CLINICORADIOLOGICAL ASSESSMENT AND TREATMENT OUTCOMES OF NON-VISCERAL VASCULAR MALFORMATIONS

THESIS

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(RADIOLOGY)

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CERTIFICATE

This is to certify that the thesis titled "**Clinicoradiological assessment and treatment outcomes of non-visceral vascular malformations**" is the bonafide work of Dr. Adarsh Ishwar Hegde carried out under our guidance and supervision, in the Department of Diagnostic and Interventional Radiology, All India Institute of Medical Sciences, Jodhpur.

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DECLARATION

I hereby declare that the thesis titled "**Clinicoradiological assessment and treatment outcomes of non-visceral vascular malformations**" embodies the original work carried out by the undersigned in All India Institute of Medical Sciences, Jodhpur.

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I want to dedicate this thesis to my father late Ishwar Hegde who was the motivator of education throughout my life and encouraged me to complete this till the very last moment. I want to extend gratefulness to my mother Mrs. Shasikala Hegde, my sister Dr. Asha Hegde and brother in law Dr. Deeparaj Hegde for their constant support.

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-Dr. Adarsh Ishwar Hegde

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LIST OF ABBREVIATIONS

VSM-Vascular malformation

VM-Venous malformation

LM-Lymphatic malformation

CM-Capillary malformation

AVM-Arteriovenous malformation

AVF-Arteriovenous fistula

KTS-Klippel trenaunauy syndrome

LFVM-Low flow vascular malformations

HFVM-High flow vascular malformations

PIC3K- Phosphoinositide 3-kinase

AKT- Ak strain transforming

mTOR- mammalian target of rapamycin

RAS- Rat sarcoma virus

ERK- Extracellular-signal-regulated kinase

HHT1-Hereditory hemorrhagic telangiectasia

VEGF-Vascular endothelial growth factor

CT – Computed tomography

USG-Ultrasonography

CLOVES-Congenital lipomatous overgrowth, venolymphatic malformation, epidermal naevi, scoliosis

MRI –Magnetic resonance imaging

DPP- Direct Puncture Phlebography

DSA-Digital Subtraction Angiography

TGF-β - Transforming growth factor beta

ISSVA- International society for study of vascular anomalies

TRICKS- Time resolved contrast kinetics

STS –Sodium Tetradecyl Sulphate

IR – Interventional Radiology

STASE- Sclerotherapy with adjunctive stasis of efflux

GROC-Global rate of overall change

SPSS- Statistical Package for the Social Sciences

INTRODUCTION

INTRODUCTION

Vascular anomalies (VA) are complex group of disorders related to vascular structures of the body, which are confusing clinically as well as radiologically in diagnosing on a day to day basis. They can range from a simple birthmark to a large lesion occupying an entire limb resulting in severe lifelong morbidity. Moreover due to misperceptions in nomenclature there has been a lot of mislabelling of these conditions and thus affecting their course of treatment. There have been only few literatures emphasising the proper classification and treatment protocol until the last decade. Recent development of multidisciplinary approach has led to the increase in understanding of vascular anomalies, also at molecular and genetic level and thus leading to a systematic classification as given by the International Society for Study of Vascular Anomalies (ISSVA) 2018.

Broadly we can categorise the vascular anomalies into tumours -a proliferative form and malformations - a non-proliferative form. Vascular tumours may or may not regress on their own, but vascular malformations rarely disappear on their own(1). Vascular malformations (VSM) are abnormal development of vessels. They can be arterial, venous, capillary, and lymphatic or mixed variety. Because of the inadvertent use of the terminologies, vascular malformations such as venous malformations have been mislabelled as hemangiomas in most of the literature. Therefore the exact prevalence of these malformations in general population are not clearly mentioned so far. Yet, the common prevalence in general population is around 0.3 to 1.5 % (2). Vascular malformations occur in the early developmental period of vasculogenesis. It is said that they occur at the time of birth, but manifest at various age groups depending upon the factors such as hormonal changes, trauma etc. In general VSMs occur commonly in children or adolescent population than adult or elderly age group. It equally affects the males and females without significant gender specific predominance. These can involve any organs such as central nervous system, abdominopelvic viscera, lungs or other soft tissues. In our study we have mainly concentrated on the VSMs of the non-visceral soft tissues.

Recent studies have shown that somatic gene mutations can be attributed as the causative factor for VSMs. These somatic genes regulates angiogenesis, proliferation, maturation, growth and apoptosis of vascular cell. Defects in the molecular signalling pathway are said to cause specific VSMs, thus opening the door for the future treatment with specific molecular targets. Some of the examples include, PI3K/AKT/mTOR pathway which is associated with

venous, lymphatic malformations, Proteus syndromes etc. RAS/MEK/ERK genes are related to capillary malformation, arteriovenous malformation etc. VEGF are related to congenital primary lymphedema.(2)

Soft tissue VSMs may manifest as various symptoms pertaining to the site including the form of pain, swelling, functional impairment or severe cosmetic concern when it occurs particularly in the exposed areas of the body.

Radiology plays an important role in the diagnosis of these VSMs. Ultrasound is the initial entity used for evaluation and MRI being the most commonly used modality, which is employed to confirm the diagnosis. Various other modalities such as radiography, Computed Tomography (CT), and fluoroscopy/Digital Subtraction Angiography (DSA) have their own importance. Clinical History and examination findings are always crucial in coming to the conclusion while diagnosing the VSMs as many of the vascular tumours or other benign conditions may mimic it.

Various treatment strategies are used for the VSMs which include surgical, interventional radiology, dermatological, molecular targets etc. A combination of different treatment strategies is frequently required in treating these entities successfully. Accordingly multidisciplinary approach is emphasized in most of the literature for treating VSMs.

AIM & OBJECTIVES

AIM AND OBJECTIVES

AIM

- Clinicoradiological assessment and treatment outcomes of non-visceral vascular malformations.

Primary objective:

- To evaluate the various clinical and radiological parameters in non-visceral vascular malformations.

Secondary objectives:

- Role of various imaging modalities in characterization of different vascular malformations according to ISSVA classification.
- To evaluate the treatment outcomes of different vascular malformations.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Classification

Malan and Puglionisi were said to work on abnormalities in vessels and they tried to classify them based on involvement of main trunks or peripheral vessels in 1964. The classification included mainly three entities –Arterial, Venous and other associated malformations(3).

Embryological aspects were highlighted and used for classification by Hamburger in 1988 based on the time of developmental arrest. He divided them into truncular and extra-truncular(3).

However credit for initial attempt in classifying the vascular anomalies in a systematic manner was given to Mulliken and Glowcki in 1982. Based on the endothelial nature, they divided anomalies into tumours and malformations. This was kept as reference for the classification made by International society for the study of vascular anomalies (ISSVA) in 1996, which was further revised in 2014 and recent version came in 2018 (Table 1). It has been widely accepted all over the world for the vascular anomalies classification.

Terminologies:-

There has been lot of misappropriation of the terminologies in the past as well as in the present situation with respect to the vascular malformations. It has been said that hemangioma term has been incorrectly used in more than 71% of PubMed indexed literature before 2000's according to Hassein et al.(4)

The word 'oma' usually gives an essence of benign tumour to it. Frequently the lymphatic malformations are termed as lymphangioma by many of the physicians/surgeons, where as in its true sense it is never a tumour and also it has no future malignant potential. According to ISSVA newer terminology has been proposed as detailed in Table2.

Table 1:- ISSVA 2018 classification for vascular anomalies

(Approved at the 20th ISSVA Workshop, Melbourne, April 2014, last revision May 2018)

<table>
<tr><th colspan="5">VASCULAR ANOMALIES</th></tr>
<tr><th>VASCULAR TUMOURS</th><th colspan="4">VASCULAR MALFORMATIONS</th></tr>
<tr><td rowspan="2">BENIGN
(Hemangiomas-Infantile, congenital, Tufted, Infantile, spindle cell etc.)

LOCALLY AGGRESSIVE /BORDERLINE
(Hemangioendothelioma-Kaposiform, Retiform, Composite etc. Kaposi sarcoma)

MALIGNANT
(Angiosarcoma, Epitheloid hemangioendothelioma etc)</td><td>SIMPLE</td><td>COMBINED</td><td>OF MAJOR NAMED VESSELS</td><td>ASSOCIATED WITH OTHER ANOMALIES</td></tr>
<tr><td>Capillary

Lymphatic

Venous

AVM

AVF</td><td>VLM

CVM

CLM

CAVM

CLVM

CLAVM

Others</td><td>Channel type or truncal vascular malformations

(A variety of abnormalities can affect major named vessels, including alternate origin, course, number, length, diameter, valves communication or persistence of embryonal vessels)</td><td>Syndromic associations</td></tr>
<tr><th colspan="5">PROVISIONALLY UNCLASSIFIED</th></tr>
<tr><td colspan="3">Fibro adipose vascular anomaly (FAVA)
Multifocal lymphangioendotheliomatosis with thrombocytopenia / cutaneovisceral angiomatosis with thrombocytopenia (MLT/CAT)
PTEN (type) hamartoma of soft tissue / "angiomatosis" of soft tissue (PHOST)PTEN</td><td colspan="2">Intramuscular hemangioma
Angiokeratoma
Sinusoidal hemangioma
Acral arteriovenous tumour</td></tr>
<tr><td colspan="5">AVM= Arteriovenous malformation, AVF=Arteriovenous fistula, VLM= venolymphatic malformation, CVM=capillary-venous malformation, CLM=capillary-lymphatic malformation, CAVM= capillary-arteriovenous malformation, CLVM= capillary-lymphatic-venous malformation, CLAVM= capillary-lymphatic-venous-arteriovenous malformation</td></tr>
</table>

Table 2:- Recommended use of terminology for Vascular Malformation

OLD TERMINOLOGY	NEW TERMINOLOGY
Port wine stain Strawberry hemangioma	Capillary malformation
Cavernous hemangioma Ossifying hemangioma	Venous malformation
Lymphangioma Cystic hygroma	Lymphatic malformation

Pathogenesis:-

Although we use the above classification system for the vascular malformation, it is crucial to know the molecular mechanism behind it. The proper understanding of the genetics will aid in the application of specific molecular targets as a treatment option in various VSMs.

