Journal of Pediatric Academy

Original Article

Year: 2025 Volume: 6 Issue: 2
Doi: 10.4274/jpea.2025.431
J Pediatr Acad 2025; 6(2): 69-73

Clinical Indications and Diagnostic Yield of Transfontanelle Ultrasound in 346 Infants: A Retrospective Single-Center Study

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Article Information

Article Type: Original Articles
Article Group: Pediatric Neurology

Received: 12.05.2025
Accepted: 18.06.2025
Epub: 23.06.2025
Available Online: 03.07.2025

Cite this article as: *Öztürk S, Özgül Gümüş Ü. Clinical indications and diagnostic yield of transfontanelle ultrasound in 346 infants: a retrospective single-center study. J Pediatr Acad. 2025; 6(2): 69-73*

Abstract

Transfontanelle ultrasonography (TFUSG) is a reliable and non-invasive imaging method used for early detection of cranial abnormalities during the neonatal and infant periods. This study aimed to evaluate the reasons for TFUSG requests, demographic features, and imaging findings in infants under one year of age. In this retrospective study, medical records of 346 infants who underwent TFUSG in the pediatric neurology outpatient clinic of a tertiary hospital between January 1, 2023, and December 31, 2024, were reviewed. Demographic data, TFUSG indications, and imaging findings were analyzed. The study included 346 infants, of whom 214 (61.8%) were male and 132 (38.2%) female, with a mean age of 3.06±2.4 months. A total of 60.1% of the infants were born prematurely. The most common indications for TFUSG were a history of prematurity and/or neonatal intensive care unit admission (56.6%), suspected seizures (20.8%), and clinical findings such as developmental delay, microcephaly, or macrocephaly (12.4%). TFUSG results revealed normal findings in 64.7% of cases, normal variants in 6.4%, and pathological findings in 28.9%. The most common pathologies included increased cerebrospinal fluid spaces (54%), germinal matrix hemorrhage (34%), and hydrocephalus (12%). Abnormal TFUSG findings were significantly more common in male infants, while no significant difference was found concerning gestational age. TFUSG is an effective imaging modality that contributes substantially to the diagnostic process in pediatric neurology outpatient settings. Further studies with larger cohorts are needed to standardize findings and improve diagnostic accuracy.

Keywords: Cranial imaging, prematurity, ultrasonography

Introduction

Transfontanelle ultrasonography (TFUSG) is an effective, safe, and non-invasive imaging technique used to evaluate the anatomy of the developing infant brain[1-3]. It is particularly valuable for assessing high-risk neonates and detecting cranial anomalies that may not appear on clinical examination. With this technique, brain structures can be visualized by applying a small ultrasound probe over the anterior or posterior fontanelle[1]. The procedure is painless and generally does not require sedation or anesthesia.

TFUSG is widely used for the evaluation of premature infants at risk of intraventricular hemorrhage, as well as

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for the diagnosis and follow-up of cranial pathologies such as hydrocephalus, subdural hematomas, and effusions. It also plays a useful role in monitoring various neurological conditions[4]. Due to its practical nature, it is frequently employed in neonatal and pediatric neurology outpatient clinics.

The main advantages of TFUSG include its portability, its ability to be performed at the bedside, the absence of radiation exposure, and its cost-effectiveness. However, the technique also has several limitations, such as reduced usefulness after fontanelle closure, occasionally insufficient anatomical detail, and variability in image quality depending on the device and the operator's experience[5,6].

This study aimed to evaluate the indications for TFUSG, demographic characteristics, and cranial imaging findings in infants aged under one year who underwent the procedure in a pediatric neurology outpatient clinic.

Highlights

- Transfontanelle ultrasonography (TFUSG) is a safe, effective, and non-invasive method for evaluating the infant brain.
- TFUSG was most frequently performed during the first postnatal month (33.5%), highlighting the importance of early cranial imaging.
- In the outpatient setting, TFUSG was commonly used to assess macrocephaly, developmental delay, and suspected seizures.
- A total of 346 infants under one year of age underwent TFUSG in a pediatric neurology outpatient clinic.
- Abnormal findings were detected in 28.9% of cases, including enlarged cerebrospinal fluid spaces, germinal matrix hemorrhage, and hydrocephalus.

Materials and Methods

This retrospective study reviewed the medical records of infants under 12 months of age who were referred for TFUSG to the pediatric neurology outpatient clinic at Kayseri City Hospital, Türkiye, between January 1, 2021, and December 31, 2022. The study commenced after the Non-Interventional Clinical Research Ethics Committee of Kayseri City Hospital granted approval (approval no. 2025/367, date: 11.03.2025). Written informed consent was obtained from the family for the publication of this case report.

