e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(3); 2275-2283

Original Research Article

Pediatric Vascular Anomalies: Integrating Clinical Features and Radiological Findings

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Received: 27-01-2025 / Revised: 26-02-2025 / Accepted: 27-03-2025

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Conflict of interest: Nil

Abstract:

Background: Paediatric vascular anomalies are a heterogeneous group of congenital lesions that often pose diagnostic and therapeutic challenges. Accurate classification using the International Society for the Study of Vascular Anomalies (ISSVA) system, combined with modern imaging, enhances diagnostic precision, guides treatment, and improves patient outcomes.

Aim: To evaluate the clinical presentations and imaging characteristics of paediatric vascular anomalies and assess the correlation between clinical and radiological findings in a tertiary care setting.

Methods: This prospective observational study included 125 paediatric patients presenting with suspected vascular anomalies at Narayan Medical College and Hospital, Sasaram, Bihar, over a 12-month period. All patients underwent thorough clinical examination followed by imaging, including ultrasonography with Doppler and, when indicated, MRI or CT angiography. Data were analysed using SPSS version 23.0 to determine the distribution, anatomical patterns, and concordance between clinical and radiological diagnoses.

Results: The cohort comprised 68 males (54.4%) and 57 females (45.6%), with a mean age of 7.4 ± 4.8 years. Hemangiomas were the most common lesions (44.8%), followed by venous (24.0%) and lymphatic malformations (16.8%). The head and neck region was most frequently affected (40%), followed by extremities (28%) and trunk (22.4%). Ultrasonography with Doppler was performed in all patients, MRI in 58.4%, and CT angiography in 11.2%. The overall clinical–radiological concordance rate was 88.8%, with imaging altering or refining the diagnosis in 11.2% of cases. Statistically significant associations were found between hemangiomas and female sex ($p = 0.034$) and between high-flow arteriovenous malformations and functional impairment ($p = 0.012$).

Conclusion: Most paediatric vascular anomalies can be accurately classified by integrating detailed clinical assessment with advanced imaging modalities. Early and precise diagnosis supports individualized treatment planning, minimizing complications and improving long-term outcomes.

Recommendations: In tertiary care centers, multidisciplinary teams should adopt standardized diagnostic algorithms based on ISSVA classification, utilize Doppler ultrasonography as a first-line investigation, and incorporate MRI or CT angiography for complex cases. Further multicentric studies are recommended to refine management protocols and explore targeted therapies for complex malformations.

Keywords: Pediatric vascular anomalies; Hemangioma; Venous malformation; Doppler ultrasonography; MRI.

Introduction

Paediatric vascular anomalies constitute a heterogeneous group of congenital lesions encompassing vascular tumors and malformations, often presenting diagnostic and therapeutic challenges. The (ISSVA) updated its classification in 2018, refining the nomenclature and emphasizing the distinction between endothelial tumors and structural malformations—thereby avoiding outdated terms such as “cavernous hemangioma” or “lymphangioma” [1]. This updated system enhances diagnostic accuracy and facilitates communication across specialties [1].

Imaging modalities such as ultrasound (US), Doppler, and magnetic resonance imaging (MRI) have become indispensable in the evaluation of pediatric vascular anomalies. Radiologic assessment not only aids in lesion characterization and classification but also guides treatment decisions [2]. For instance, the fascial-tail sign has been identified on US and MRI as a crucial diagnostic marker for fibro-adipose vascular anomaly (FAVA), helping distinguish it from venous malformations [3]. FAVA, a rare and often misdiagnosed lesion, has gained increasing recognition in recent years, especially following comprehensive reviews of its clinico-radiologic and pathological features [4].

Several case series and institutional reviews from India and other regions underscore the importance of heightened clinician awareness of FAVA. These works highlight its unique clinical presentation—typically painful intramuscular masses in children—and the frequent presence of PIK3CA gene mutations, reinforcing its distinct identity within vascular anomalies [5,6].