Primarily the vascular morphogenesis consists of two important steps such as Vasculogenesis and Angiogenesis. *Vasculogenesis* consists of formation of hemangioblasts in the extra-embryonic mesoderm of yolk sac to formation of endothelial cells and the formation of primary capillary plexus of endothelium (PCPE). *Angiogenesis* is the formation of blood vessels from these PCPE. Angiogenesis will always be at equilibrium i.e. between the stimulation and inhibition. It will usually continue to occur unless inhibited or pro-angiogenetic factors are removed.

Following are the some of the important molecular pathways involved in the vascular malformations as described in figure 1 (2)

1. PI3K/AKT/mTOR.
2. Vascular endothelial growth factor (VEGF)
3. RAS/RAF/MEK/ERK
4. Angiopoietin-TIE2
5. Transforming growth factor beta (TGF-β)

Important molecular pathways involved in the vascular malformations

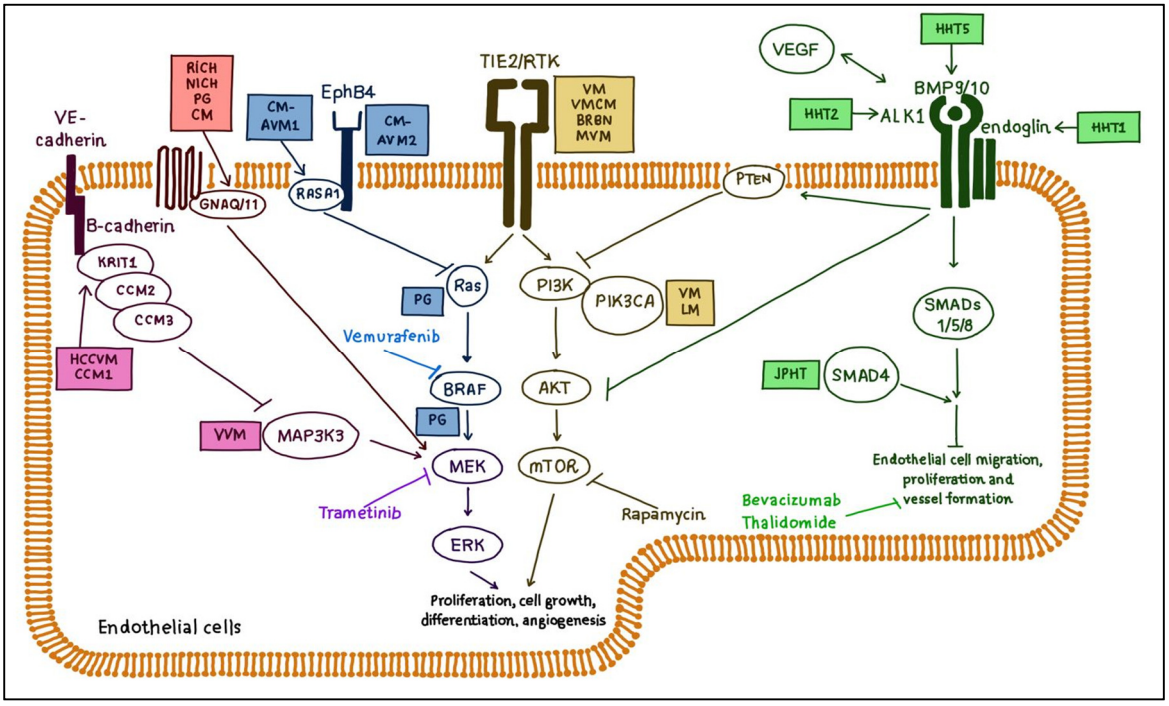


Figure 1:- Important molecular pathways involved in the vascular malformations

Recent study shows vascular anomalies are known occur because of the disrupted endothelial receptor and associated intracellular signalling pathways involved in the PI3kinase(K), AKT, MAPK, and SMAD signalling.

Familiar vascular malformations are commonly autosomal dominant (AD). These result in loss of function of a gene. However, vascular malformations are caused most commonly by somatic mutations.

Some of the somatic mutations are described in Table 3 (4).

We can expect multiple molecular based classifications in near future.

Table 3:- Somatic mutations and associated syndromes

VASCULAR MALFORMATIONS	GENETIC MUTATIONS
Venous malformation(VM)	TEK/TIE,PIK3CA
PROS(CLOVES, FAVA, KTS)	PI3K3CA
Capillary malformation (CM)	GNAQ,GNA11
Blue Rubber bleb nevus syndrome	TEK/TIE2
Proteus Syndrome	AKT
Arteriovenous malformation(AVM)	KRAS,NRAS,BRAF,MAP2K1

Epidemiology: - Kennedy WP et al. reported the overall incidence of congenital VSMs as 1.08 % ranging from 0.83 to 4.5 % based on comprehensive review of 238 studies (12). Children and young adults are the majority of presenting patients as compared to the older age groups. No evidence of sex, race and predilection or socioeconomic predilection has been documented in the literature.

Role of Imaging:-

USG: - Ultrasound imaging is the initial modality of imaging in VSMs due to its advantages such as fast and real-time investigation, low cost and lack of ionizing radiations(5). Compressibility of vascular spaces, presence of phleboliths and presence of the thrombus can be easily detected. Colour and spectral doppler can help in characterising the flow of VSMs. Its limitations include inability to delineate extent of the disease especially in large and multicompartmental lesions. Contrast enhanced ultrasound (CEUSG) is the new entity for VSMs characterization, however it's accuracy for detection and characterization of type of VSM is under research. A useful application of CEUSG can be for follow-up to look for the response in patients treated with sclerotherapy.

MR imaging: - Non contrast MRI is a good modality for assessing the extent of the VSMs, however characterizing to specific malformation subtype becomes challenging. Hence utilization of contrast enhancement will help in confirming the lymphatic vs non-lymphatic types of vascular malformations. However, to characterise the flow in these subtypes

becomes challenging if dynamic contrast imaging like time resolved sequences, example TRICKS (Time Resolved Imaging of Contrast Kinetics) are not employed. Use of gradient based sequences will help in detecting the phleboliths. Diffusion imaging is another important sequence to differentiate malignant tumours mimicking VSMs from VSMs. Including routine and fat suppressed sequences is obligatory as some hemangiomas may contain fatty component and fibrofatty replacement in a muscle is a feature of FAVA. Thus MRI plays a significant role in not only diagnosing VSMs but also ruling out other differential diagnosis with added advantage of using nonionizing radiations.

Computed Tomography: - Non contrast CT provides limited information to detect particular subtype of VSMs, although lesion extension can be fairly ascertained. Phleboliths can be picked up early by CT. CT angiography can be utilized in the situations when MR is not available, which will certainly rule out high flow vascular malformations. Due to its high ionizing radiation dose and inability to characterize nature of soft tissue lesion accurately its role in VSMs is limited.

Conventional Radiographs:- plays insignificant role to characterize the VSM, however it can help in assessing bone involvement such as hypertrophy, hypotrophy, erosions , pathological fractures and periosteal reactions(6). Detecting phleboliths on radiographs is another added advantage.

Phlebography and Digital Subtraction Angiography (DSA):- Phlebography (direct nidus opacification) and angiography can be cultured in the management whenever USG and MRI fail to give the diagnosis or in cases of any ambiguity. These act as a problem solver and are also useful for preoperative assessment for sclerotherapy and embolization. By directly puncturing the nidus the flow patterns and volume can be easily evaluated(7). Limitations mainly include the invasive nature, painful procedure and high radiation exposure which occurs during angiography.

Subtypes of vascular malformations and their characteristics

As such vascular malformation types are numerous. However basic understandings of simple vascular malformations is imperative for diagnostic radiologist.

Venous malformation:-

These are the most common VSMs encountered in the routine OPDs. VMs arise due to errors occurring in the venous connection leading to complex dilated networks of veins. These dilated veins are said to be dysfunctional as it lacks the smooth muscle within its walls. (5) It can be unicompartmental or multicompartmental. It can occur almost equally in all the parts of the body such as head and neck, extremities or trunks. VMs are said to occur congenitally however the expression of symptoms usually occur in the adolescent or early adulthood. Symptoms can range from mild pain, swelling to bleeding, severe pain and occasionally functional limitations based on the location and extent of the lesion. There can be diurnal variation in lesions present in the extremities, as they engorge with the gravity and decrease on elevating a limb or compression massage. Sudden enlargement can happen, if there is intralesional thrombus formation or following trauma(8). D-dimers are found to be elevated in cases of painful venous malformation having thrombus in upto 45% cases(9).

On grey scale images, the VMs are most commonly heterogeneous lesion, largely contain hypoechoic area and rarely hyperechoic areas. Phleboliths are said to be pathognomonic, although are seen in only upto 16% of cases (10). Usually VMs shows monophasic low flow on colour doppler, however it is not rare to find no flow or just noise even with lowest pulse repetition frequency. Biphasic waveform can suggest the possibility of capillary component within VMs (10). The mere presence of vessels with arterial flow within it doesn't make it AVM or neoplasm, instead these can be a neighbouring vessels which are harmlessly traversing though the malformation(8). Radiographs can demonstrate phleboliths. CT scans can pick up early/tiny phleboliths, adjacent bone changes and gross soft tissue extension. But MRI plays an imperative role in proper diagnosis and characterization of VMs. These are hypo to isointense on T1WI, hyperintense on T2WI. Sometimes T1 hyperintensities can be seen in the lesion because of fat or thrombus. T2 hypointense foci can be secondary to phleboliths, which can be confirmed on gradient images or other imaging modalities. Layering of hemorrhages can lead to fluid-fluid levels (11). Wide variety of contrast enhancement pattern can be seen on postcontrast T1 images ranging from subtle heterogeneous to homogeneous pattern. Dynamic contrast imaging shows venous phase filling of contrast either in the form of puddling, or channel type filling. Direct puncture phlebography (DPP) allows visualisation of VMs with their flow characteristics and draining pattern.

