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Original Research Article

MDCT angiography in evaluation of pediatric hemangiomas and peripheral vascular malformations

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ABSTRACT

Background: To evaluate the role of MDCT angiography in peripheral hemangiomas and vascular malformations in pediatric patients.
Methods: Total of 36 consecutive pediatric patients with clinically suspected peripheral hemangiomas and peripheral malformations were included in the study. MDCT angiography and doppler sonography was done for all patients. Final diagnosis was made by response to treatment and follow up. The statistical significance of various MDCT findings and post processing techniques was calculated. p value of <0.05 was considered significant.
Results: Venous malformations were the most common. The MDCTA features which were significant in diagnosing venous malformations were phleboliths (p=0.039), peak enhancement in venous or delayed phase, absence of soft tissue mass, lacy tangle of vessels on maximum intensity projection and volume rendered images. Features significant in diagnosing arteriovenous malformations were tortuous arterial feeders, peak enhancement in arterial phase (0.0001), early draining vein (p=0.0001), venous phase wash out (p=0.0001), tense tangle of vessels on maximum intensity projection and volume rendered images (p=0.0003). Phleboliths (p=0.43) and venous or delayed phase peak enhancement (p=0.69) were overlapping features in congenital hemangiomas and venous malformations. Arterial phase enhancement (p=0.10) and early draining veins (p=0.39) were overlapping features in infantile proliferating hemangiomas and arteriovenous malformations. However, presence of soft tissue mass (p=0.0001) and lack of venous phase wash out (p=0.0003) were differentiating features for hemangiomas.
Conclusions: MDCT angiography can be used as a highly accurate modality to diagnose hemangiomas and vascular malformations. It has an advantage over color Doppler in depicting entire extent of deep lesions.

Keywords: CT angiography, Hemangioma, MDCT, Pediatric, Vascular malformation, Venous malformation

INTRODUCTION

Vascular neoplasms and malformations have been a troublesome area for diagnosis and management. The disease requires multidisciplinary care and the nomenclature is non-uniform. The classification has been evolving ever since Mullicken et al, made some sense out of it in the year 1982.[1] The most recent and acceptable classification is by ISSVA in 1996, which has been last updated in 2014.[2,3] The clinical presentation is highly variable, ranging from mild cosmetic deformity or nondescript swelling to grotesque lesions or even high output failure. Visceral involvement in head and neck and body lesions makes matters even more complex.[4] Radiologist has a role not only to make a diagnosis but is an integral part of the management team as an interventionist.

Radiographs have limited but crucial role by unequivocal detection of phleboliths as a typical rounded density with a central lucency. Initial imaging modality for evaluation is doppler sonography. It solves the preliminary questions of whether the lesion is of vascular origin, high or low flow, and also depicts presence and absence of soft tissue mass which is the main feature to separate hemangiomas and vascular tumors from other malformations. Real time maneuvers like breathing, valsalva, dependent positioning also help in distinguishing lymphatic from venous malformations.[5,6]

The questions left unanswered after a thorough doppler examination are the extent of lesion, the feeding and draining vessels, deeper visceral or osseous involvement.[2]

These questions need a cross sectional modality with wider FOV. Since long, it is a settled argument in literature that MRI is best suited for the purpose. CT scan, although provides the answers, loses the argument due to high radiation dose of a multiphasic CT examination in pediatric patients. CT offers advantages over MRI like better spatial resolution for small arterial feeders, better depiction of bowel and osseous lesions, easier interpretation of head and neck lesions free from susceptibility artifacts of skull base and airway, and shorter scanning times requiring much less sedation than MRI.[7] Even today, a MDCT scanner is far more widely available in resource -poor countries and is less expensive than a high-end MRI scanner and compatible expertise. It may be a reasonable approach to evaluate the role of multiphasic MDCT in these patients, acquiring delayed scans at low doses and keeping the radiation dose to a minimum.[8]

METHODS

A prospective study was done in the Department of Radiodiagnosis in our institution in collaboration with Department of Pediatric Surgery.

Thirty six consecutive pediatric patients with known or suspected hemangioma or peripheral vascular malformations coming to our institution over a period of 18 months were included in the study. The study excluded previously treated lesions, patients with known allergy to contrast material, CNS, pulmonary and other visceral lesions. One case was later histopathologically diagnosed as embryonal rhabdomyosarcoma of orbit and another turned out to be sarcoma with liver metastasis. They were excluded from calculations. Thus, a total of 34 cases were included in the study.

Each patient was duly counselled, and an informed consent was obtained. All patients included in the study underwent proper history, clinical examination after which they were subjected to MDCT angiography (MDCTA) and doppler sonography.

Clinical examination included evaluation of the following features: location of the lesion, size of the lesion, multifocality, color, position test, presence of bruit, presence of ulceration, prominent veins, and any deformity if present.

All patients included were subjected to CT angiography on Philips Brilliance 40 CT unit. Moderate sedation was administered when required.