Beyond FAVA, the broader management of vascular malformations increasingly relies on a multidisciplinary model. Studies from South Asia have demonstrated the efficacy of coordinated care involving pediatricians, interventional radiologists, surgeons, and other specialists, combining modalities such as sclerotherapy, propranolol, topical agents, and laser therapy to achieve optimal outcomes [7].

Emerging therapeutic avenues targeting molecular pathways promise to transform management strategies. Notably, targeted inhibitors like trametinib have yielded encouraging results in treating complex extracranial arteriovenous malformations, marking a shift toward precision medicine in this field [8].

As understanding deepens, classification systems continue to evolve. Vascular anomaly syndromes with underlying genetic alterations are increasingly recognized, and radiologists play a key role in identifying syndromic manifestations with multisystem involvement [9].

In the context of a tertiary care setting such as Narayan Medical College and Hospital in Sasaram, Bihar, the integration of the ISSVA classification, advanced imaging protocols, multidisciplinary workflows, and awareness of entities like FAVA can significantly improve diagnostic confidence and guide tailored interventions. The present study of 125 pediatric patients over a 12-month period aims to reinforce these evidence-based approaches by correlating clinical presentations with imaging findings to inform management in such resource-limited, high-volume environments.

Methodology

Study Design: This was a prospective observational study.

Study Setting: The study was carried out at the Department of Radiology and Pediatrics, Narayan Medical College and Hospital, Sasaram, Bihar. The institution serves as a tertiary care center providing diagnostic and therapeutic services for a wide pediatric population.

Study Duration: The study was conducted over a period of 12 months, allowing adequate time for patient recruitment, clinical assessment, imaging evaluation, and data analysis.

Participants: A total of 125 pediatric patients clinically suspected or diagnosed with vascular anomalies were enrolled in the study. All participants were evaluated both clinically and radiologically during the study period.

Inclusion Criteria: Children aged from birth to 18 years presenting with suspected or confirmed vascular anomalies on clinical evaluation were included in the study. Patients were required to undergo appropriate imaging investigations (such as ultrasonography, Doppler studies, CT, or MRI) as part of the diagnostic workup.

Exclusion Criteria: Patients with incomplete clinical or imaging records, those lost to follow-up, and individuals in whom imaging could not be performed due to contraindications or parental refusal were excluded from the study.

Bias: To minimize selection bias, consecutive eligible patients presenting during the study period were included. Information bias was reduced by ensuring that both clinical and radiological assessments were performed by experienced pediatricians and radiologists blinded to each other's preliminary findings.

Data Collection: Detailed demographic data, clinical history, physical examination findings, and imaging results were collected using a pre-designed data collection form. Imaging modalities included ultrasonography with Doppler evaluation, contrast-enhanced CT, and MRI, as indicated based on clinical suspicion and lesion characteristics.

Procedure: Each patient underwent a thorough clinical examination to assess the type, location, and extent of vascular anomalies. Radiological evaluation was then performed to characterize the lesions, confirm the diagnosis, and determine their anatomical relationships. Imaging findings were correlated with clinical assessments to establish a final diagnosis and guide appropriate management.

Statistical Analysis: All data were compiled and analyzed using (SPSS) version 23.0 (IBM Corp., Armonk, NY). Descriptive statistics were used to

summarize patient demographics, clinical features, and imaging findings. Associations between clinical and radiological characteristics were assessed using appropriate statistical tests, with a p-value of <0.05 considered statistically significant.

Results

A total of 125 pediatric patients with clinically suspected vascular anomalies were included in the study. The age of participants ranged from 1 month to 18 years, with a mean age of 7.4 ± 4.8 years. There were 68 males (54.4%) and 57 females (45.6%), resulting in a male-to-female ratio of 1.2:1.