Dubois et al. classified VMs into 3 morphological patterns (12) (Figure 2)

a. Spongy pattern-consisting of honeycomb cavities and late venous drainage,
b. Cavitatory pattern-consisting of a predominant cavity, which is said to be most common type and
c. Dysmorphic pattern-consists of varying sized dysmorphic veins.

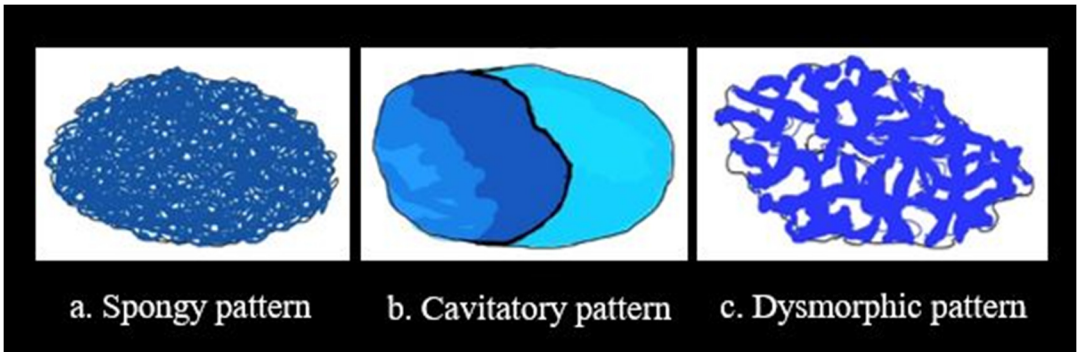


Figure 2:- ***Dubois classification of VMs***

Puig et al. classified these venous malformations into 4 types based of DPP as follows(13)(Figure -3)

1. Type I-Isolated (almost) lesions without venous connection.
2. Type II- lesions that drain into normal veins.
3. Type III- lesions with drainage into dysplastic veins;
4. Type IV- lesions composed of venous ectasia.

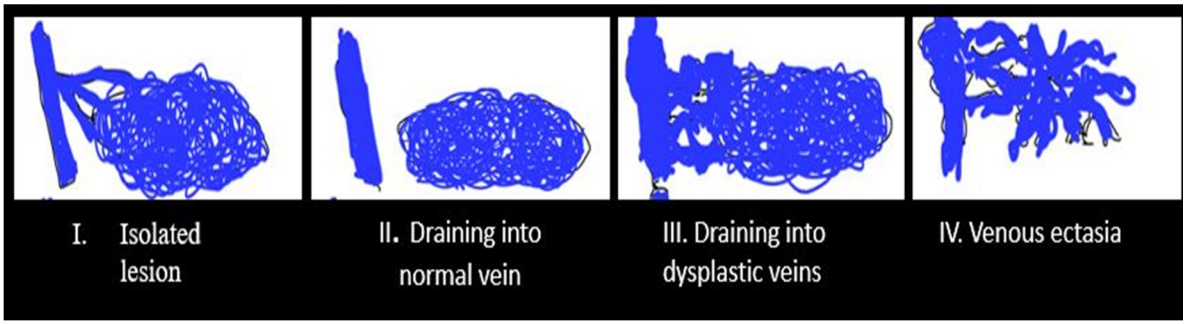


Figure 3:- Classification of VMs by Puig et al.

Lymphatic malformations:-

Lymphatic malformations (LMs) occur as result of sequestration of lymphatic channels with resultant secretion of fluid into the cavity by its wall. The accumulation of fluid can result in various symptoms with predominant presentation as swelling. These are usually multicystic in nature. Head and neck is common site for these LMs upto 75%(14). The cysts can be of variable sizes. Based on the sizes of the cysts within LMs, it is divided into macrocystic (>1cm) or microcystic (<1 cm) (15). However most of the lymphatic malformations are composed of both macro and microcysts. Hence a further classification was proposed by Dubois et al (15) based on the percentage of macrocysts within these lesions –

A->70% macrocysts,
B- Between 40% and 70% macrocysts and
C- < 40% macrocysts.

Microcystic type were further classified into 3 types based on the fluoroscopic characteristics by Malic et al(16) –

1. Open cell type-where there is free interconnection between cysts,
2. Closed cell type in which no intercystic communications and
3. Lymphatic channel type.

The lesions can sometimes come to notice due to sudden hemorrhage within these cysts or secondary infections.

On ultrasound they appear as anechoic cysts with multiple sepatations (multicystic and multispetated) with flow at the septae. Unlike venous malformations, these are non-compressible or sometime mildly compressible. It may contain echogenic debris, secondary to intralesional hemorrhage or high protein contents. On MR imaging LMs can be hypo, iso or mildly hyperintense on T1WI, hyperintense on T2WI. Neither dynamic contrast nor post contrast studies show filling of contrast within cysts except subtle enhancement of the septations and walls of these cysts. Similar imaging can be seen in complex ganglion cysts adjacent to the joint cavity, which can be easily differentiated based on the history and contents within it.

Capillary malformations:-

Capillary malformations (CMs) are results of abnormal proliferation of network of capillaries frequently seen in the dermis and subcutaneous tissue causing pinkish discoloration of skin, notably known as port wine stain. They are usually congenital and do not involute (5) unlike hemangiomas. Most of them are seen on face, however can occur at any part of the body. They may occur alone or combined, along with others malformations in combined malformations or malformation associated syndromes. The CMs presenting one side of face with involvement of ipsilateral ophthalmic division of trigeminal nerve, should raise the possibility of Sturge weber syndrome (5). They are most often diagnosed clinically. CMs appear as hypoechoic areas in the dermis and subcutaneous tissue with extensions range from 0.2 to3.5mm thickness(17). On MRI they can be appreciated as skin thickening with subtle signal abnormality (18). Contrast enhancement may or may not be seen in CMs.

Arteriovenous malformations and fistula:-

These two entities are considered under High flow vascular malformations. Essentially there is abnormal shunting of arterial blood into the veins directly (AVF) or indirectly via a intervening nidus (AVM) in these lesions (19). As a result, there is oxygen and metabolic insufficiency in the adjacent organ eventually resulting in ischemia, necrosis and ulceration. Hypoxia triggers biomarkers involved in vasculogenesis such as VEGF, TGFs and metalloproteinase leading to a constant feedback loop causing abnormal proliferation of vessels.(20)

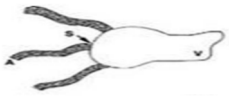
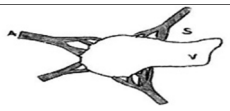
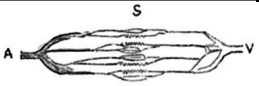
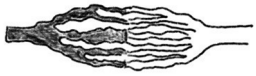
On examination the overlying area appears warm with palpable thrills/bruits. Clinically AVMs can present in these 4 stages as said shown in the Figure 4 by Schrobinger et al (21)

Table 4:- Clinical classification of AVM by Schrobinger et al.

Stage I	**Quiescence**: may or may not have vascular skin stain, warmth of the affected tissues, and arteriovenous shunts can be detected by doppler ultrasound. The arteriovenous malformation is present but causes no clinical symptoms.
Stage II	**Expansion of arteriovenous malformation lesion**: Stage I plus enlargement, pulsations, palpable thrill, audible bruit, and enlarged arterialized tortuous/tense veins.
Stage III	**Destructive tissue changes**: Stage II plus dystrophic skin changes, skin ulcerations that can be nonhealing, bleeding from ulcerated skin or mucosal surfaces, overt tissue necrosis, and lytic lesions of bone may occur.
Stage IV	**Decompensation**: Stage III plus **congestive cardiac failure** with increased cardiac output, abnormally lowered peripheral vascular resistance, and venous hypertension secondary to tissue and skin changes.

Few literature articulates AVF as a type of AVM. On ultrasound, there can be tortuous conglomeration of vessels with low resistant arterial waveform and high vessel density. Connecting channels will have turbulent flow and the venous end contains pulsatile high velocity flow. CT can reasonably delineate the pathology well by demonstrating early draining dilated veins from the arterial shunting showing serpentine and enlarged feeding arteries. MRI show flow voids on Spin Echo sequences, with corresponding high signal on gradient echo sequences. Dynamic contrast studies reveal nidus and shunting of vein in arterial phase and postcontrast imaging reveals arterial enhancement. DSA is gold standard in diagnosis as well as preoperative planning of AVM. Cho et al. divided these 3 types as described in the Table 5 (22). From treatment perspective, nidus can be divided into focal or diffuse type. Focal variants are relatively easier to treat than the diffuse variety.

Table 5:- Cho's Angiographic Classification of AVM

TYPE I		Not more than three different feeding arteries shunt to a single draining vein which is a single direct arteriovenous fistula
TYPE II		Multiple arterioles shunt to a single draining vein
TYPE IIIA		Non-hypertrophied arterial feeders are connected to multiple non-hypertrophied draining veins.
TYPE IIIB		Multiple hypertrophied feeding arteries are connected to multiple hypertrophied draining veins

Combined vascular malformations:

These are combination of various subtypes of low flow malformations or low flow with high flow malformations. Identifying them accurately is crucial as it directly incriminates the outcome for VSMs. Because of the complex nature of these lesions, their treatment and response requires multidisciplinary effort and long term follow up (1).

Vascular malformations of the major vessels:

This category involves anomalies in number, origin, length, course and diameter (aplasia, hypoplasia and ectasia/aneurysm) of any large-caliber vessel. For example persistant sciatic vein or lateral marginal vein is also considered under this category(5).

Associated with other anomalies:

These are the group of syndromes with underlying specific genetic mutations. There can be involvement of visceral vascular malformations upto 40% patients who have extensive cutaneous and soft tissue malformations(5). Some of the syndromes are highlighted in the following Table 6.

Table 6:- Syndromic associations of vascular malformations.

