (%) where appropriate. BMI=Body mass index, TORCH=Toxoplasma gondii, other, rubella virus, cytomegalovirus and herpes simplex virus, MRI=Magnetic resonance imaging, NA=Not applicable.

P<0.05 indicates a significant difference and statistically significant P-values are in bold

[a]Pearson chi-square, [b]Student t-test, [c]Mann Whitney-U test, [d]Fisher's exact test

groups, with unilateral VM being more frequent in the late-onset group (60.4% vs. 27.8%), while bilateral VM was more common in the early-onset group (72.2% vs. 39.6%, P=0.002). Similarly, asymmetric VM was more prevalent in the late-onset group (68.8% vs. 46.3%), whereas the early-onset group had a higher proportion of symmetric VM (53.7% vs. 31.2%, P=0.037). Regarding intrauterine changes, intrauterine regression was more commonly observed in the late-onset group (29.2% vs. 16.7%), while intrauterine progression was higher in the early-onset group (46.3% vs. 60.4%). Additionally, intrauterine stabilization was significantly more frequent in the early-onset group (37% vs. 10.4%, P=0.007). No significant differences were found between the groups in terms of transience (P=0.092), severity of VM (P=0.547), or amniotic fluid status (P=1.000). These findings suggest that early-onset VM is more frequently associated with non-isolated, bilateral, and symmetric forms, whereas late-onset VM is more likely to be isolated, unilateral, and asymmetric (Table 2).

Within the scope of the study, a total of 31 pregnant women accepted pregnancy termination. In terms of pregnancy outcomes, the termination rate was significantly higher in the early-onset group (44.4% vs. 14.6%, P=0.001), while the live birth rate was significantly higher in the late-onset group (85.4% vs. 55.6%). Although there was no significant difference

Table 2. Perinatal ultrasound characteristics of VM in the early-onset and late-onset groups

	Early-onset group (n=54)	Late-onset group (n=48)	P value
Isolated or not			**<0.001[a]**
Isolated	16 (29.6%)	34 (70.8%)	
Non-isolated	38 (70.4%)	14 (29.2%)	
Laterality			**0.002[a]**
Unilateral	15 (27.8%)	29 (60.4%)	
Bilateral	39 (72.2%)	19 (39.6%)	
Symmetry			**0.037[a]**
Symmetric	29 (53.7%)	15 (31.2%)	
Asymmetric	25 (46.3%)	33 (68.8%)	
Transience			0.092[a]
Transient	13 (24.1%)	19 (39.6%)	
Non-transient	41 (75.9%)	29 (60.4%)	
Intrauterine changes			**0.007[a]**
Intrauterine regression	9 (16.7%)	14 (29.2%)	
Intrauterine progression	25 (46.3%)	29 (60.4%)	
Intrauterine stabilization	20 (37%)	5 (10.4%)	
Severity of VM			0.547[a]
Mild	28 (51.9%)	30 (62.5%)	
Moderate	8 (14.8%)	6 (12.5%)	
Severe	18 (33.3%)	12 (25%)	
Amnion fluid			1[a]
Normal	48 (88.9%)	44 (91.7%)	
Oligohydramnios	1 (1.9%)	0 (0%)	
Polyhydramnios	5 (9.3%)	4 (8.3%)	

Data are shown as n (%). VM=Ventriculomegaly

P<0.05 indicates a significant difference and statistically significant P-values are in bold.

[a]Pearson chi-square

between the groups in terms of gestational week, prematurity rate, birth weight and cesarean section rates (P>0.05). Apgar scores at the 1st and 5th minute were significantly higher in the late-onset group (P=0.028 and P=0.042) (Table 3).

When additional anomalies detected by prenatal ultrasonography were compared, the proportion of cases without additional anomalies was significantly higher in the late-onset group (70.8% vs. 29.6%, P<0.001). Central nervous system (CNS) anomalies were more common in the early-onset group (44.4% vs. 18.8%), but there was no significant difference between the groups in terms of non-CNS anomalies (7.4% vs. 6.3%, P>0.05). However, multisystem anomalies were more common in the early-onset group (18.5% vs. 4.2%), suggesting that early-onset cases may be associated with more complex fetal anomalies (Table 4).