The following algorithm was used in performing CT:

- Scout view for planning
- Non contrast CT: 5mm slices limited to the involved area for any phleboliths, hemorrhage and localizer image for care bolus was taken.
- MDCTA

Contrast volume and injection rate: 2ml/kg body weight for 300mgI/ml at 1-2ml /s.

First pass contrast enhancement by bolus tracking, venous phase and delayed phase (when indicated in hemangiomas and low flow malformations) was taken.

Radiation dose adjustment: mAs and kVp was altered as per age and size of patient to minimum required levels. Scan range was carefully restricted to cover only the essential area. Pitch, detector rows, gantry rotation was adjusted to balance radiation dose, scan duration, spatial resolution, noise and artifact levels. Scan parameters are tabulated in Table1.

Table 1: Scan parameters.

Parameters	Values
Collimator thickness	1-2.5mm
Pitch	1.5
Slice thickness	1-2.5
kVp	80-120
mAs	
<10kg	chest-40
	abd/limbs/h&n-60
11-20kg	chest-50
	abd/limbs/h&n-70
21-30kg	chest-60
	abd/limbs/h&n-80

Image post processing: Multiplanar reconstruction (MPR), Maximal intensity projection (MIP) and Volume rendering (VR) techniques were used for image post processing.

CT image interpretation

NCCT images were assessed for presence of phleboliths. Arterial phase images were assessed for presence of feeding arteries their number, identification, size, tortuosity and pattern of entrance into the lesion.

Presence or absence of nidus was also noted. Venous structures showing early enhancement in arterial phase were interpreted as early draining veins. Washout of contrast was noted. 2min images and further delayed 15 min images, if acquired, were assessed for any progressive lesion enhancement and the pattern of enhancement. On MIP reformations homogenous mass like appearance or vascular tangle like appearance, whether tense or lacy tangle was noted. On VR cauliflower head like appearance or vascular tangle like appearance was noted.

Extent of lesions was studied in phase of maximum enhancement. The head and neck lesions were assessed for any involvement of salivary glands, anterior neck musculature, muscles of mastication. In vascular lesions affecting limbs the relationship with underlying muscles, the muscular compartments affected were demonstrated. Any deeper extent of lesions into viscera as demonstrated by enhancing channels along bowel walls and urinary bladder wall was assessed. Any bony or soft tissue hypertrophy of affected limb was observed.

Color doppler

All selected patients underwent evaluation under Color Doppler done on Phillips HD 11 XE machine. Presence of solid tissue mass, size, echogenicity, calcification, vessel location (central or peripheral), arterial flow, venous flow, Peak arterial flow velocity, RI, Peak venous flow velocity, vessel density (no. of vessels /cm^2 in the area with highest vascularity) were noted.

- DSA was done when interventional therapy was contemplated.
- Percutaneous sclerotherapy was done in patients with low-flow lesions.
- Follow up was taken for 1-6 months by clinical parameters and color doppler.

Final diagnosis was conducted for each patient, a final diagnosis was assigned taking into account the clinical history, physical examination findings, evolution of the lesion, color doppler, CT angiography findings, DSA and response to treatment.

Statistical analysis

Fisher exact test was used to determine the statistical significance of 3D-MDCT angiography features which help to distinguish between:

- Hemangiomas and vascular malformations
- High-flow and low-flow vascular malformations.

RESULTS

Of the 34 vascular lesions studied a total of 19 low flow malformations (14 venous, 3 venolymphatic and 2 lymphatic malformations) 10 hemangiomas and 5 arteriovenous malformations were finally diagnosed. The CT angiography findings along with follow up/treatment and final diagnosis are summarized in Table 2. The key findings of various lesions are depicted in Figure 1 to 6.

The usual clinical presentation of infantile hemangiomas was in infancy with a well-defined red violaceous swelling. The lesion appeared as a soft tissue mass on NCCT, which showed intense enhancement on arterial phase. Feeding arteries were seen entering the lesion in an organized manner. Early draining veins were also seen in some cases. There was no contrast wash out on venous phase. MIP reconstruction showed an enhancing mass, looking like a cauliflower head on VR images (Figure 1).

Non involuting congenital hemangioma usually present in early childhood as a violaceous color swelling. They show few focal areas of vascular enhancement in a soft tissue mass on venous phase. Maximum enhancement is seen on delayed phase (Figure 2).

Venous malformations usually present in early or late childhood with a localized or large swelling. Phleboliths could commonly be seen on NCCT. Peak enhancement was seen in venous phase with multiple vascular channels within the lesion. No soft tissue mass was present as was seen in hemngioma. The channels appeared as lacy tangles on MIP reconstruction (Figure 3).

Lymphovenous malformations presented similarly with a skin colored swelling. Vascular enhancing channels intervened with non-enhancing cystic areas could be seen on venous phase (Figure 4).