SYNDROMES	FEATURES
Klippel-Trenaunay syndrome	CM + VM +/-LM + limb overgrowth
Parkes Weber syndrome	CM + AVF + limb overgrowth
Servelle-Martorell syndrome	Limb VM + bone undergrowth
Sturge-Weber syndrome	Facial + leptomeningeal CM + eye anomalies +/-bone and/or soft tissue overgrowth
Maffucci syndrome	VM +/-spindle-cell hemangioma + enchondroma
CLOVES syndrome	LM + VM + CM +/-AVM+ lipomatous overgrowth
Proteus syndrome	CM, VM and/or LM + asymmetrical somatic overgrowth
Bannayan-Riley-Ruvalcaba syndrome	CM, VM and/or LM + asymmetrical somatic overgrowth
CLAPO syndromes	lower lip CM + face and neck LM + asymmetry and partial/generalized overgrowth

Provisionally unclassified:-

This contains few heterogeneous group of newly diagnosed vascular malformations as shown in the Table -1. All these entities have different genetic etiology. More studies are required to classify them systematically. One important example amongst these is Fibroadipose Vascular Anomaly (FAVA). It predominantly affects adolescent female and typically presents with swelling, pain without any cutaneous discolouration.

Treatment in Vascular malformations:-

Treatment of vascular malformation is topic of debate in the present-day situation. There is radical increase in the incidence of the VSM with increase in recognition of these entities mostly due to modern radiological imaging and increase in awareness amongst patients. But complete treatment and robust guidelines are sparse in the literature. Paediatricians, otorhinolaryngologists, general surgeons, pediatric surgeons, plastic surgeons and interventional radiologists are some of the branches of medicine involved in management of VSMs. It has been found in many studies that treatment requires multidisciplinary approach. Despite the integrated approach and latest available treatment methods it is difficult to completely treat malformations. Therefore, the primary goal of the treatment should be focused on improving the quality of life of these patients. Symptomatic relief combined with radiological remission should be assessed whilst evaluating response criteria for VSMs.

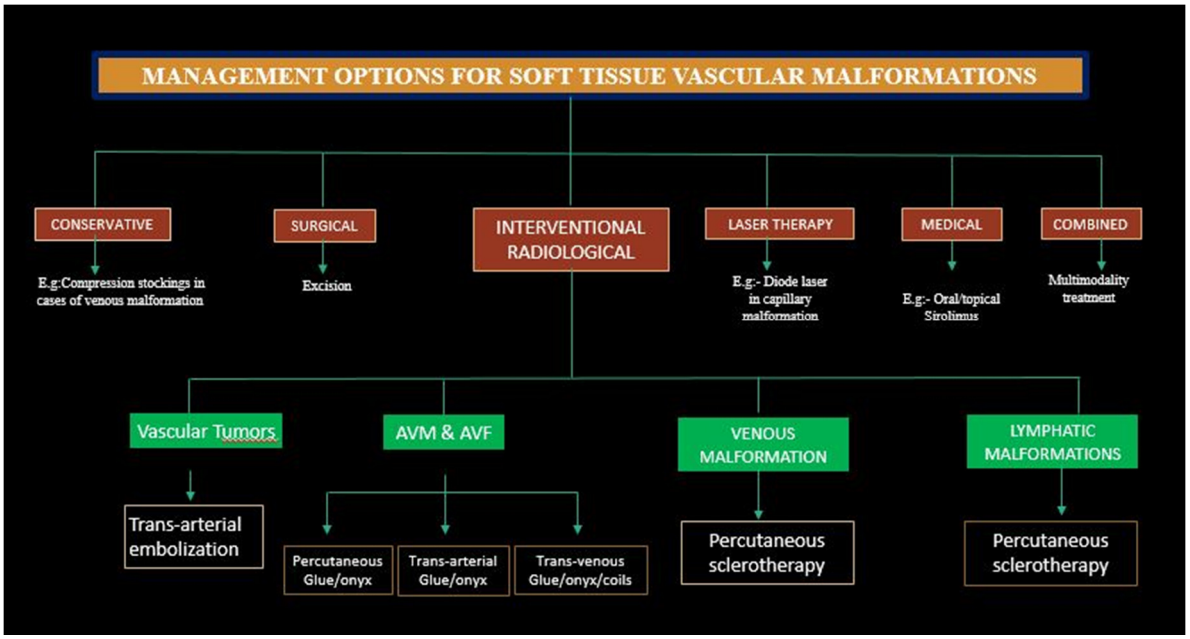


Figure 4:- A brief overview of management of VSMs

1) Interventional radiology:- Image guided intervention and percutaneous techniques are the first line therapies in modern day practice for the treatment of vascular malformations irrespective of the subtypes, except capillary malformations (23). Polidocanol, bleomycin, sodium tetradecyl sulphate (STS), absolute ethanol, polyvinyl alcohol, ethanolamine oleate, n-butyl cyanoacrylate, foam and various types of coils and polymer microspheres can be employed in the treatment as described below in the Table 7.

A. LM/VM- Percutaneous sclerotherapy is the preferred IR technique widely used in the venous malformations. Different sclerosant agents can be used as described in the table 7. No evidence of superiority of single sclerosant agent has been established so far. Different methods/techniques for sclerotherapy has been described. Introduction of sclerosant is after creating its foam is the most commonly used and effective method and is called as Tessari technique. Sclerosant is taken inside a 5cc syringe and connected to 3 way stopcock which is in turn connected with another syringe containing equal amount of air. Now both of them are agitated in to and fro motion, producing a foam sclerosant. This results in increased viscosity which further increases the dwell time. Though complete disappearance of the entire malformation is rare, but sclerotherapy alleviates the symptoms and results in contraction of the lesion (24). Multiple settings are usually necessary and the same should be counselled to the patients. Sometimes there can be recanalization and additional few settings can be required after 6 months to 1 year.

TECHNIQUE OF SCLEROTHERAPY:-

It can be 1) Basic or 2) Sclerotherapy with Adjunctive stasis of efflux techniques (SATSE).
Informed consent and adequate part preparations are the initial steps. Following that vascular access is achieved with proper cannulation of desired vessel which leads to a successful administration of therapeutic agents. 21 to 25 G butterfly needles can be used for superficial lesion and spinal needles can be used for the deeper lesions. Improper cannulation leads to extravasation of contrast which will have drastic complications such as compartment syndrome, adjacent area of necrosis etc. Sclerosants should be used as per institutional protocol or as per clinician's choice. A contrast run has to be taken initially to know the characteristics of VM/LM, its drainage pattern and/or draining veins. Amount of contrast agent required to fill the channels of the malformations should be approximately considered as amount of sclerosant needed for treatment, keeping in mind of the upper limit of every

sclerosant respectively. Although multiple sclerosants available none of the prospective studies are conducted which says the supremacy of one over the other(25).

Table 7:- Embolising agents used in treatment of VSMs.

Agent	Subtype	Mechanism	Advantages	Disadvantages
Ethanol	VM, LM	Endothelial damage, Denaturation of blood proteins and Thrombus formation	Highly potent Fast action Less expensive Easy to obtain	Painful Skin blisters Nerve damage Muscle contracture DVT, Pulmonary thromboembolism
Polidocanol (95% hydroxypolyethoxydodecane)	Varices, VM, LM	Dehydration of endothelial cells leading to occlusion	Intrinsic local anaesthetic effect	Reversible cardiac arrest Slow recanalization.
Sodium tetradecyl sulfate (STS)	VM	Intimal necrosis	Less side effects	Slow recanalization
Ethanolamine Oleate	VM	Thrombus formation	Less penetrative into the vascular wall and hence less neurological complications.	Acute renal injury due to haemolysis
Bleomycin (antitumor cytotoxic antibiotic)	LM>> VM	Nonspecific inflammatory reaction	Similar efficacy as alcohol in	Pulmonary fibrosis (Long term usage and

			superficial VM	high dosage) Hyperpigmentation Ulceration
OK-432	LM	Inflammation, cytokine release, increased endothelial permeability	Minimal systemic side effects in head and neck	Fever Pain Local inflammation
Onyx (Ethylene vinyl alcohol copolymer)	AVM/ AVF	Cohesive property-causing precipitation	Non-adherence, progressive solidification	Skin discolouration due to tantalum powder.
Glue	VM/AVM/AVF	Adhesive property-causing polymerization	Preop bleeding prevention	Perivascular inflammation. Catheters blockage

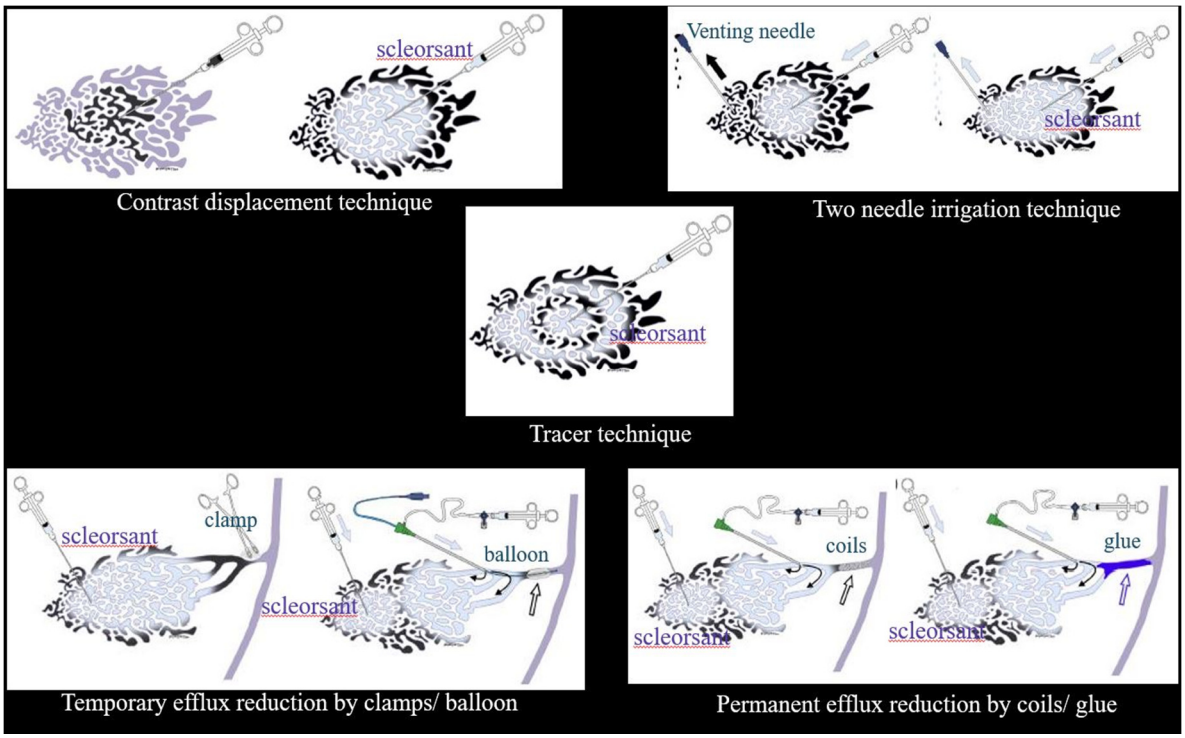


Figure 5:- Different Techniques of sclerotherapy

(Source- Legiehn GM. Sclerotherapy with Adjunctive Stasis of Efflux (STASE) in Venous Malformations: Techniques and Strategies. Techniques in Vascular and Interventional Radiology. 2019 Dec; 22(4):100630.**)**

Tracer technique- Administration of small amount of contrast after the initial instillation of sclerosant which forms concentric rings of white and dark rings.