DISCUSSION

In this study, the effects of fetal VM on prenatal ultrasonographic findings, neonatal outcomes and perinatal

Table 3. Pregnancy outcomes

	Early-onset group (n=54)	Late-onset group (n=48)	P value
Pregnancy outcomes			**0.001[a]**
Live birth	30 (55.6%)	41 (85.4%)	
Termination of pregnancy	24 (44.4%)	7 (14.6%)	
Live birth analysis	**n= 30**	**n=41**	
Gestational age at delivery (week)	38 (2)	38 (2)	0.421[b]
Prematurity (<37 weeks)	5 (16.7%)	5 (12.2%)	0.512[a]
Birth weight (gram)	2720±966	3014±555	0.111[c]
Cesarean section	20 (66.7%)	27 (65.9%)	0.943[a]
Apgar score at 1st minute	8 (3)	9 (1)	**0.028[b]**
Apgar score at 5th minute	9 (2)	10 (1)	**0.042[b]**
CAPO	9 (30%)	10 (24.4%)	0.538[a]
NICU admission	8 (26.7%)	9 (22%)	0.531[a]
Transient tachypnea of the newborn	4 (13.3%)	1 (2.4%)	0.151[d]
Neonatal sepsis	0 (0%)	0 (0%)	NA
Respiratory distress syndrome	5 (16.7%)	4 (9.8%)	0.471[d]
Continuous positive airway pressure	4 (13.3%)	3 (7.3%)	0.435[d]
Mechanical ventilation	2 (6.7%)	2 (4.9%)	1[d]
Phototherapy for neonates	4 (13.3%)	1 (2.4%)	0.151[d]
Necrotizing enterocolitis	0 (0%)	1 (2.4%)	1[d]
Intraventricular hemorrhage	0 (0%)	0 (0%)	NA
Seizure history	1 (3.3%)	0 (0%)	0.412[d]

Data are shown as mean±standard deviation or median (interquartile range) or n (%) where appropriate. CAPO=Composite adverse perinatal outcome, NICU=Neonatal intensive care unit, NA=Not applicable.

P<0.05 indicates a significant difference and statistically significant P-values are in bold

[a]Pearson chi-square, [b]Student t-test, [c]Mann Whitney-U test, [d]Fisher's exact test

prognosis were compared between early and late onset groups. In this study, we found that early-onset fetal VM was more frequently associated with additional anomalies, bilateral, symmetric involvement, and progressive ventricular enlargement, whereas late-onset VM was more commonly isolated, unilateral, asymmetric and had a higher likelihood of spontaneous regression. The higher rate of chromosomal abnormalities and MRI-detected additional anomalies in the early-onset group supports the hypothesis that early-onset VM is often part of a broader pathological process rather than an isolated finding. Furthermore, pregnancy termination was significantly more common in the early-onset group, while live birth rates were higher in late-onset cases, suggesting a better perinatal prognosis for late-onset VM. Additionally, Apgar scores at both the 1st and 5th minutes were significantly higher in the late-onset group, reinforcing the association between early-onset VM and poorer neonatal outcomes. These findings highlight the importance of distinguishing between early- and late-onset VM in clinical practice to better predict prenatal progression and neonatal prognosis.

Previous studies suggest that early- and late-onset VM have distinct etiological and clinical courses. Early-onset fetal VM has been associated with a higher prevalence of structural and chromosomal anomalies, contributing to a less favorable perinatal

Table 4. Associated abnormalities found on prenatal ultrasound

	Early-onset group (n=54)	Late-onset group (n=48)	P value
Absent	16 (29.6%)	34 (70.8%)	**<0.001**[a]
CNS	24 (44.4%) Agenesis of the corpus callosum (n=5) Dysgenesis of the corpus callosum (n=2) Open spina bfida (n=11) Z-shaped brain stem (n=1) Dandy Walker malformation (n=1) Vein of Galen aneurysmal (n=1) Dural sinus thrombosis (n=1) Interhemispheric cyst (n=1) Hypoplastic cerebellum (n=1)	9 (18.8%) Agenesis of the corpus callosum (n=4) Open spina bfida (n=4) Intraventricular hemorrhage (n=1)	
Non-CNS	4 (7.4%) Right aortic arch (n=1) Single umbilical artery (n=1) Diaphragmatic hernia (n=1) ARSA (n=1)	3 (6.3%) HL-FL shortening (n=1) Diaphragmatic hernia (n=1) Bilateral pyelectasis (n=1)	
Multiple systems	10 (18.5%) Bilateral renal agenesis and diastematomyelia (n=1) Midline syndactyly and cranial irregularities (n=1) Megacystis, rhombencephalosynapsis and single umbilical artery (n=1) Bilateral pelviectasis+cleft lip and palate (n=1) Unilateral pyelectasis+ inlet VSD+ right aortic arch (n=1) Cleft lip, absent stomach, hypoplastic cerebellum, pericardial effusion, low-set ears (n=1) Lymphatic drainage disorder, Rocker bottom, syndactyly (n=1) Corpus callosum dysgenesis, VSD, Mitral atresia, persistent left superior vena cava, aortic hypoplasia (n=1) Bilateral pes equinovarus, small bladder, pericardial effusion (n=1) Absent CSP, cystic hygroma, skin edema, microphthalmia, pleural effusion, two arteries observed, absent stomach, clenched hands, bilateral pes equinovarus (n=1)	2 (4.2%) Diaphragmatic hernia, Tetralogy of Fallot, right atrial aneurysm, cleft lip/palate (n=1) Dysmorphic corpus callosum, cleft lip, hypertelorism, congenital hepatic fibrosis, generalized ascites, autosomal recessive polycystic kidney disease, severe micromelia, fetal dextrocardia, inlet VSD, hypoplastic aorta (n=1)	