Venous malformations could be syndromic. A case of Klippel-Trinauney was diagnosed in our study. Patient's clinical presentation was with limb swelling with tortuous veins and nevi. NCCT showed phleboliths in anterior wall of urinary bladder.

Venous phase showed abnormal enhancing vessels in right thigh and gluteal muscles. Right femoral vein was not visualized. There was abnormal wall enhancement of rectosigmoid colon. An abnormal vessel noted draining to femoral vein coursing from anterior to posterior aspect of thigh suggesting vein of Serville (Figure 5).

Arteriovenous malformations were less common and appeared as bright reddish swelling. Arterial phase showed intense enhancement of multiple tortuous vessels with early opacification of draining veins. Venous phase showed washout of contrast. Arterial VR image showed tense tangle of vessels. DSA was used for embolization (Figure 6).

Significance of MDCTA findings is given in Table 3. All AVMs showed maximum enhancement in arterial phase. Majority (n=11/12) venous malformations showed maximum enhancement in the venous phase.

Table 2: Summary MDCTA findings and final diagnosis.

MDCTA											
NC	**A**	**V**	**D 2m**	**D 15 r**	**W**	**MIP**	**VR**	**Extent**	**MDCTA diagnosis**	**Procedure**	**Final diagnosis**
p		m			-	lt,c	nu	ant.neck musc, submandibular gland	VM	sclerotherapy	VM
-				m	-	ma	nu	ant.chest wall muscles	H	sclerotherapy	VM
-			m		-	ma		lower lip	H	clinical	NICH
-	m				-	ma	ca,f, rt	columella of nose nasal alae	H	clinical	IH
p		m			-	lt,c	nu	lower lip, masseter, temporalis	VM	sclerotherapy	VM
p		m			-	lt,c	nu	whole Lt upper limb muscular compartment	VM	sclerotherapy	VM
-			m		-	lt,c	lt	parotid,masseter, temporalis	VM	sclerotherapy	VM
-	m,e				-	ma	ca,f, rt	ant-lateral thigh, skin and s/c tissue	H	clinical	IH
-	m,e				+	c	tt, torf,ni	gluteal skin,s/c tissue gluteal muscles	AVM	DSA	AVM
-	m,e				+	c	tt, torf,ni	skin,s/c tissue	AVM	DSA	AVM
p		m			-	lt,c	nu	lower limb postero- lateral muscle comptt visceral extension	VM	sclerotherapy	VM
-	m,e				+	c	tt, torf,ni	pinna skin and s/c tissue	AVM	DSA, EMBOL	AVM
p			m		-	lt,c	nu	lower limb musc.comptt gluteal muscles	VM	sclerotherapy	VM
p				m	-	ma	nu	skin,s/c tissue	H	clinical	RICH
-					-	nu	nu	inguinal skin & s/c tissue	LM	sclerotherapy	LM
p			m		-	lt,c	nu	muscles of feet	VM	sclerotherapy	VM
p		m			-	lt,c	nu	parotid,masseter, temporalis	VM	sclerotherapy	VM
p			m		-	lt,c	nu	anterior muscle comptt.of forearm	VM	sclerotherapy	VM
-					-	nu	nu	antero lateral muscle comptt.of forearm, wrist	LM	sclerotherapy	LM
-		m			-	lt,c	nu	ant.neck musc., parotid pterygoids	VLM	sclerotherapy	VLM
-	m,e				-	ma	ca,f, rt	skin,s/c tissue	H	clinical	IH
-		m			-	lt,c	nu	lower limb musc.comptt gluteal muscles,bony hypertrophy	VM	sclerotherapy	VM
p			m		-	ma	nu	skin,s/c tissue	H	sclerotherapy	VM
-				m	-	ma	nu	upper lip,columella	H	clinical	RICH
-	m,e				+	c	tt, torf,ni	skin,s/c tissue,gluteal muscles	AVM	DSA	AVM
-			m		-	ma	nu	parotid	H	clinical	
-	m,e				-	ma	ca,f, rt	skin,s/c tissue	H	clinical	IH
-		m			-	lt,c	nu	serratus ant, subscapularis	VM	sclerotherapy	VM
-		m			-	lt,c	nu	whole lower limb muscular comptt.	VM	sclerotherapy	VM
p			m		-	ma	nu	skin,s/c tissue	H	clinical	RICH
-	m,e				-	c	tt,f,rt	pinna skin and s/c tissue	AVM	clinical	IH
-	m,e				+	c	tt, torf,ni	skin,s/c tissue	AVM	DSA	AVM
p		m			-	lt,c	nu	whole lower limb musculature,gluteal muscles,visceral extension	VLM	sclerotherapy	VLM
-		m			-	lt,c	nu	ant.neck musculature	VLM	sclerotherapy	VLM

NC-non contrast, A-arterial phase, V-venous phase,D-delayed,W-washout, p-phlebolith, m-maximum enhancement, e-early draining vein, + present, -absent, lt-lacy tangles, tt-tense tangles, c-channels, f-feeder, torf-tortuous feeder, rt f-rt angled insertion of feeder, ma-mass, nu-not useful, H-hemangioma, IH-infantile hemangioma, RICH-Rapidly involuting hemangioma, NICH-non involuting hemangioma, VM-venous malformation, LM-lymphatic malformation, VLM-venolymphatic malformation, AVM- Arteriovenous malformation.