Contrast displacement technique: - The administrated sclerosants (white-without contrast mixture) displaces the previously administered contrast agents peripherally.

Two needle irrigation technique: - Two needles are placed in a lesion, and 1 is used to vent out the previously administrated contrast agent and another one is to inject the sclerosants thereafter.

STASE technique(26):- When a lesion has a prominent draining vein, most of the sclerosant injected will directly get vanished from the lesion, hence the sclerotherapy is less successful. To prevent this the outflow of venous channels can be blocked leading to stasis of contrast which increases the dwell time and accelerate effectiveness of sclerosants. Outflow can be limited by temporary or permanent methods. Temporary method includes external

compression by gauze or clamps, temporary balloon occlusion. Permanent methods include coil embolization or glue embolization of outflow tracts.

Direct visualisation of these sclerosants during its administration into the lesion can be done by ultrasonography, wherein these channels are seen getting replaced by dirty shadowing created by the sclerosant foams.

B. **AVM/AVF-** Endovascular embolization is the treatment of choice of treatment in symptomatic AVM/AVF (27). Schrobinger I and II classes didn't require any treatment in study conducted by for a mean period of 5.6 years(28). Stage III and IV should be treated as there is high chance of complications. The intervened AVM to be characterized based on the pattern of formation of arteriovenous shunting. Whenever there is single draining vein, it is recommended to do a venous occlusion using coils or vein sclerosis along with nidus embolization. This dramatically changes the response rate. Nidus embolization should be the main target. It can be achieved either by percutaneous approach or endovascular access and superselective embolization by using microcatheter. During percutaneous approach of the nidus, the embolising agents like glue should be refluxed into the supplying arterioles. Ethanol can be used where there is no proximity of vital structure or nerve coursing adjacent to it as it has high chance of transmural damage property. Glue and onyx are preferred agents as the complication rates are less than the ethanol. Endovascular plugs can be used at the venous end. However non-target proximal embolization and coiling should not be practiced as there is high chance of recruitment of new vessels by the nidus distally and thus leading to reformation of AVM.

2) **Surgical:-**

A. **LM- Macrocystic LMs** usually contain a well-defined borders which will have mass effect on adjacent structures. These are easily amenable for surgical resection. Preservation of neurovascular structures should be kept in mind helping in avoiding such complications. If it is impossible to spare neurovascular bundles, then only debunking is done. Incisions should be taken along the sin creases, especially in young children as there will be decreased chances of functional and/or cosmetic disability in the future.

Nowadays resections are usually done for sclerosant non-responsive vascular malformation or small lesion restricted to one plane.

Microcystic components are usually difficult to resect as they are more infiltrative and have less chance to get a clear dissection plane(29). However in some exceptional cases where microcystic LM are localised in a certain tissues such as superficial aspect of tongue or an extremity muscle, surgical excision can be preferred provided it is not associated with any disability.

B. **VM-** These are slightly different as compared to the LMs, surgically. VMs are made serpentine vessels with lack of muscular tissue within it which causes stasis, thrombosis and sometimes consumptive coagulopathy. This makes VMs potential risk factor for postoperative bleeding and poor outcomes. Surgical aim should be a staged process of reduction of the bulk rather than stout efforts excise entire lesion. Several principles can help in reducing the bleeding complications such as non-stick bipolar cautery dissection, use of tourniquets, identification of neurovascular bundles, wide exposure of surgical field. Gelfoam-soaked thrombin covered by surgical pledges can be used to stop diffuse bleeding if required (29).

C. **AVM/AVF**- Very challenging to treat for any surgeons with high rates of recurrences and complications. Only focal kind of AVM can be handled well by surgery, with preservation of adjacent structure. As the diffuse lesions are larger in size multimodality treatment should be offered to the patient (30).

3) **Laser therapy**: - ND: YAG laser is an excellent adjunct to selectively treat mucosal VMs using photothermolysis. Targeted ND: YAG laser will shrink VMs of mucosa, strengthen the mucosal walls, and help stabilize the airway. The ND: YAG laser technique involves polka-dotting the area of interest approximately 1 cm apart using 18-25 W and a 1second pulse duration. This procedure helps preserve overlying functional mucosa

4) **Medical management:** - It is well known that infantile hemangioma responds well with oral propranolol, however it has shown less effective in VSMs. Genetic derangements with understanding of pathways involved in the VSMs has revolutionised in recent years with advent of few novel drugs. One amongst them is oral Sirolimus, a mTOR inhibitor which has shown a decent response with regard to symptomatic and radiological relief and acceptable side effects(31). It can be used as OD oral dosage or as topical application for a period of 2 years. Complications related to sirolimus includes mouth ulcers,

peripheral edema, diarrhoea, impaired wound healing, headache, chest pain, abdominal pain, hypercholesterolemia, upper respiratory tract infection and pneumonitis. However detailed research and long term results are yet to be evaluated. Some of the other similar drugs include alpelisib (PI3K inhibitor) and miransertib (AKT inhibitor).

5) **Combined Therapy: -** It is usage of IR, surgical or laser methods in combination tailored according to the patient. It is said to be the best method when the vascular malformation is extensive. Superficial skin and subcutaneous components can be handles by using Nd: YAG lasers in case of VMs and Pulsed diode lasers in case of CMs. Use of embolization agents before surgery by interventional radiologists may help the VMs to contract and convert into hard mass, which can then easily be resected by surgeons(29). Super-selective arterial embolization followed by surgical resection is said to be gold standard treatment for AVM. Sirolimus can give added advantage if used along with surgery and can prevent overstimulation of vascular growth factor and prevent recruitment of new vessels (30).

6) **Conservative:** - Not necessary that all the VSMs have to be intervened. Because few percentage of the people will be always asymptomatic, for these category reassurance is required most often by explaining the non-neoplastic etiology to the patients. Sometimes the patient can be offered compression bands, asked to avoid certain activities, or NSAIDs according to the situation. Unnecessary intervention may cause more harm/introduce new symptoms which the malformation didn't have before per say.

PUBLISHED LITERATURES

- In a retrospective study conducted by **Michael E. Lidsky et al** (32) using a multidisciplinary approach included 135 patients. Among 105 low-flow vascular malformations (LFVM), 23(21.9%) underwent conservative management, 38 (36.2%) underwent sclerotherapy, 18 (17.1%) underwent surgery, and 8 (7.6%) were had combination of treatment. Of the 31 high-flow vascular malformations (HFVM), 8 (25.8%) underwent conservative treatment, 8 (25.8%) underwent transcatheter arterial embolization, 6(19.4%) underwent embolization followed by sclerotherapy, and 5(16.1%) were resected. Patients in all groups managed conservatively had minimal alteration in status. In LFVM group resulted in improvement in 84.2% by sclerotherapy group, 88.9% improved in surgical resection group, and 100% improvement in combination therapy. In HFVM 87.5% improved with embolization technique, 80% among surgical group and 100% improvement in combination therapy.

- In a retrospective study conducted by **Sumera Ali et al.**(33) total of 116 patients were included. 245 sclerotherapy sessions were performed. 2.5 months was the median follow up period from the last procedure. 37(32%) had significant improvement, 31(27%) had moderate improvement, 20 (17%) had mild improvement in, 21 (18%) had no improvement in and 7 (6%) worse than before. Major post-procedural complications were nerve injuries in 6 patients (5%), deep vein thrombosis in 5 (4%), muscle contracture in 2 (2%), infection in 3 (3%), skin necrosis in 4 (3%) and other complications in 3 (3%).

- In a study conducted by **Misbah et al**(34), 15 patients (8 male, 7female) with peripheral VSM. 10 had LFVM and 5 had HFVM. Sodium Tetradecyl sulfate (STS) was used 10 (66.67%), glue with lipoidal in 3(20.0%), and bleomycin 1 patient (6.67%). Coils with PVA and a covered stent were used in one and a combination of coil, PVA, and gel foam was used in one patient. 11(73%) patients had marked response and 4 had partial response. Foot gangrene was seen in 1 patient as complication. 1 had stent thrombosis without clinical consequences. 2 patients had recurrence. Sclerotherapy with or without embolization is a safe and effective treatment modality, with clinical response approaching 100%.

- In a study conducted by **Woo-Sung Yun et al.**(35), total 148 VM patients were included in the study who underwent sclerotherapy. Symptomatic improvement was seen in

28%. Based on imaging studies, 42 (27%) had markedly improvement. 16% of patients had a "good response". On multivariate analysis, female gender, no or delayed visualization of drainage vein, and a well-defined margin on MRI were independent predictors of "good response".

- In a study conducted by **Gulsen et al.**(36) 19 patients were included in study with 89 sessions of sclerotherapy. 4 (21%) patients had complete symptomatic recovery, 12 patient had moderate improvement (63%), Unchanged in 3 (16%). No major complications were encountered. 65 % encountered minor complications like pain and swelling which were resolved by taking NSAID within a few days.