Data are expressed as n (%). ARSA=Aberrant right subclavian artery, CNS=Central nervous system, CSP=Cavum septi pellucidi, FL=femur length, HL=humerus length, VSD=ventricular septal defect

prognosis [4]. Consistent with this, our study found that additional anomalies were significantly more prevalent in early-onset cases compared to late-onset cases (70.4% vs. 29.2%, P<0.001). In a large-scale study, Bhatia *et al*. reported that aneuploidy, agenesis of the corpus callosum, spina bifida, and Dandy-Walker malformation were among the most common anomalies in early-onset VM, whereas late-onset cases were more often isolated and associated with aqueductal stenosis, cerebral hemorrhage, and porencephaly [2]. In another study examining the etiology of fetal VM in detail, Pappas *et al*. [7] reported that early-onset cases were generally associated with neurodevelopmental malformations and chromosomal anomalies, whereas late-onset VM was mostly isolated and had a better prognosis. Our findings align with these results, reinforcing that early-onset VM is frequently part of a broader pathological process, whereas late-onset VM is more likely to be an isolated, potentially regressive condition.

Wang *et al*. [4] conducted a study comparing the ultrasonographic characteristics of early- and late-onset VM cases and reported significant differences between the two groups. According to their findings, isolated, unilateral, asymmetric involvement is more common in late-onset VM, whereas bilateral, symmetric involvement and additional structural anomalies are more common in early-onset cases. Our study is largely consistent with these results. The rate of bilateral and symmetric involvement was significantly higher in early-onset cases (P=0.037), whereas late-onset VM cases were more often unilateral and asymmetric. Furthermore, Wang *et al*. [4] showed that the rate of intrauterine progression was significantly higher (P=0.03) in early-onset mild VM cases. It has also been reported in the literature that early-onset VM is more likely to progress and may have a more unfavorable neurodevelopmental prognosis [8]. Similarly, in our study, it was found that ventricular enlargement tended to progress in early-onset VM, and this increased poor pregnancy outcomes.

In our study, the rates of additional anomalies in the early-onset VM group were significantly higher by both ultrasonography (70.4% vs. 29.2%, P<0.001) and MRI (35.4% vs. 16.7%, P=0.030). As reported in the literature, MRI is a superior method compared to ultrasonography in detecting corpus callosum anomalies, posterior fossa defects, and migration disorders [9, 10]. The most common CNS anomalies in early-onset cases were agenesis of the corpus callosum, open spina bifida, and brainstem anomalies, suggesting that early-onset VM may be part of a broader spectrum of neurodevelopmental disorders rather than an isolated finding. Similarly, multisystem anomalies affecting the renal, cardiac, and skeletal systems were more frequent in early-onset cases, with severe structural abnormalities such as bilateral renal agenesis, diastematomyelia, and megacystis, further supporting the poor fetal prognosis in this group. Consistent with our findings, Wang *et al*. [4] also reported that CNS and multisystem anomalies were significantly more prevalent in the early-onset VM group compared to late-onset cases. These similarities between studies further emphasize the importance of comprehensive prenatal evaluation, including MRI and genetic testing, in early-onset VM cases to better predict prognosis and optimize perinatal management.