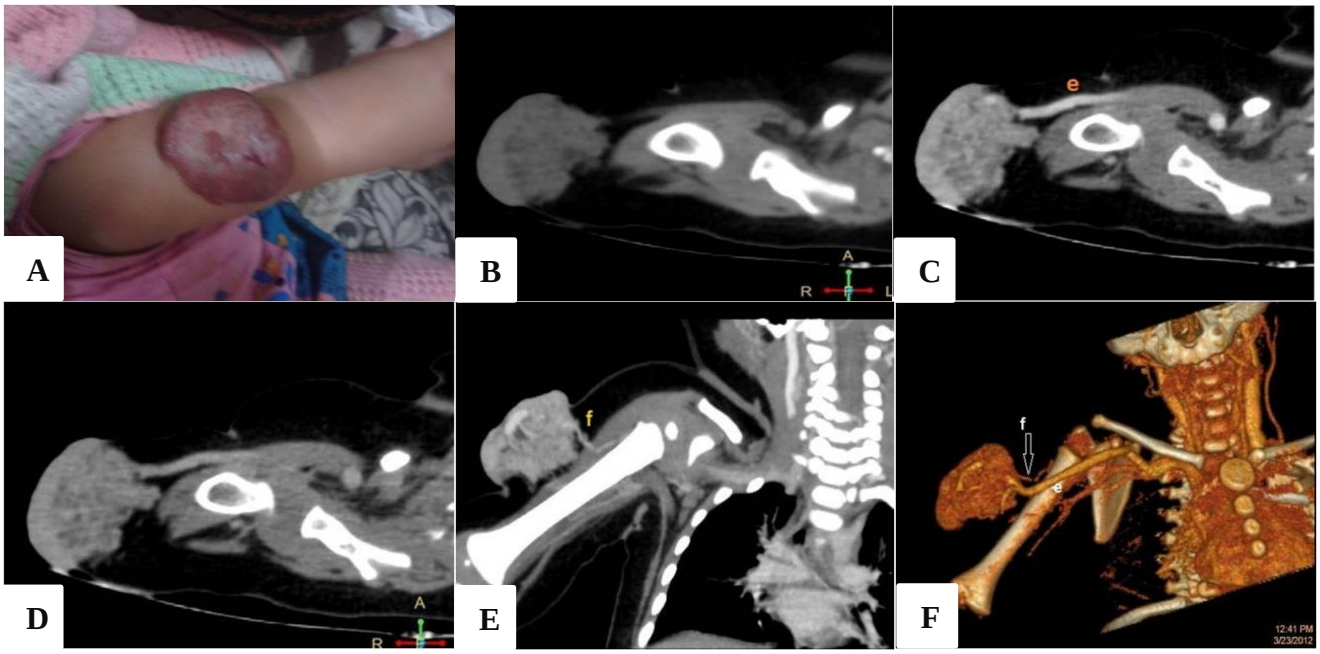

Figure 1: Infantile hemangioma. (A): clinical photograph showing a reddish round swelling, (B): NCCT shows a soft tissue mass, (C): arterial phase showed intense enhancement with early draining "e" left subclavian vein, (D): venous phase showing no contrast wash out, (E): MIP image shows an enhancing mass supplied by "f" feeding artery, (F): VR image shows cauliflower head like appearance.

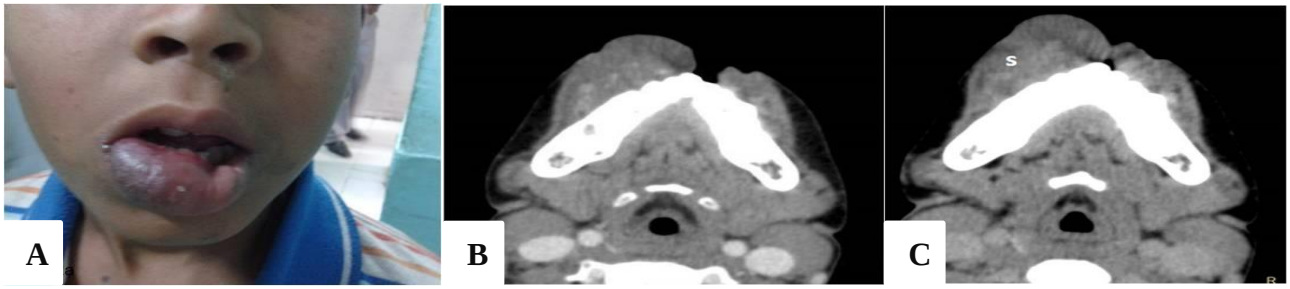

Figure 2: Non involuting congenital hemangioma. (A): clinical photograph shows a violaceous swelling of lower lip, (B): venous phase shows few small enhancing areas, (C): delayed image at 2mintues shows expanded area of enhancement.