- In a study conducted by **Tan et al.** (37) , a total of 226 treatment sessions were performed (mean, 3.1 sessions per patient; range, 1–13 sessions). After treatment, 11 (15%) were asymptomatic, 20 (28%) had marked improvement. 17 (24%) mildly improved, 20 (28%) were unchanged, and 4(5.6%) had worsening. 35 patients underwent MR imaging before and after treatment. The size of the VVM was seen to decrease in 19 patients (54%), be unchanged in 11 (31%), and increase in five (14%). A reduction in lesion size at MR imaging did not correlated with a positive clinical response. Infiltrative lesions had a poorer outcome when compared to localized lesions. There were 0 major complications and 7 minor complications.

- In a study conducted by **J.Delgado et al.**(38), technical success was 97%. 2.1 (range 1-5) was the mean number of procedures per patient. 33 procedures were followed up. Decrease in swelling, improvement of foot function and a significant decrease in pain ($p<0.003$) was reported. All patients improved after sclerotherapy. Percutaneous sclerotherapy is an effective option for treating foot VMs was their conclusion. Skin complication rates are higher with shorter VM-to-skin surface distance.

- In a study conducted by **Johanna Aronniemi et al.**(39), 127 patients who had received sclerotherapy for peripheral venous malformation were analysed. They applied Clavien–Dindo classification to grade the severity of complications. With a sample size of 127 treated case, overall complication rate was 12.5%. 83% was minor which was managed conservatively. 4(3.4%) severe complications related to blood coagulation. They used mainly

detergent sclerosants in 85.7%, and ethanol in 5.7% and bleomycin (4.2%). In 4.2% of the procedures combined glue, coils, endovascular laser or particles to sclerotherapy. Overall complication rate per procedure was 12.5%. Most complications (83.3%) were local and managed conservatively. 4 were severe complications. Subcutaneous lesion location and ethanol significantly increased the risk of local complications.

- In a study conducted by **Guevera et al.**(40), 17 patients were analysed. 24% of patients had complete resolution, 24 % had partial relief of symptoms without need for further intervention 35 % had some improvement. 2 minor complications were seen.

- In a study conducted by **Bagga et al.**(41) , 4.35 was the mean number of sessions in VM and 2.64 in LM. Among VM, 114 patients (51.1%) had excellent response to treatment (>60%) and 75.8% patients had an acceptable response (>30%). All LM patients had an acceptable response.

- In a study conducted by **Giurazza et al.**(42) vascular malformations were distributed 8 in the upper and 5 the in lower limbs, 2 in head and neck, and 1 in Trunk. At 6 month follow up clinical success were obtained in all cases, 81.2% had radiological success rate. No major complications 5 (31.2%) had minor complications

MATERIALS & METHODS

MATERIALS AND METHODS

STUDY DESIGN

Institutional ethics committee approval was obtained vide letter number: AIIMS/IEC/2019-20/989. This was a prospective observational study conducted in the department of Diagnostic and Interventional Radiology AIIMS JODHPUR, Rajasthan and included patients who presented between January 2020 to June 2021.

All the patients who were referred to the department of Interventional Radiology from various departments with clinical suspicion of vascular malformations were examined and further assessed by imaging modalities to confirm vascular malformation.

Informed written consent was obtained from every patient/guardian after detailed explanation of all aspects of the study as per the consent form (Annexures).

INCLUSION CRITERIA

1. All the patients who approached or referred to the department of Radiology from various departments having non-visceral soft tissue vascular malformations.
2. All patients who underwent treatment either conservative, interventional radiology (sclerotherapy/endovascular embolization) or surgery were included in this study.

EXCLUSION CRITERIA

1. Non-consenting patients
2. Hemangiomas and vascular tumours
3. Post traumatic vascular malformations
4. Previously treated vascular malformations

Study duration: One and half years.

Sample size: The sample size is calculated based on previously published study done by Lidsky et al. Assuming a population proportion of 1% prevalence of vascular malformations and sample proportion of 6% and alpha error of 5%, the, with 80% power the sample size is estimated to be 62.

Study design:-

- The patients who presented to outpatient facility or emergency wing of All India Institute of Medical sciences, Jodhpur with suspected vascular malformations were analysed using various imaging modalities (Radiographs/Grey scale-colour Doppler USG/CEMRI/CT angiography/Direct percutaneous phlebography).
- All the patients who were diagnosed based on multiple imaging modalities were subjected to the analysis after taking informed consent. In children <18years of age, consent of the patient were taken along with consent from their parents/guardian.
- Detailed demography, presenting symptoms, duration of symptoms were asked and detailed clinical examinations were performed.
- All the patients were explained in detail about their condition and the decision of treatment was decided after taking opinion from multidisciplinary team. The treatment groups included conservative, surgery, interventional radiology, and combination/combined therapy.
- Conservative groups are the ones who were having minimal symptoms and did not cause hampering of day today activity. This approach included patients which were either directed by multidisciplinary team or opted by patient/guardian (in case of <18years) only. In this group the patients were instructed either to wait or watch /provided with medications /instructed to use compression stockings (especially in case of low flow malformations) involving the extremities.
- The interventional radiology group consisted of the patients who underwent percutaneous sclerotherapies or endovascular embolization only as the treatment modality. As these modalities consisted of multiple sessions, the patients were asked to follow up after every 4-6 weeks for the treatment. Sclerotherapy was done in majority of the patients. End point of the sclerotherapy was defined as the state in which there were no compressible spaces to inject sclerosants or when the patient is completely free of the initial presenting symptoms.
- Surgical approach group consisted of patients who underwent surgical excision as the only treatment modality.
- Combined/combination group included the patient who underwent both interventional radiological techniques and surgical techniques as a method of treatment.

- Patient were evaluated at 1 week, 1month and at 3 months interval to look for any complications as directed by the history and a routine clinical examination and ultrasound check-up.
- Also any postoperative complications were looked for such as major complications (that requires either intervention or prolonged hospitalization such as extensive tissue necrosis, infection, haemorrhage) or minor complications (which don't need interventions or prolonged hospital stay)
- All the patients were re-imaged minimum after 3rd month (from last treatment session) using either USG or MRI to look for the status of vascular malformations. Pre and post treatment size using 3 dimensional volume technique (a*b*c/2) were obtained in all patients to determine the radiological outcome. Patients were simultaneously analysed for the symptomatic relief using 5 points scale, VAS pain scale and Global rate of change scale (GROC).
- At the end symptomatic and radiological outcome were obtained by the following methods.

- **RADIOLOGICAL OUTCOME (5 points scale)** (43)**:-**

Table 8:- 5 points scale to measure radiological outcome

1=Worsened
2=Unchanged
3=Mild response
4= Marked response
5= Near-complete/complete response

Worsened as defined as significant increase in the size of the lesion (>20% the initial presentation).

Unchanged was defined as malformations whose total size (volume) remained same as before or without much change (<20%) as compared to the pre-treatment condition.

Mild response was defined as malformation whose total size (volume) reduced 20-50% as compared to the pre-treatment condition.

Marked response was defined as malformations whose total size (volume) 50-90% as compared to the pre-treatment condition.

Near complete/Completely response was defined as the malformations whose total size (volume) reduced >90% as compared to the pre-treatment condition.

- **SYMPTOMATIC OUTCOME (5 points scale)**(43)**:-**

Table 9:- 5 points scale to measure symptomatic outcome

1=Worsened
2=Unchanged
3=Mild response
4= Marked response
5= Near complete/complete response

Worsened as defined as any kind of significant increase in the symptoms (>20% the initial presentation).

Unchanged was defined as patients whose symptoms was same as before or without much change (<20%) as compared to the pre-treatment condition.

Mild response was defined as patients whose symptoms have reduced 20-50% as compared to the pre-treatment condition.

Marked response was defined as patients whose symptoms have reduced 50-90% as compared to the pre-treatment condition.

Near complete/Complete response was defined as the patients whose symptoms have reduced >90% as compared to the pre-treatment condition.

GROC rating- Global rating of change scale was used to see symptomatic change after the treatment as per patient's opinion. This scale is being used in many articles as assessment of treatment response of vascular malformation.

Table 10:-GROC table for measuring symptomatic outcome

GLOBAL RATING OF CHANGE (GROC) SCALE		
A very great deal worse (-7)	About the same (0)	A very great deal better (7)
A great deal worse (6)		A great deal better (6)
Quite a bit worse(-5)		Quite a bit better (5)
Moderately worse (-4)		Moderately better (4)
Somewhat worse (-3)		Somewhat better (3)
A little bit worse(-2)		A little bit better (2)
A tiny bit worse(-1)		A tiny bit better (1)

Visual Analogue Scale (VAS) for pain: - For the clinical assessment of pain reduction pre and post visual analogue scale was used.

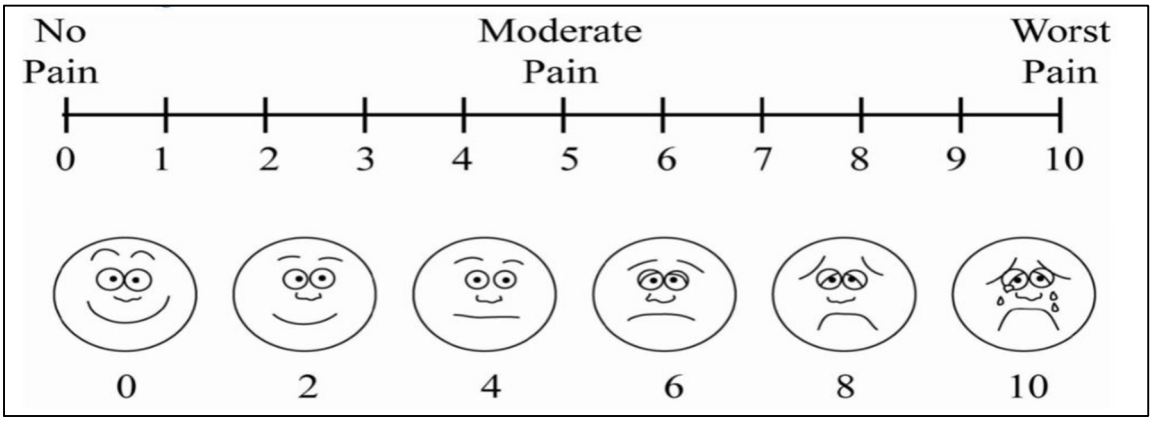


Figure 6:-Visual Analogue scale for pain (44)

ETHICAL CONSIDERATION

- Informed written consent was taken from all study patients/guardians of all the patients as per the attached performa. No pressure or coercion was exerted on patients for participation in the study.
- Confidentiality and privacy was maintained at all stages.
- Study involves imaging and therapeutic aspects that is part of standard care.
- No extra cost than usual was applied on patients.