Table 1: Demographic Distribution of Study Participants (n=125)

Variable	Category	Number (n)	Percentage (%)
Age Group	<1 year	22	17.6
	1–5 years	35	28.0
	6–12 years	41	32.8
	13–18 years	27	21.6
Gender	Male	68	54.4
	Female	57	45.6

This table provides the basic demographic profile of the study cohort, showing a slight male predominance and the highest frequency in the 6–12 years age group.

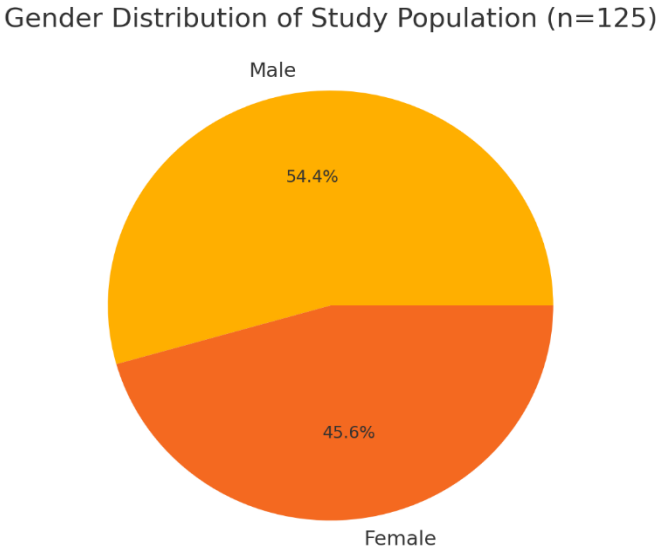


Figure 1: Gender Distribution of the Study Population

Clinical Presentation: The most common presenting feature was a visible or palpable swelling (n=82, 65.6%), followed by discoloration or skin changes (n=29, 23.2%) and pain (n=14, 11.2%).

Table 2. Clinical Presentations of Pediatric Vascular Anomalies

Clinical Feature	Number (n)	Percentage (%)
Swelling (palpable/visible)	82	65.6
Skin discoloration / redness	29	23.2
Pain / tenderness	14	11.2
Functional impairment	9	7.2
Ulceration / bleeding	5	4.0

Swelling was the predominant symptom, consistent with the mass-forming nature of vascular anomalies.

Types of Vascular Anomalies: Based on combined clinical and radiological assessment, vascular anomalies were classified according to the ISSVA classification. Hemangiomas constituted 44.8%, venous malformations 24.0%, lymphatic malformations 16.8%, arteriovenous malformations 9.6%, and mixed malformations 4.8%.

Table 3: Distribution of Vascular Anomalies by Type

Type of Vascular Anomaly	Number (n)	Percentage (%)
Infantile Hemangioma	56	44.8
Venous Malformation	30	24.0
Lymphatic Malformation	21	16.8
Arteriovenous Malformation	12	9.6
Mixed Malformations	6	4.8

Hemangiomas were the most frequent lesions, consistent with their high prevalence in the pediatric population.