Many hemangiomas (n=5) also showed peak enhancement HU in arterial phase. Three hemangiomas showed maximum enhancement in 2mt phase while 1 in delayed 15mt phase. Difference of maximum arterial enhancement between hemangiomas and AVMs (p= 0.10) as well as for maximum delayed phase enhancement between hemangiomas and venous malformations (0.69) is not significant. Phase of maximum enhancement can differentiate only between low flow malformations and AVMs but not hemangiomas and other malformations.

Early draining vein was seen in 4/10 hemangiomas [Figure 1(C)] and all (n=5) AVMs; difference is not significant (p= 0.39). None of the low flow malformations showed early draining veins. Presence of early draining vein was found to be a significant feature distinguishing AVMs and low-flow malformations (p=0.0001).

Wash out of contrast was seen in all AVMs [Figure 6 (C)] and none of the hemangiomas and low flow malformations. Difference between hemangiomas and high flow malformations (p= 0.0003) as well as between high and low flow malformations (p=0.0001) is highly significant. Phleboliths were noted in 12 cases, of which 10 were venous malformations and 2 were hemangiomas.

Arterial feeders of hemangiomas when identified showed a proper organized way of insertion into the lesion (n=5) while AVM feeders where tortuous and inserted in a disorganized way (n=5). All AVMs showed the presence of nidal aneurysm. On MIP reconstruction, 9 hemangiomas and 2 venous malformations showed

appearance of homogenously enhancing soft tissue mass. Difference is highly significant (p=0.0001). Most venous and venolymphatic malformations (n=15/17) showed the appearance of lacy tangles of vessels. AVMs also showed appearance of tangle of channels but tense in appearance.

VR appearance

Low flow malformations did not attain the contrast density required to produce a volume reconstructed image. High flow malformations appeared like a tense tangle. Most (n=4/5) hemangiomas gave the appearance of cauliflower head. Difference between hemangiomas and AVM for tense tangle of vessels is highly significant (p=0.0003).

Color doppler findings

Five lesions showed soft tissue on grey scale, soft tissue and channels both were present in 5 lesions. 22 lesions showed only channels on greyscale. 2 lesions showed cystic spaces on grey scale. They showed no flow on doppler. Five lesions showed draining veins having high velocity pulsatile flow synchronous with arterial pulse i.e. arterialization of veins. Based on doppler findings 2 cases diagnosed as hemangiomas in CT were reassigned diagnosis as venous malformation One case diagnosed as AVM in CT angiography was reassigned as hemangioma as there was no arterialization of draining vein. Thus, a total of 14 venous malformations,10 hemangiomas, 5 AVMs, 3 lymphovenous malformations and 2 lymphangiomas were diagnosed.

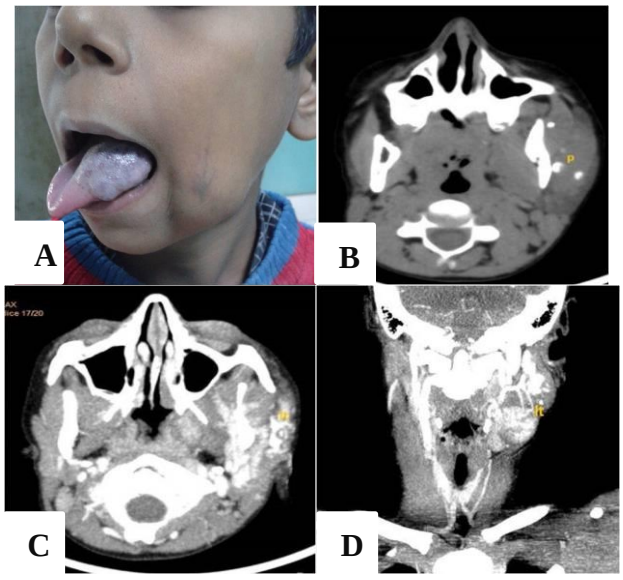

Figure 3: Venous malformation. (A): a violaceous swelling is seen in lower lip, (B): NCCT shows multiple calcified "p" phleboliths, (C) P: Venous phase shows multiple vascular channels, (D): MIP image shows lacy tangles of venous channels.

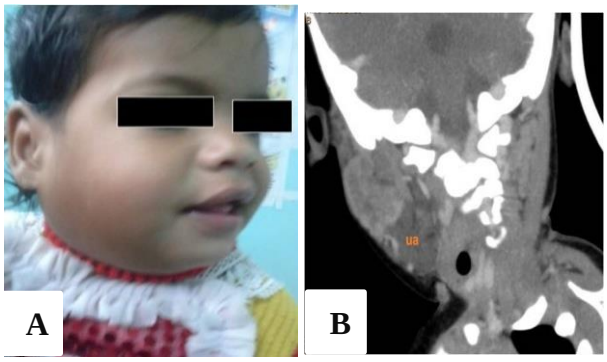

Figure 4: Lymphovenous malformation. (A): skin colored swelling is seen in the right cheek, (B): venous phase shows vascular enhancing and "ua" unenhancing areas.