In addition, in a large-scale study by Carta *et al*. [11], it was emphasized that neurodevelopmental prognosis was generally favorable in isolated cases of VM, but cases with large ventricular diameter (>15 mm) or progression carried a higher risk. Another important study by Ali *et al*. [12] examined the long-term neurodevelopmental outcomes of fetal VM cases. In this study, it was reported that the majority of isolated and mild VM cases had normal neurodevelopmental outcomes, but progressive VM was associated with severe motor and cognitive sequelae. Similarly, our study demonstrated that early-onset VM cases exhibited a greater tendency for ventricular enlargement and progression over time. This progressive nature of early-onset VM was associated with poorer pregnancy outcomes, including significantly lower live birth rates (55.6% vs. 85.4%, P=0.001) and a higher frequency of pregnancy termination compared to late-onset cases. Furthermore, neonatal outcomes were also worse in the early-onset group, as reflected by significantly lower Apgar scores at both the 1st and 5th minutes. These findings highlight the importance of monitoring ventricular dynamics in early-onset VM, as progressive ventricular dilation may influence clinical decision-making and pregnancy management. These data suggest that, especially late-onset and isolated cases, offer a better prognosis, and follow-up protocols should be individualized accordingly.

VM is associated with most common chromoso-

mal abnormalities, particularly trisomy 21, trisomy 18, and sex chromosome anomalies [13]. The frequency of chromosomal anomaly in cases of fetal VM varies depending on factors including the degree of ventricular enlargement, the presence of additional structural anomalies, and the onset time of VM. In the literature, while the rate of chromosomal anomaly varies between 3-5% in isolated cases of VM, this rate increases up to 17-20% in cases accompanied by additional anomalies [14]. Bhatia *et al*. [2] reported that chromosomal abnormalities were more common in the early-onset VM group and the aneuploidy rate in this group was 13.4%. Wang *et al*. [4] also supported these findings and reported that early-onset VM was generally associated with genetic syndromes, whereas late-onset VM cases had mostly normal chromosomal structure. In our study, the rate of chromosomal anomaly was found to be higher in the early-onset VM group (16.7% vs. 8.3%), but the difference was not statistically significant (P=0.246). In terms of prenatal genetic evaluation, cytogenetic testing and other genetic tests are recommended, especially in cases of VM accompanied by additional anomalies or showing progression. In our study, the rate of cytogenetic testing was found to be significantly higher in the early-onset VM group (53.7% vs. 29.2%, P=0.021), suggesting that this group should be evaluated more in terms of genetic analysis.

The decision to terminate pregnancies with fetal VM varies depending on the degree of ventricular enlargement, progression, presence of additional anomalies and chromosomal abnormalities [15]. In the literature, it has been reported that pregnancy termination rates are higher in cases of severe VM (>15 mm) and progressive VM, whereas isolated and mild cases are more frequently continued [16]. In a study by Chervenak *et al*. [17], 26% of pregnancies diagnosed with VM resulted in elective abortion. In another study by Vintzileos *et al*. [18], 20% induced abortion was reported in similar cases. It has been emphasized that termination rates are higher, especially in cases of VM associated with early onset and multisystem anomalies. In our study, the termination rate was significantly higher in the early-onset VM group (44.4% vs. 14.6%, P=0.001). This finding suggests that early-onset VM is usually associated with more severe fetal pathologies and families may be more prone to termination decision in this situation. Similarly, Wang *et al*. [4] reported that pregnancy termination rates were higher in the early-onset VM group, whereas late-onset and isolated cases were more frequently continued. These findings emphasize that the decision for termination should be based not only on ventricular size but also on the presence of additional anomalies, progression in ventricular diameter, and genetic outcomes. It is especially important to evaluate VM cases with early onset and associated with multisystem anomalies more carefully and to inform families in detail during prenatal counseling.

The less favorable prognosis observed in early-onset VM may be explained by its occurrence during critical stages of fetal neurodevelopment, when neuronal proliferation, migration, and cortical organization are highly active. Disruption of these processes in the first half of gestation is often linked to underlying genetic or complex structural anomalies, which may affect multiple organ systems [11]. In contrast, late-onset VM generally develops after key neurodevelopmental milestones, frequently due to mechanical obstruction of cerebrospinal fluid pathways or mild intraventricular hemorrhage, and is therefore more likely to be isolated, non-progressive, and associated with a favorable prognosis [2]. These mechanistic differences have direct implications for prenatal counseling and management. In early-onset VM, the higher likelihood of associated anomalies and ventricular progression justifies a more intensive monitoring strategy, including comprehensive neurosonography, fetal MRI, and genetic evaluation. Conversely, late-onset isolated cases, particularly those showing stability or regression, can be managed with less intensive surveillance, and counseling can emphasize their generally favorable outlook. By tailoring follow-up and counseling strategies to the timing of onset, ventricular dynamics, and associated findings, clinicians can provide more accurate prognostic information and optimize perinatal outcomes.