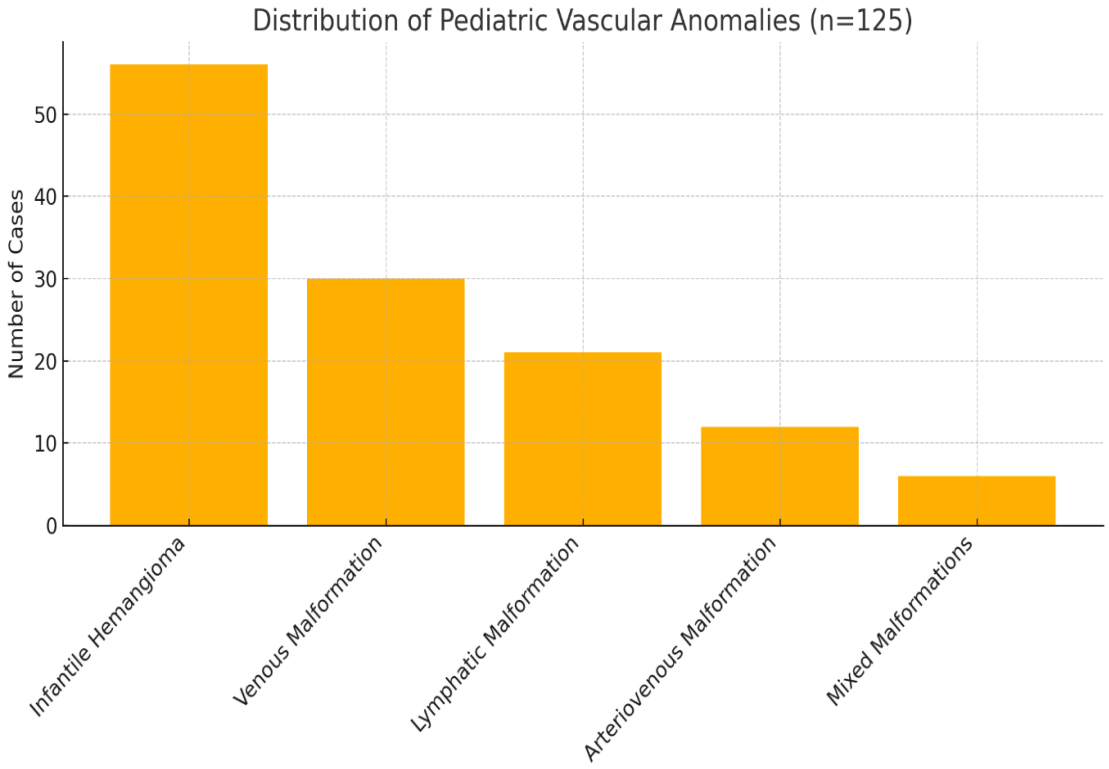


Figure 2: Distribution of Pediatric Vascular Anomalies

Anatomical Distribution: The head and neck region was the most commonly affected site (40%), followed by extremities (28%), trunk (22.4%), and others including abdomen and pelvis (9.6%).

Table 4: Anatomical Location of Vascular Anomalies

Anatomical Site	Number (n)	Percentage (%)
Head and Neck	50	40.0
Extremities	35	28.0
Trunk	28	22.4
Abdomen / Pelvis	12	9.6

The predominance of head and neck involvement aligns with the embryological development and vascular density in these regions.