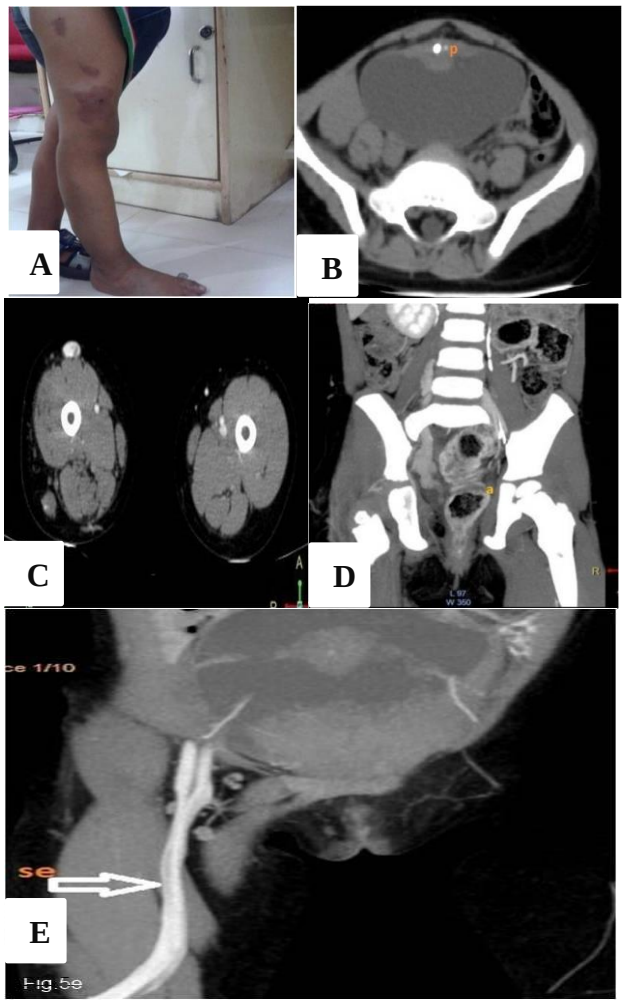

Figure 5: Klippel-Trenauny syndrome with veisceral involvement. (A): right lower limb is wollen with multiple cutaneous nevi, (B): NCCT shows phleboliths in uninary bladder wall, (C): Venous phase shows absence of right femoral vein and multiple anomalous veins, (D): MIP images show hyperenhancing rectosigmoid colon, (E): vein of Serville is traced on the MIP reconstructed image.

Follow-up and final diagnosis

Five patients diagnosed as hemangioma were administered which were in proliferating phase were administered oral prednisolone started on 3mg/kg/d for 1 month tapered by 0.5ml every 2-4 weeks and discontinued in 6-9 months when the lesions showed signs of involution and decrease in size. Rest of the hemangiomas were kept on observation. They showed decrease in size in 6-9 months duration. Patientsdiagnosed as venous/venolymphatic/lymphatic malformations (n=19) were administered sclerotherapy using polidocanol.