Demographic data, including age, sex, gestational age, and clinical indications for TFUSG, were collected and analyzed. In the majority of cases, TFUSG was performed on the same day as the outpatient clinic visit.

Patients were categorized into five age groups based on their age at the time of the TFUSG request: 0-1 month, 1-3 months, 3-6 months, 6-9 months, and 9-12 months. Only examinations performed at our institution were included; TFUSG studies conducted at external centers were excluded.

All TFUSG examinations were conducted by experienced pediatric radiologists using a high-resolution ultrasound system equipped with an 11 MHz sector transducer, optimized for detailed pediatric neuroimaging.

TFUSG findings were classified into three categories: normal, normal variants, and pathological. Normal findings included symmetric lateral ventricles, normal parenchymal echogenicity, and age-appropriate intracranial structures. Normal variants were defined as benign anatomical deviations not associated with clinical or radiological signs of increased intracranial pressure, including cavum septum pellucidum (CSP), mild ventricular asymmetry, isolated septum pellucidum cysts (<10 mm), and mildly widened subarachnoid spaces (≤5 mm). Pathological findings included hydrocephalus, germinal matrix hemorrhage (GMH), congenital malformations, and/or cerebrospinal fluid (CSF) space enlargement exceeding 5 mm with accompanying mass effect or ventricular dilation.

In a subset of patients, additional neuroimaging with magnetic resonance imaging (MRI) or computed tomography (CT) was performed based on clinical indications such as abnormal TFUSG findings or ongoing neurological concerns. As MRI or CT was performed only in selected cases, the classification of findings was based solely on TFUSG results.

Statistical Analysis

Statistical analyses were performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation, and categorical variables as counts and percentages (%). The chi-square test was used to assess associations between categorical variables. A p-value <0.05 was considered statistically significant.

Results

A total of 373 infants were initially evaluated for inclusion in the study. However, nine patients did not have scheduled appointments , seven underwent the procedure at external centers, six had incomplete medical records, and five were excluded due to inadequate anterior fontanelle opening. As a result, the final study population comprised 346 infants. The recruitment and study flow are presented in **Figure 1**.

Among the 346 patients included, boys constituted 61.8% (n=214), and girls 38.2% (n=132). The patients' mean age was 3.06±2.4 months (minimum 5 days, maximum 12 months). TFUSG was most frequently performed on infants aged 0-1 month at 33.5%. Analysis showed that 52.3% of the patients were born preterm with the majority of this group consisting of late preterm (34-37 weeks) infants. Low birth weight (<2500 grams) was detected in 43.6% of the infants. Head circumference evaluation revealed microcephaly in 6.1% (n=21) and macrocephaly in 9.2% (n=32). The most common reasons for requesting TFUSG were prematurity (32.7%), a history of neonatal intensive care unit (NICU) admission (24.6%), and seizure suspicion (20.5%). Other indications included antenatal cystic lesions (10.1%), abnormal head circumference (8.4%), and developmental delay (4%). **Table 1** summarizes the demographic and clinical characteristics of the study population.

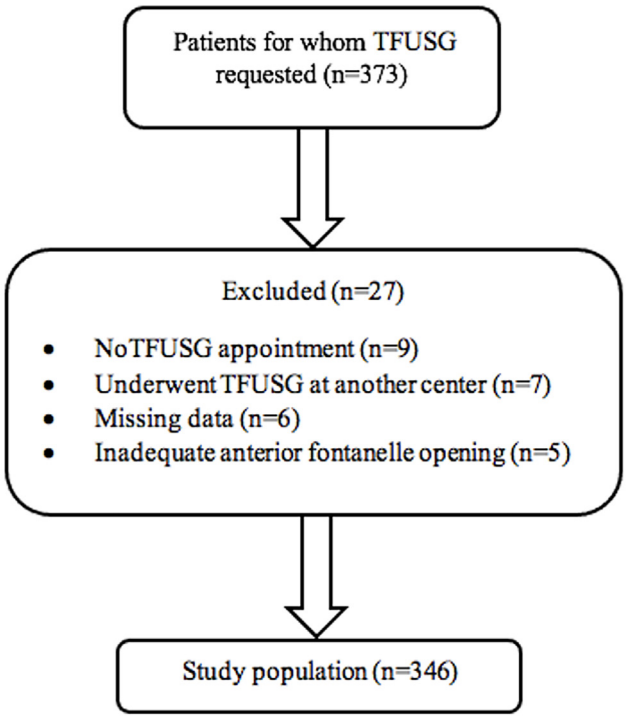

Figure 1. Flowchart of patient recruitment and study inclusion
TFUSG: Transfontanelle ultrasonography

Normal TFUSG findings were observed in 62.4% of the cases, and normal variants, including benign enlargement of the subarachnoid space, mild ventricular asymmetry, isolated septum pellucidum cyst, or CSP, were observed in 6.4%. Pathological findings were identified in 108 infants (31.2%). The most frequently observed abnormality was enlargement of CSF spaces (n=56, 51.9%), typically characterized by widened extracerebral spaces or ventriculomegaly that do not meet the criteria for hydrocephalus.