STATISTICAL ANALYSIS

Calculations were done using SPSS software version 28. For numerical variables, arithmetic means and standard deviation were calculated. Analysis of means was done with Wilcoxon signed rank test (non-parametric analysis) between the groups. Cross tables were applied and Fisher's exact test was used to compare categorical variables. A p-value of less than 5 percent ($p<0.05$) was regarded as statistically significant.

OBSERVATION & RESULTS

OBSERVATIONS AND RESULTS

During the study period, a total of 98 patients presented / referred to radiology department in view of suspected vascular malformation. Out of these 2 did not give consent for the study. 9 patients were diagnosed hemangiomas and other 8 patients into rest of the soft tissue benign tumours. 6 patients had traumatic/infectious vascular disease. Out of 73 remaining patients 11 had lost to follow up after the initially imaging modality during the study. A total of 62 consecutive patients who fulfilled all inclusion criteria constitute the study group.

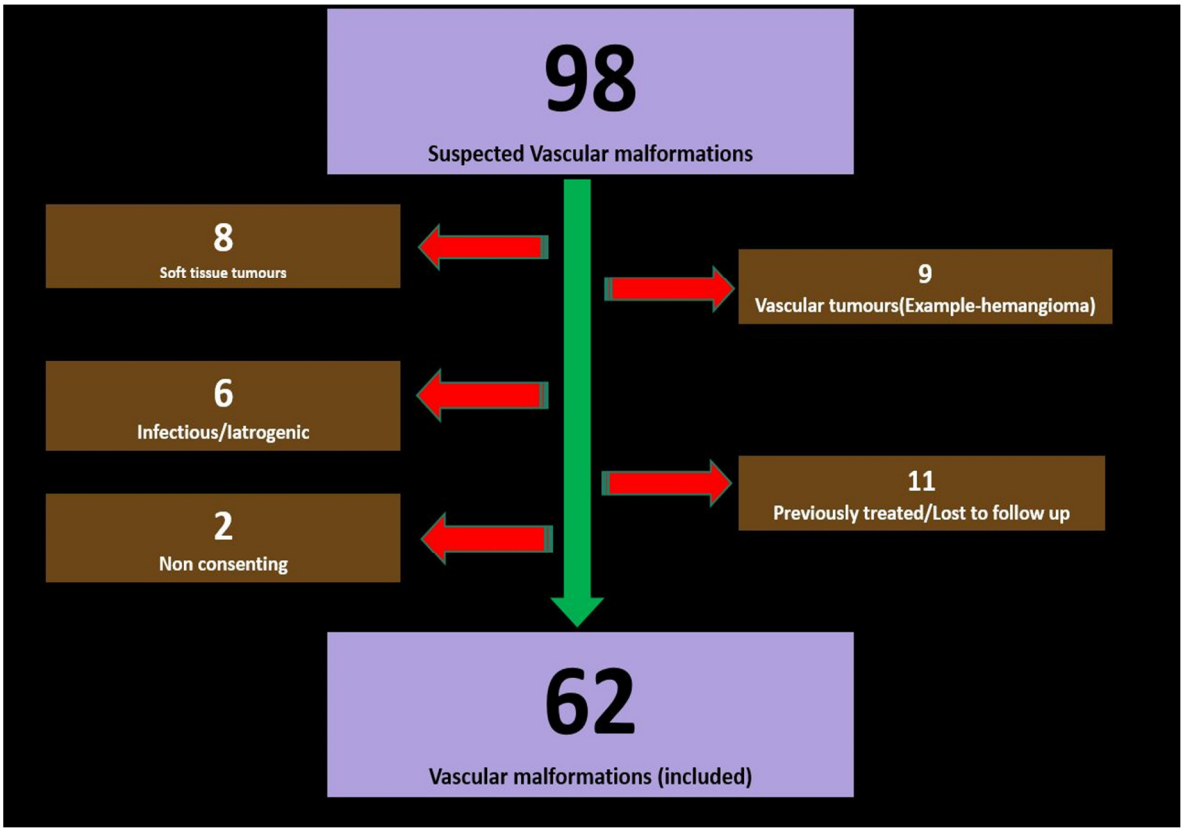


Figure 7:- Flow chart depicting the selection of study population

i) Gender distribution:-

Out of 62 patients, 38(61.3%) were males and 24(38.7%) were females.

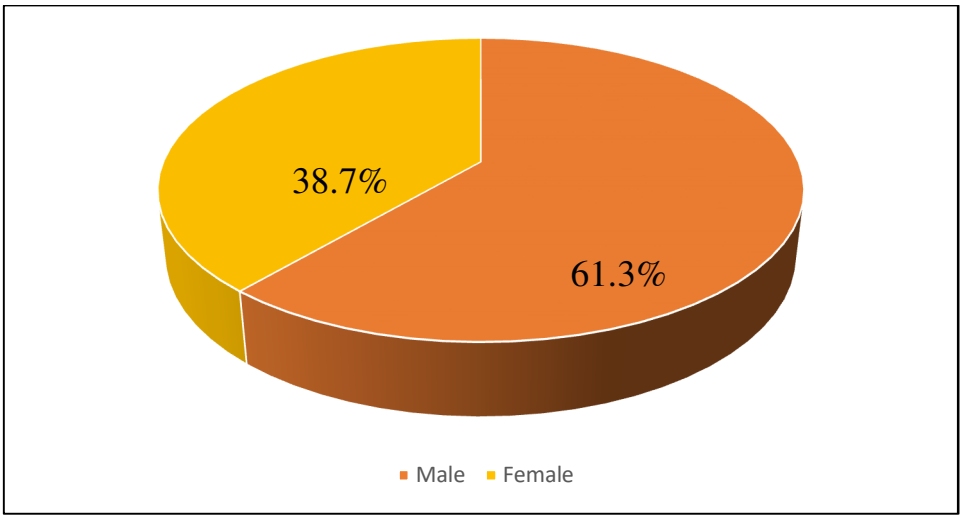


Figure 8:- Pie chart depicting the gender distribution in the study population

ii) Age distribution: -

Median age range of our study was 18 years, age ranging from 4 months to 64 years. Majority of the patients i.e. 41.9% belonged to 2nd decade. 88.8% of the patient belonged to <30 years of age suggesting that the vascular malformations mainly affects children and young adults. Only 1 patient had actually developed the symptoms after 50 years.

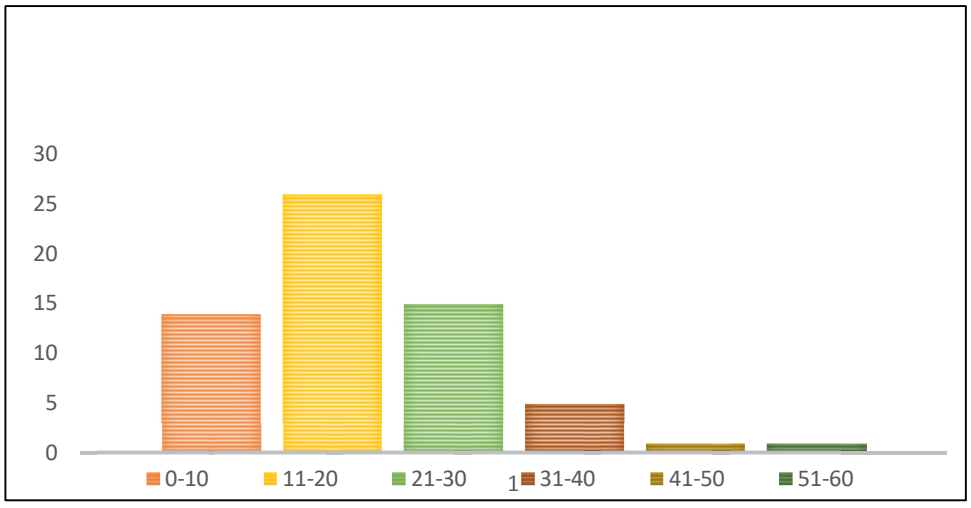


Figure 9:- Column chart depicting the age group distribution in the study population

iii) Presenting symptoms: -

Swelling was the dominant complaint which made the patient to come to the OPD in 90% of the cases, followed by pain in 50% of the patients. 4.8% limitation of movements due to proximity to the joints. 6.5% had ulcers. Acute bleeding was seen in 1 patient who was having venous malformation over tongue.

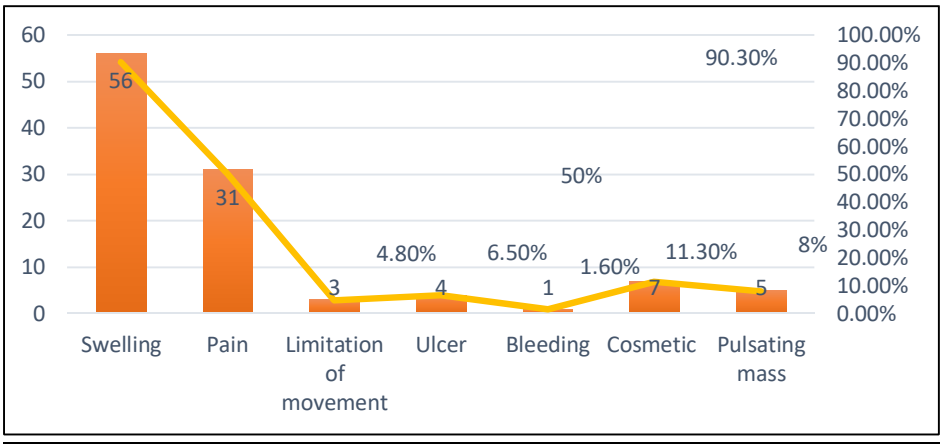


Figure 10:- Column chart depicting the distribution of presenting symptoms in the study population

iv) Distribution of vascular malformations: -

Head & Neck and Lower limbs were nearly equally involved with 37% and 36% respectively. 21% had upper limb involvement. Whereas trunk was least affected i.e.in 6% of patients only.