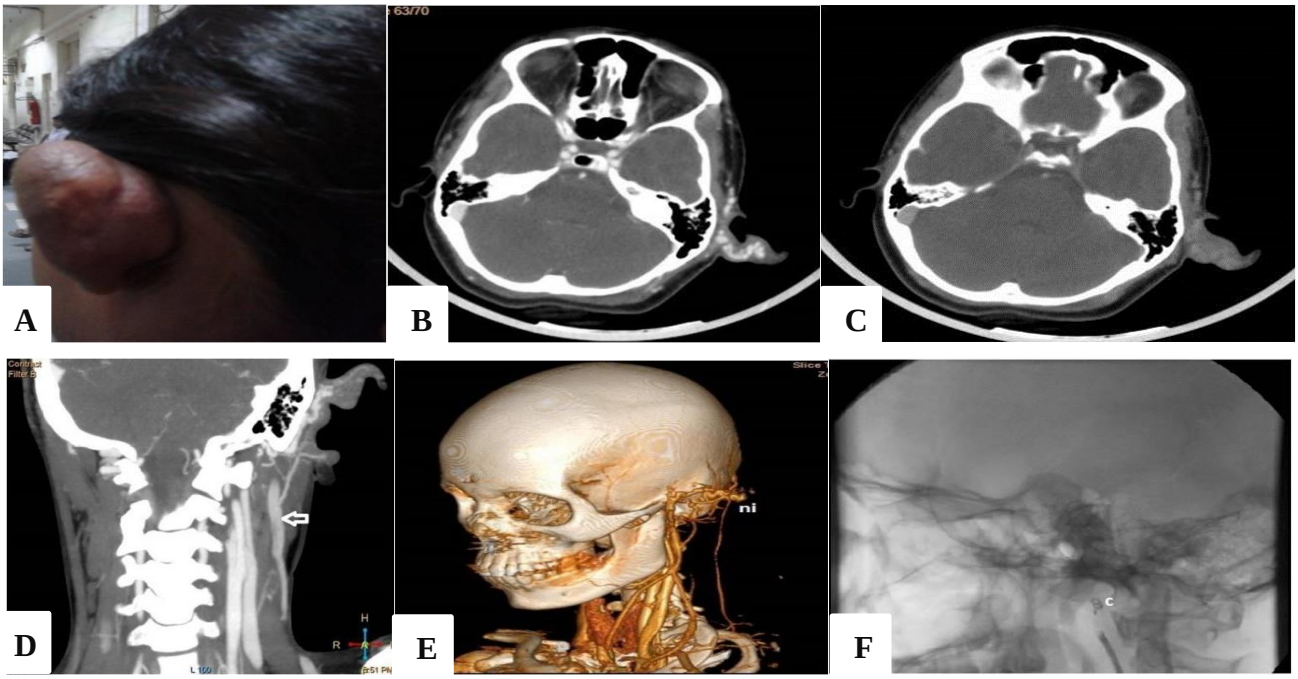

Figure 6: Arterio-venous malformation left pinna. (A): reddish lesion is seen on the pinna, (B): arterial phase shows tortuous feeders and early opacification of left external jugular vein, (C): venous phase shows contrast wash out, (D): ARTERIAL MIP coronal image showed early draining vein (arrow), (E): Arterial VR image shows the nidus "ni", (F): DSA image after embolization with coils "c".

Table 3: Significance of MDCTA features.

MDCTA feature	Significance
Phlebolith	Significant in differentiating low flow and high flow malformations
	Not significant in differentiating hemangiomas and vascular malformations
Maximum enhancement in arterial phase	Significant in differentiating low flow and high flow malformations
	Not significant in differentiating hemangiomas and AVM
Delayed phase enhancement	Not significant in differentiating hemangiomas and low flow vascular malformations
Early draining vein	Significant in differentiating high flow and low flow malformations
	Not significant in differentiating hemangiomas and vascular malformations
Washout	Significant in differentiating AVM and low flow malformations
	Significant in differentiating AVM and hemangiomas
Soft tissue mass	Significant in differentiating hemangiomas and vascular malformations
Cauliflower head appearance	Significant in differentiating hemangiomas and vascular malformations
Lacy tangles and tense tangles	Significant in differentiating high flow and low flow malformations

Follow up was done once in a month. Multiple sittings for injection of sclerosant were needed. There was decrease in swelling and channels in doppler in 6-9 months duration.

Five patients diagnosed as AVM were subjected to Digital Subtraction Angiography and diagnosis was confirmed. However, coil embolization was done in two of them. After coil embolization there was reduction in

size in a follow up of 2 months. 1 case did not give consent for the embolization. Embolization could not be performed in one case due to technical difficulties as there were many large tortuous feeders.

Of the 34 vascular lesions studied a total of 14 venous malformations, 10 hemangiomas, 5 AVMs, 3 venolymphatic malformations and 2 lymphatic malformations were diagnosed. Thus, a total of 19 low-flow vascular lesions were diagnosed.

DISCUSSION

A Of the 34 cases evaluated, MDCTA diagnosis was correct in 31 cases, giving a diagnostic accuracy of 91.2%. 2 venous malformations (n=14) and 1 hemangioma(n=10) were misdiagnosed. CT angiography correctly diagnosed all the high-flow lesions (n=5).

On plain scans the presence of phleboliths were noted in hemangiomas (n=2) and venous/venolymphatic malformations (n=10). None of the high-flow malformations showed presence of phleboliths. It was found that presence of phleboliths significantly differentiates low-flow and high-flow malformations (p=0.039) however no such significance in differentiation between hemangiomas and vascular malformations were found (p=0.45). This is in concordance with study by Paltiel et al.[5]

Dubois et al, in their review maintain that hemangiomas show persistent enhancement, so do the venous malformations which enhance peripherally and slowly after contrast injection.[9] AVMs on the other hand are seen as highly enhancing lesions with numerous feeding and efferent vessels without persistent tissue staining. This is in concordance with our study in which none of the hemangiomas (n=10) and low-flow vascular malformations (n=19) showed washout of contrast. All the AVMs in the study (n=5) showed washout of contrast. Thus, washout of contrast was found to be a characteristic feature of AVMs (p=0.0001)

It was also found that phase of maximum enhancement can also be used to differentiate high-flow and low-flow malformations. All the high-flow malformations (n=5) enhanced maximum in arterial phase whereas none of the low-flow malformations (n=19) enhanced in arterial phase (p=0.0001).