Strengths and Limitations

Building on these observations, our study provides a comprehensive evaluation of early- and late-onset fetal VM, comparing their prenatal ultrasound characteristics, pregnancy outcomes, and neonatal prognosis. One of the key strengths of our study is its detailed assessment of ventricular dynamics, emphasizing the progressive nature of early-onset VM, which has been less frequently highlighted in previous research. The

use of both prenatal ultrasonography and fetal MRI allowed for a more precise evaluation of associated anomalies, enhancing the reliability of our findings. Furthermore, by comparing pregnancy outcomes between the two groups, our study contributes valuable clinical insights into the management of VM, particularly in cases with progressive ventricular enlargement.

However, some limitations should be acknowledged. First, this study was conducted in a single center, which may limit the generalizability of the findings to broader populations. Additionally, while we analyzed the association between VM and chromosomal abnormalities, not all cases underwent invasive genetic testing, which may have affected the identification of underlying genetic conditions. Another limitation is that our study primarily focuses on prenatal findings and short-term neonatal outcomes; therefore, long-term neurodevelopmental follow-up is needed to further assess the prognostic implications of early- versus late-onset VM. Despite these limitations, our study provides clinically significant findings that reinforce the importance of differentiating early- and late-onset VM in prenatal counseling and pregnancy management. Future studies with larger, multi-center cohorts and long-term follow-up data would further clarify the impact of ventricular progression on neurodevelopmental outcomes and refine clinical management strategies.

CONCLUSION

This study highlights the clinical differences between early- and late-onset fetal VM. Early-onset VM was more frequently associated with progressive ventricular enlargement, bilateral involvement, and additional anomalies, whereas late-onset VM was more commonly isolated with a higher likelihood of spontaneous resolution. Pregnancy outcomes were also poorer in early-onset cases, emphasizing the need for closer prenatal monitoring, including detailed ultrasound, fetal MRI, and genetic evaluation. Future studies with long-term follow-up are needed to further refine clinical management strategies.

Ethics Approval and Consent to Participate

This study was approved by the Ankara Etlik City Hospital Scientific Research Evaluation and Ethics Committee (Decision No: AEŞH-BADEK-2025-0259; date: 26.03.2025). All procedures were conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. Informed consent was waived because of the retrospective nature of the study. All data were anonymized, and participant confidentiality was strictly maintained.

Data Availability

All data generated or analyzed during this study are included in this published article. The data that support the findings of this study are available on request from the corresponding author, upon reasonable request.

Authors' Contribution

Study Conception: RD; Study Design: RD; Supervision: SC; Funding: N/A; Materials: GK; Data Collection and/or Processing: MAO, DDB, HA, EB; Statistical Analysis and/or Data Interpretation: AAF; Literature Review: RD; Manuscript Preparation: RD; and Critical Review: RD, SC.

Conflict of Interest

The author(s) disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The author(s) disclosed that they did not receive any grant during the conduction or writing of this study.

Acknowledgments

The author(s) have no acknowledgments to declare.

Generative Artificial Intelligence Statement

The author(s) declare that no artificial intelligence-based tools or applications were used during the preparation process of this manuscript. The all content of the study was produced by the author(s) in accordance with scientific research methods and academic ethical principles.

Editor's Note

All statements made in this article are solely those of the authors and do not represent the views of their

affiliates or the publisher, editors, or reviewers. Any claims made by any product or manufacturer that may be evaluated in this article are not guaranteed or endorsed by the publisher.