GMH was the second most common pathology, detected in 38 cases (35.2%). Most GMH cases were low-grade (grade I-II) and typically associated with prematurity. Several patients demonstrated coexisting mild ventricular dilation. Hydrocephalus was diagnosed in 14 infants (13%), most of whom presented with macrocephaly or rapidly increasing head circumference. These cases were referred for further imaging and specialist evaluation, some underwent neurosurgical intervention, including shunt placement.

Follow-up neuroimaging with brain MRI or cranial CT was performed in 81 of 346 patients (23.4%), primarily due to abnormal TFUSG findings or persistent clinical concerns. In 69 of these cases (85.2%), TFUSG findings were confirmed by MRI/CT, including diagnoses of GMH, hydrocephalus, or structural anomalies. Minor discrepancies were observed in 12 cases (14%), such as underestimation of ventricular size, or identification of subtle white matter abnormalities not detected on TFUSG. No clinically significant misdiagnoses were identified.

Statistical analysis revealed a significant association between abnormal TFUSG findings and male sex (p=0.002) as well as prematurity (p=0.029). Notably,

Table 1.
Demographic and clinical characteristics of the study population (n=346, %)

Variable	Category	n	Percentage (%)
Gender	Male	214	61.8%
	Female	132	38.2%
Age at time of TFUSG	0-1 months	116	33.5%
	1-3 months	107	31%
	3-6 months	88	25.4%
	6-9 months	28	8.1%
	9-12 months	7	2%
Gestational week	Premature (<37 weeks)	181	52.3%
	Extreme preterm (<28 weeks)	16	4.6%
	Very preterm (28≤32 weeks)	30	8.7%
	Moderate preterm (32≤34 weeks)	49	14.1%
	Late preterm (34-37 weeks)	86	24.9%
	Term (≥37 weeks)	165	47.7%
Birth weight	<2500 g	151	43.6%
	2500-4000 g	185	53.5%
	>4000 g	10	2.9%
Head circumference	Microcephaly	21	6.1%
	Normocephaly	293	84.7%
	Macrocephaly	32	9.2%
Indications for requesting TFUSG	Prematurity	111	32.1%
	NICU history	85	24.6%
	Seizure suspicion	72	20.8%
	Antenatal cystic lesions	35	10.1%
	Micro--/macrocephaly	29	8.4%
	Developmental delay	14	4%
TFUSG results	Normal	216	62.4%
	Variant of normal	22	6.4%
	Pathological findings	108	31.2%
	Enlargement of CSF spaces	56	16.2%
	Hydrocephaly	13	4%
	Germinal matrix hemorrhage	35	11%

TFUSG: Transfontanelle ultrasonography, CSF: Cerebrospinal fluid, NICU: Neonatal intensive care unit

Table 2.
Demographic analysis of patients with abnormal TFUSG findings

		n	%	p
Gender	Female	29	26.4%	**0.002***
	Male	81	73.6%	
Gestational week	Premature	67	57%	**0.029***
	Mature	43	43%	

TFUSG: Transfontanelle ultrasonography

52.3% of infants with pathological findings were born preterm, and the late preterm group represented the largest proportion (**Table 2**).

Discussion

In this retrospective analysis of 346 infants referred for TFUSG, pathological findings were identified in approximately one-third (31.2%) of the cohort. This is consistent with previous studies reporting cranial abnormalities in 25-35% of similar pediatric populations undergoing ultrasound evaluation[7,8]. The most commonly observed pathology was the enlargement of CSF spaces, accounting for over half of the abnormal cases. While mild subarachnoid space widening (≤5 mm) is considered a benign variant, especially in preterm or low-birth-weight infants, enlargement exceeding 5 mm accompanied by features such as ventricular dilation, cortical thinning, or clinical symptoms was classified as pathological, following published normative data[9-11].