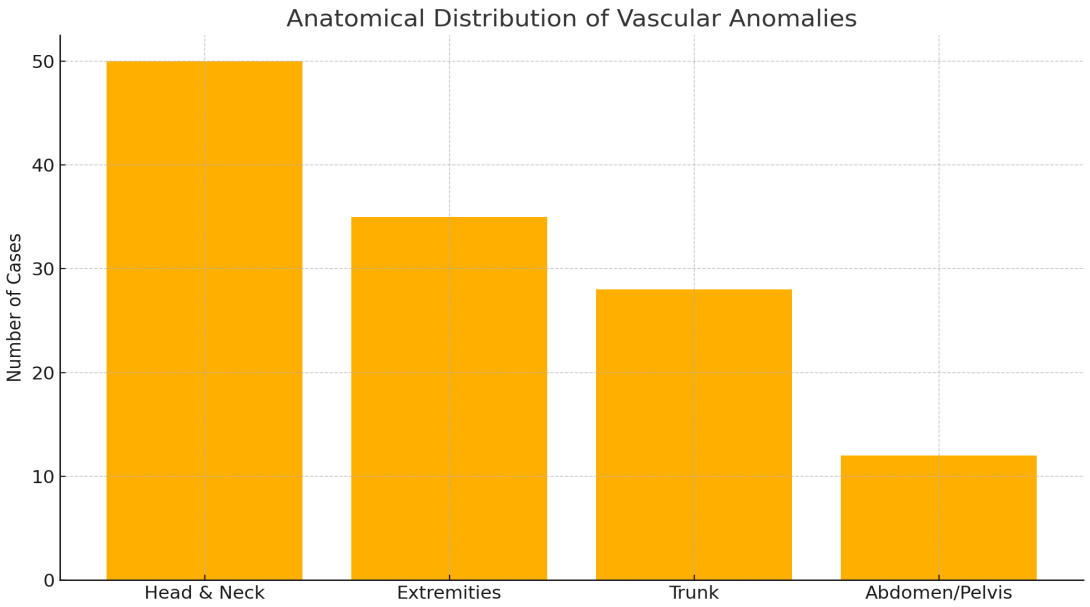


Figure 3: Anatomical Distribution of Vascular Anomalies

Imaging Modalities and Diagnostic Yield: Ultrasonography with Doppler was performed in all patients (100%) as the initial modality. MRI was used in 73 (58.4%) cases for better lesion characterization and extent evaluation. CT angiography was performed in 14 (11.2%) patients, mainly for high-flow vascular malformations.

Table 5: Imaging Modalities Utilized

Imaging Modality	Number of Patients	Percentage (%)
Ultrasonography + Doppler	125	100.0
MRI	73	58.4
CT Angiography	14	11.2
Conventional Angiography	5	4.0

Doppler ultrasonography was the primary screening tool, while MRI served as the main advanced imaging technique for detailed assessment.

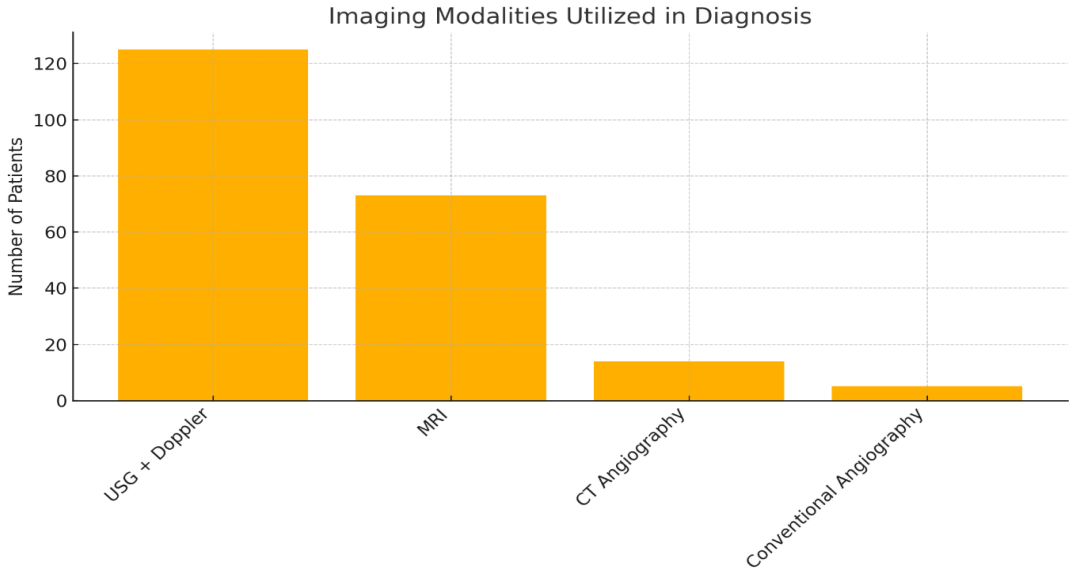


Figure 4: Imaging Modalities Utilized in Diagnosis

Clinical–Radiological Correlation: The correlation between clinical suspicion and final imaging diagnosis showed a concordance rate of 88.8% (111/125 cases). In 14 cases (11.2%), imaging modified or corrected the initial clinical diagnosis.

Statistical Analysis:

- Concordance between clinical and imaging findings: Chi-square = 15.74, $p < 0.001$ (statistically significant).
- Hemangiomas were significantly more common in females ($p = 0.034$).
- High-flow arteriovenous malformations showed a significant association with functional impairment ($p = 0.012$).