REFERENCES

1. Society for Maternal-Fetal Medicine (SMFM); Fox NS, Monteagudo A, Kuller JA, Craigo S, Norton ME. Mild fetal ventriculomegaly: diagnosis, evaluation, and management. Am J Obstet Gynecol. 2018;219(1):B2-B9. doi: 10.1016/j.ajog.2018.04.039.
2. Bhatia A, Thia EWH, Bhatia A, Ruochen D, Yeo GSH. Sonographic spectrum and postnatal outcomes of early-onset versus late-onset fetal cerebral ventriculomegaly. J Matern Fetal Neonatal Med. 2022;35(23):4612-4619. doi: 10.1080/14767058.2020.1857358.
3. Giorgione V, Haratz KK, Constantini S, Birnbaum R, Malinger G. Fetal cerebral ventriculomegaly: What do we tell the prospective parents? Prenat Diagn. 2022;42(13):1674-1681. doi: 10.1002/pd.6266.
4. Wang X, Zhang S, Wang J, Zhang S, Feng L, Wu Q. Follow-up outcome analysis of 324 cases of early-onset and late-onset mild fetal ventriculomegaly: a retrospective cohort study. Eur J Med Res. 2024;29(1):128. doi: 10.1186/s40001-024-01709-7.
5. Rosseau GL, McCullough DC, Joseph AL. Current prognosis in fetal ventriculomegaly. J Neurosurg. 1992;77(4):551-555. doi: 10.3171/jns.1992.77.4.0551.
6. Winkler A, Tölle S, Natalucci G, Plecko B, Wisser J. Prognostic Features and Long-Term Outcome in Patients with Isolated Fetal Ventriculomegaly. Fetal Diagn Ther. 2018;44(3):210-220. doi: 10.1159/000480500.
7. Pappas A, Adams-Chapman I, Shankaran S, et al; Eunice Kennedy Shriver National Institute of Child Health and Human Development Neonatal Research Network. Neurodevelopmental and Behavioral Outcomes in Extremely Premature Neonates With Ventriculomegaly in the Absence of Periventricular-Intraventricular Hemorrhage. JAMA Pediatr. 2018;172(1):32-42. doi: 10.1001/jamapediatrics.2017.3545.
8. Horgos B, Mecea M, Boer A, et al. White matter changes in fetal brains with ventriculomegaly. Front Neuroanat. 2023;17:1160742. doi: 10.3389/fnana.2023.1160742.
9. Kyriakopoulou V, Vatansever D, Elkommos S, et al. Cortical overgrowth in fetuses with isolated ventriculomegaly. Cereb Cortex. 2014;24(8):2141-2150. doi: 10.1093/cercor/bht062.
10. Di Mascio D, Sileo FG, Khalil A, et al. Role of magnetic resonance imaging in fetuses with mild or moderate ventriculomegaly in the era of fetal neurosonography: systematic review and meta-analysis. Ultrasound Obstet Gynecol. 2019;54(2):164-171. doi: 10.1002/uog.20197.
11. Carta S, Kaelin Agten A, Belcaro C, Bhide A. Outcome of fetuses with prenatal diagnosis of isolated severe bilateral ventriculomegaly: systematic review and meta-analysis. Ultrasound Obstet Gynecol. 2018;52(2):165-173. doi: 10.1002/uog.19038.
12. Ali F, Gurung F, Nanda S, et al. Perinatal and neurodevelopmental outcomes of fetal isolated ventriculomegaly: a systematic review and meta-analysis. Transl Pediatr. 2024;13(4):555-574. doi: 10.21037/tp-23-548.
13. Zhao D, Cai A, Wang B, Lu X, Meng L. Presence of chromosomal abnormalities in fetuses with isolated ventriculomegaly on prenatal ultrasound in China. Mol Genet Genomic Med. 2018;6(6):1015-1020. doi: 10.1002/mgg3.477.
14. Huang RN, Chen JY, Pan H, Liu QQ. Correlation between mild fetal ventriculomegaly, chromosomal abnormalities, and copy number variations. J Matern Fetal Neonatal Med. 2022;35(24):4788-4796. doi: 10.1080/14767058.2020.1863941.
15. Chu N, Zhang Y, Yan Y, Ren Y, Wang L, Zhang B. Fetal ventriculomegaly: Pregnancy outcomes and follow-ups in ten years. Biosci Trends. 2016;10(2):125-132. doi: 10.5582/bst.2016.01046.
16. Hudgins RJ, Edwards MS, Goldstein R, et al. Natural history of fetal ventriculomegaly. Pediatrics. 1988;82(5):692-697.
17. Chervenak FA, Duncan C, Ment LR, et al. Outcome of fetal ventriculomegaly. Lancet. 1984;2(8396):179-181. doi: 10.1016/s0140-6736(84)90477-x.
18. Vintzileos AM, Campbell WA, Weinbaum PJ, Nochimson DJ. Perinatal management and outcome of fetal ventriculomegaly. Obstet Gynecol. 1987;69(1):5-11.