However, it was found that hemangiomas (n=10) also enhanced in delayed phases (n=5) so did the low-flow vascular malformations (n=6), thus delayed phase enhancement was not found useful in differentiating hemangiomas and low-flow malformations (p=0.69).

Presence of early draining vein was found in hemangiomas (n=4) and AVMs (n=5). While early draining vein was absent in all low-flow vascular malformations (n=19). Presence of early draining vein was found to be a significant feature distinguishing AVMs and low-flow malformations (p=0.0001).

However, presence of early draining vein was not found to be a significant feature distinguishing hemangiomas and vascular malformations(p=0.39). The presence of early draining vein in infantile hemangioma has been described in the literature and differentiation of infantile hemangiomas and AVM with this respect in imaging is difficult.[9-11]

It was observed that doppler was useful in this respect to differentiate hemangiomas and high-flow malformations. In the hemangiomas showing early draining veins doppler showed venous flow in the draining veins whereas in AVMs arterialization of draining veins was observed. This is at par with previous studies and literature maintaining that the arterialization of veins is a specific feature of arteriovenous shunting and is seen in high-flow lesions.[5,10,11]

On MIP reformations 9 out of 10 hemangiomas showed appearance of soft tissue enhancing mass while only two venous malformations showed similar appearance. Appearance of enhancing soft tissue mass was found to be significant in differentiating hemangiomas from vascular malformations (p=0.0001). This is in concordance with studies by Bittles et al, and Leng et al, where they found hemangiomas to be soft tissue enhancing mass in 2D images.[12,13] Also, this can be considered as the CT equivalent of soft tissue appearance on grey scale USG which was the only multivariate predictor to differentiate hemangiomas from vascular malformations as assessed by Paltiel et al.[5]

Venous/venolymphatic malformations (n=17) on MIP reformations were noted as lacy tangle of channels. This appearance for low-flow malformations has also been described in studies.[12,13]

However, in present study 2 low-flow malformations were noted as soft tissue mass with delayed enhancement. Doppler was helpful in correctly diagnosing them as venous malformations as on grey scale they showed channels instead of soft tissue mass.

On VR images AVMs appeared as tense tangle of vessels. It was found to be significant in differentiating AVMs from hemangiomas (p=0.0003). This appearance has also been noted in previous studies in the topic.[12-14]

Another 3D feature of AVMs described in the previous studies by Bittles et al, Leng et al and Tao et al, was the presence of tortuous feeders entering the lesion in a disorganized way.[12-14] This finding was also found in present study where all the AVMs (n=5) had tortuous feeders entering the lesion in a disorganized way.

VR appearance of hemangioma described in previous studies is a lobular mass with 2 to 3 small feeding vessels

entering the lesion in an orderly manner.[12-14] The feeding vessels were not tortuous. 4 of the hemangiomas in our study showed a cauliflower head appearance. All of them showed feeders that were not tortuous and entering the lesion in an organized manner. This appearance was significant in distinguishing hemangiomas from vascular malformations (p=0.0045) as none of the vascular malformations showed this appearance also AVMs (n=5) showed tortuous feeders entering the lesion in disorganized manner. Literature and the previous studies maintain that CT angiography with reformation techniques enables to demonstrate the anatomy of lesions and their stereoscopic relationship with surrounding structures. CTA combined with image manipulation techniques including MIP, MPR and 3D volume rendering are invaluable for providing anatomic information relevant to treatment planning.[9,10,12-14]

In present study MPR reformation was particularly found to be useful in this respect. Multiplanar reconstruction enabled to define the extent of the lesions and was useful in trace the draining and feeding vessels. Of the 34 lesions included in pr study 3 lesions had visceral extension.

It was able to delineate this extension by CT angiography whereas by doppler it was not able to demonstrate the visceral extension and channels along bowel wall due to obscured window by bowel gas and soft tissue. Superior spatial resolution of CT angiography was also useful in demonstrating the involvement of muscles, deep structures which include parotid and submandibular glands in head and neck region.

One patient with arteriovenous malformation was not subjected to coil embolization as there were multiple tortuous feeders. CT angiography was able to demonstrate the multiple tortuous feeders from internal iliac artery while doppler failed in this respect as it was able to demonstrate only one arterial feeder and draining vein. It was also not able to trace the feeder on doppler due to obscured window. This highlights the importance of CT angiography in proper patient management.z

Present study although has a small sample size, it is the study on vascular lesions and 3D-MDCTA which has largest sample size to date. The previous studies by Bittles et al, Leng et al and Tao et al have smaller sample sizes with n=11, n=16, n=5 respectively.[10,13,14]

CONCLUSION

CT angiography provides a fast and useful investigation in assessment of pediatric peripheral vascular lesions. Not only it is effective in determining the extent of lesion and relationship with surrounding structures, when coupled with MIP and VR reformations it is useful in characterizing the lesion and aiding in diagnosis for a proper management.

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