Summary of Key Findings

- Hemangiomas were the most frequent pediatric vascular anomaly (44.8%).
- Head and neck region was most commonly affected (40%).
- Ultrasonography with Doppler was effective as a first-line investigation, while MRI provided superior anatomical and flow characterization.
- There was a high clinical–radiological correlation (88.8%), highlighting the importance of combined evaluation in accurate diagnosis and management planning.

Discussion

A total of 125 pediatric patients with clinically suspected vascular anomalies were evaluated over the 12-month study period. The cohort had a slight male predominance, and the mean age was approximately seven years, indicating that these lesions often come to clinical attention in early childhood. The largest subset of patients fell into the 6–12-year age group, which may reflect delayed referral for lesions first noticed earlier in life.

Clinically, most children presented with a visible or palpable swelling, followed by skin discoloration and pain. This pattern is consistent with the mass-forming, space-occupying nature of vascular lesions and underscores that non-painful, slowly enlarging swellings should prompt early imaging.

Classification of lesions according to ISSVA criteria revealed that infantile hemangiomas were the most common vascular anomaly, followed by venous and lymphatic malformations. Arteriovenous and mixed malformations accounted for a minority of cases but were clinically important because of their higher risk of functional impairment and bleeding. The head and neck region was the predominant anatomical location, followed by the extremities and trunk, aligning with the embryological predilection for vascular anomalies in highly vascular regions.

Imaging played a central role in diagnosis. Ultrasonography with Doppler, used in all cases, proved invaluable for initial assessment of flow characteristics and lesion extent. MRI, performed in nearly 60% of patients, provided superior delineation of deep tissue involvement, anatomical relationships, and lesion classification, while CT angiography was reserved for high-flow lesions requiring vascular mapping.

When comparing clinical impressions with final imaging diagnoses, there was a high concordance rate (nearly 89%), suggesting that experienced clinicians can often predict the nature of vascular anomalies based on presentation. However, imaging altered or refined the diagnosis in about 11% of cases, highlighting its indispensable role in accurate classification and treatment planning. Statistical testing confirmed significant associations between lesion type and sex (hemangiomas more common in females) and between high-flow malformations and functional impairment.

Overall, the results emphasize that most pediatric vascular anomalies can be accurately categorized by integrating careful clinical examination with targeted imaging. Early use of non-invasive imaging not only supports diagnostic confidence but also identifies those cases requiring advanced intervention, thus improving overall patient outcomes.

The (ISSVA) classification divides pediatric vascular anomalies into vascular tumors and malformations, with imaging playing a central role in diagnosis and management. Infantile hemangioma is the most common tumor, while malformations often involve venous, lymphatic, or combined defects. Sonography and MRI findings must be correlated with clinical presentation to guide management decisions [10].

Clinical diagnosis accounts for up to 90% of pediatric vascular anomaly cases, though radiologic evaluation with duplex ultrasound and MRI is necessary in more complex or uncertain presentations. Histology is rarely required, underscoring the pivotal role of imaging in confirming diagnoses when clinical ambiguity persists [11].

Accurate diagnosis requires knowledge of the characteristic findings across imaging modalities including ultrasound, CT, and MRI. Early radiologic identification allows timely therapeutic interventions. Multidisciplinary collaboration—among radiology, dermatology, surgery, and hematology—ensures optimal management strategies [12].