The most frequent indication for TFUSG was evaluation of infants with a history of prematurity and/or NICU admission. This is consistent with previous studies highlighting prematurity as the leading cause for cranial ultrasound referral in early infancy. Additional indications included suspected seizures, abnormal neurodevelopment, and atypical head circumference measurements. These patterns reflect the clinical utility of TFUSG in the initial evaluation of infants with diverse neurological risk factors in the outpatient setting[10,11].

GMH, detected in 35.2% of pathological cases, was primarily low-grade (grade I-II) and strongly associated with prematurity. This aligns with established evidence indicating that the fragile germinal matrix vasculature in preterm neonates predisposes them to hemorrhage, particularly within the first week of life[4,5]. Hydrocephalus was identified in 13% of abnormal cases, often presenting with macrocephaly or rapid increases in head circumference, necessitating neurosurgical evaluation in several instances.

Importantly, 23.4% of patients underwent additional neuroimaging (MRI or CT), primarily due to abnormal TFUSG findings or persistent clinical suspicion. Advanced imaging confirmed TFUSG findings in over 85% of these cases, particularly in the diagnosis of GMH, hydrocephalus, and structural anomalies. These results support the diagnostic reliability of TFUSG as an initial imaging modality. Minor discrepancies, such as the underestimation of ventricular size or subtle white matter abnormalities not detected on ultrasound, highlight the known limitations of ultrasound resolution and the continued role of MRI in comprehensive neuroimaging when clinically indicated[5,6].

The male-to-female ratio in our study was 1.62, within the range reported by previous literature (1.03 to 1.69)[10-13]. Notably, abnormal TFUSG findings were prevalent in male infants, which may reflect sex-specific vulnerabilities in early brain development. Male neonates, especially those born prematurely, are more susceptible to perinatal brain injury due to delayed oligodendrocyte maturation, increased sensitivity to hypoxia-ischemia, and lower levels of neuroprotective hormones such as estrogen[14]. This may explain the higher incidence of GMH and ventricular abnormalities observed in male infants.

Unlike many previous studies, in which term infants formed the majority, our cohort has a nearly equal distribution of preterm and term births. A significant proportion of the abnormalities, including GMH and CSF space enlargement, were observed among late preterm infants (34-37 weeks), suggesting that even marginal prematurity may warrant careful neuroimaging surveillance.

Overall, the findings reinforce the value of TFUSG in early diagnostic workup in pediatric neurology outpatient settings. While it cannot replace MRI in detecting subtle cortical or white matter abnormalities, TFUSG provides a rapid, safe, and cost-effective tool that can guide clinical decision-making, especially when used in conjunction with follow-up imaging in selected cases.

Study Limitations

This study has several limitations. First, its retrospective design may introduce selection and documentation biases, as the analysis relied on the accuracy and completeness of existing medical records. Second, the study was conducted at a single tertiary-care center, which may limit the generalizability of the findings to other populations or clinical settings, particularly in primary care. Third, although all TFUSG scans were interpreted by experienced pediatric radiologists, confirmatory imaging with MRI or CT was used to address the potential for inter-operator variability in TFUSG findings. This may have affected the accuracy of final diagnostic classifications. Lastly, long-term neurodevelopmental outcomes were not assessed, limiting our ability to determine the clinical significance and prognostic implications of some sonographic abnormalities.

Conclusion

TFUSG is a rapid, safe, and non-invasive imaging modality that provides valuable diagnostic information in infants under one year of age without the need for sedation or exposure to radiation. In this retrospective study, TFUSG enabled the identification of pathological cranial findings in approximately one-third of patients, underscoring its diagnostic utility in outpatient pediatric neurology settings. The higher prevalence of abnormalities in male infants and those born preterm may reflect underlying neurodevelopmental susceptibilities, which warrant further investigation. Given the high concordance between TFUSG and advanced imaging in a subset of cases, TFUSG can serve as an effective first-line modality for initial correlation, are needed to refine diagnostic criteira, validate normal variants, and establish standardized protocols for TFUSG interpretation in early childhood.

Ethics

Ethics Committee Approval: The study commenced after the Non-Interventional Clinical Research Ethics Committee of Kayseri City Hospital granted approval (approval no. 2025/367, date: 11.03.2025).

Informed Consent: Written informed consent was obtained from the family for the publication of this case report.

Footnotes

Authorship Contributions: Öztürk S: Concept, Data Collection or Processing, Analysis or Interpretation, Literature Search, Writing; Özgül Gümüş Ü: Concept, Data Collection or Processing, Analysis or Interpretation, Literature Search, Writing.

Conflict of Interest: The authors declare no conflicts of interest.

Financial Disclosure: The authors declared that this study received no financial support.

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