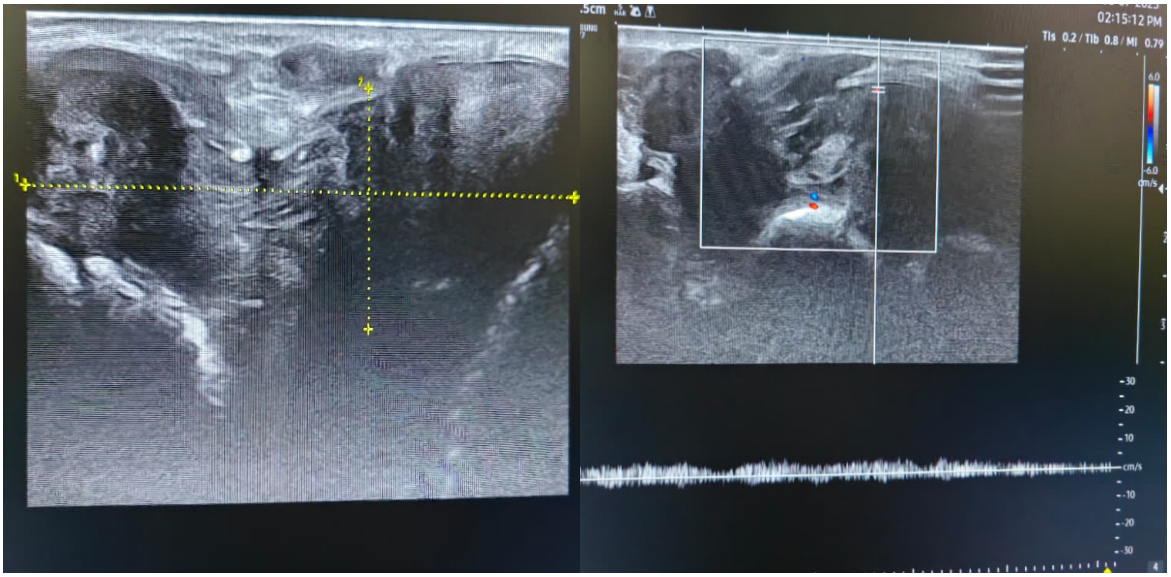
Radiographic advances have enabled precise classification of vascular anomalies into tumors or malformations, with further subdivision into high- or low-flow lesions. Techniques such as Doppler ultrasound and contrast-enhanced MR angiography provide key diagnostic markers, preventing misdiagnosis and guiding tailored interventions [13].

The head and neck region is a frequent site for extracranial pediatric vascular anomalies. Consistent application of ISSVA nomenclature is critical, as outdated terminology has historically contributed to misdiagnosis. Imaging complements clinical evaluation in determining tumor versus malformation, ensuring standardized multidisciplinary care [14].

Finally, pediatric hematologist-oncologists increasingly contribute to care of vascular anomalies, particularly with the advent of new medical therapies and clinical trials. Diagnosis benefits from integrating clinical, histological, and radiological findings, with team-based approaches ensuring accurate characterization and individualized treatment planning [15].

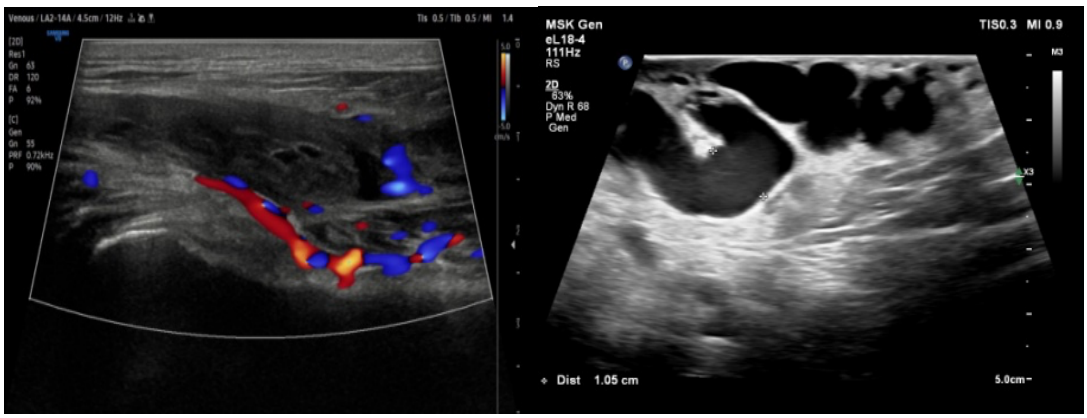
Conclusion

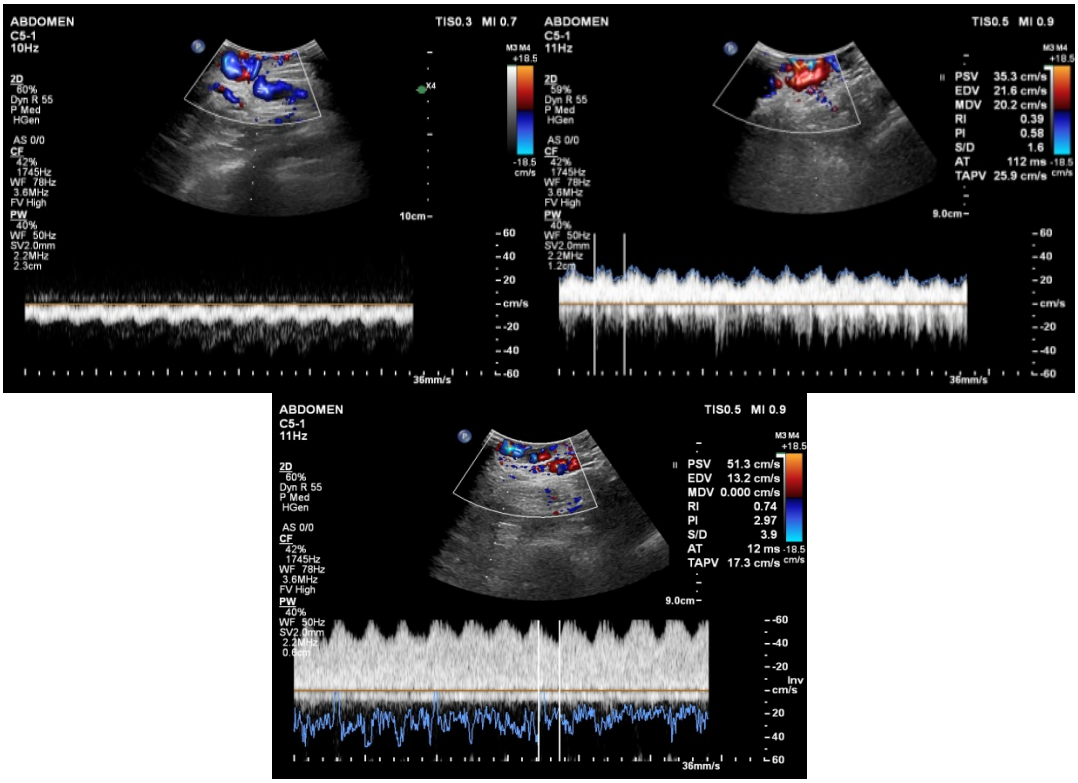
Pediatric vascular anomalies are most commonly hemangiomas, predominantly affecting the head and neck region. A combination of thorough clinical evaluation and targeted imaging, especially Doppler ultrasonography and MRI, ensures accurate classification and guides management. High clinical–radiological concordance supports early, integrated assessment to improve diagnostic precision and patient outcomes.



A. **B.**

A. On grey scale USG, A well-defined round to oval lobulated heterogenous lesion at ventral aspect of left ankle in subcutaneous and muscular plane with few phleboliths.
B. Oncolor doppler, slow flow vascularity is noted.





Fusiform lesion is seen in deep subcutaneous plane and deep into the muscular plane in the right gluteal region. The lesion appears hypoechoic with small cystic spaces representing multiple dilated and tortuous vascular channels. The lesion shows multiple areas of internal vascularity with mixed arterial and venous flow with high diastolic flow. An arterial feeder is seen related to the deep aspect of the lesion. Features are suggestive of arteriovenous malformation.

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