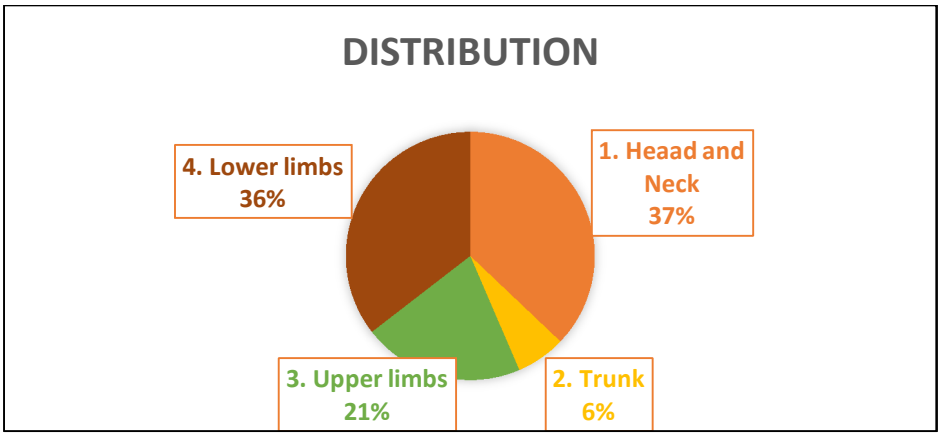


Figure 11:- Pie chart depicting the distribution of vascular malformation in the different parts of the body

v) Types of vascular malformations: -

Following are the different types of vascular malformations seen in the study. Majority (77.47%) were simple vascular malformations. Among all, venous malformation was the most common occurring in around 34(54.8%) patients followed by Lymphatic malformation in 8(13%). According to flow dynamics, 7(11.3%) were high flow and remaining 55(88.7%) were low flow malformations.

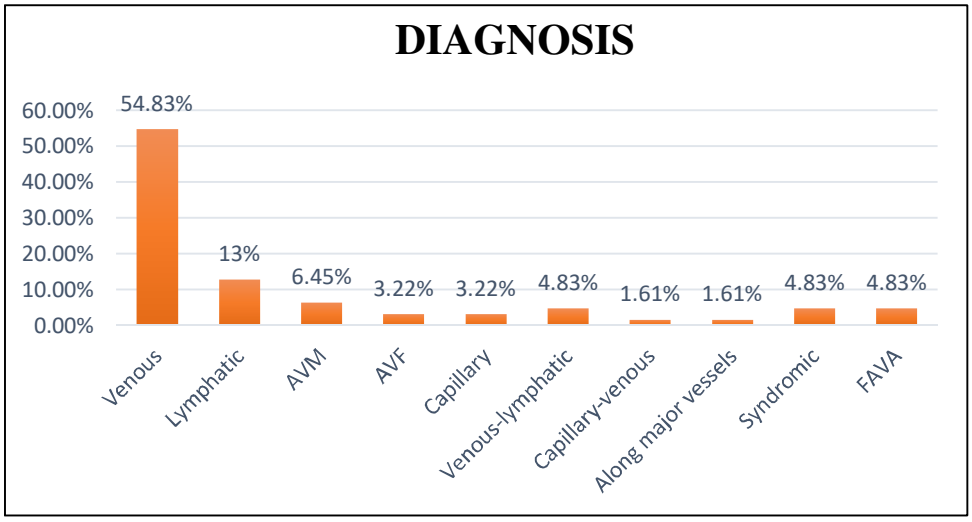


Figure 12:- Column chart depicting the different vascular malformations diagnosed in our study

vi) Incorrect use of terminology: -

A total of 35 patients had undergone some kind of imaging outside. Interestingly we observed 24 (68%) patients were mislabelled as hemangioma even after diagnosing its characters well.

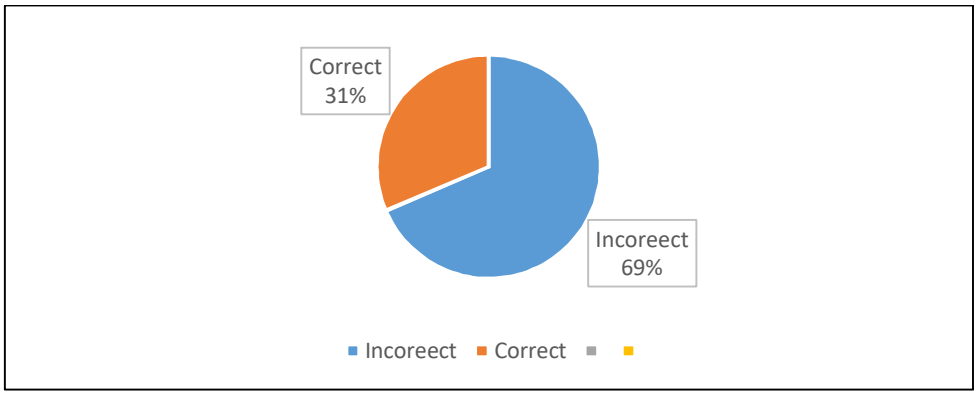


Figure 13:- Pie chart depicting the percentage of VMs having incorrect use of terminology before presenting to the department.

vii) **Phleboliths: -** Total 17(27.4%) patients had phleboliths. 16 patients had simple venous malformation and one patient had venous-lymphatic malformation. Taking 1.4% as the disease prevalence, sensitivity and specificity was calculated.

Table 11:-Statistics table for role of phleboliths in detecting simple venous malformation

Simple Venous Malformation	YES	NO	Total
Phlebolith present	16	1	17
Phlebolith absent	19	26	45
Total	35	27	62

STATISTICS	VALUE	95%CI
Sensitivity	45.71%	28.83% to 63.35%
Specificity	96.30%	81.03% to 99.91%
Positive Predictive Value	14.9%	2.42% to 55.37%
Negative Predictive Value	99.2%	98.92% to 99.42%
Positive Likelihood Ratio	12.34	1.74 to 87.36
Negative Likelihood Ratio	0.56	0.41 to 0.77
Accuracy	95.59%	87.11 o 99.17 %

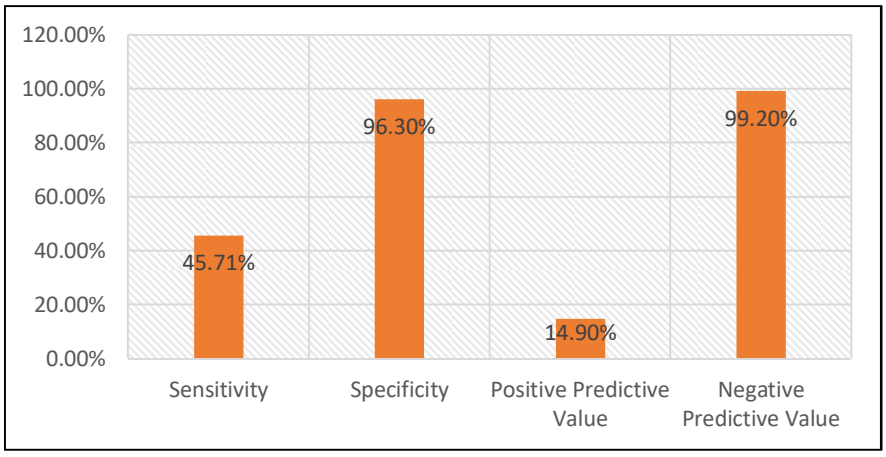


Figure 14:- Column chart depicting sensitivity, specificity, positive predictive value and negative predictive value of phlebolith in case of simple venous malformation.

viii) Diagnostic utility of USG, Non-contrast MRI and CEMRI with TRICKS:-

For diagnosis: - USG alone was able to diagnose 64% of the vascular malformations accurately, Addition of non-contrast MRI lead to 3% increase in the diagnosis. However CEMRI with TRICKS was able to diagnose the disease in 95.1% of the cases.

Table 12:-Role of imaging modalities in independently diagnosing subtype of VSMs

USG alone	64%
USG with Non-contrast MRI	67%
CEMRI with TRICKS	95.16%

For disease extension:- USG alone was able to measure the vascular malformation size accurately in 29.03%, while non-contrast MRI could correctly measure in 93.54% of the cases and CEMRI with TRICKS certainly measured accurately in all the cases.

Table 13:- Role of imaging modalities in depicting the extension of the VSMs

USG alone	29%
Non-contrast MRI	93.54%
CEMRI with TRICKS	100%

ix) Treatment modalities used: - Among 62 patients, 42% patients underwent IR techniques as sole modality of treatment. 38.8% were on conservative group. 9.6% had undergone surgery alone and 9.6% had underwent both surgery and IR procedures.

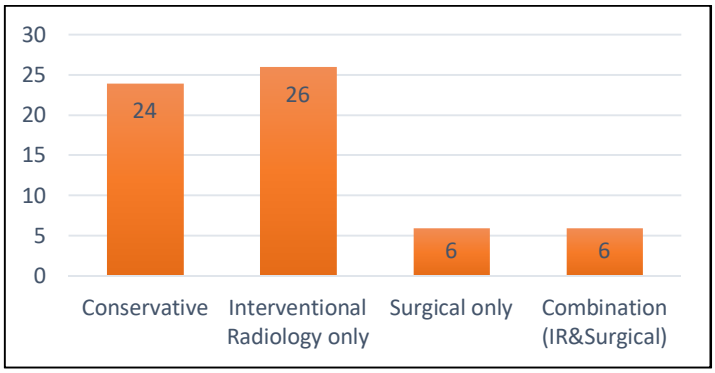


Figure 15:- Column chart depicting the number of patients undergoing various treatment modalities.

- A total of 70 interventional radiology sessions were performed (2.1 session per patient, range 1-5). Among these 38 were usg guided alone and 32 included use of fluoroscopy. Amongst low flow vascular malformation 25 patients were treated with 3% polidocanol, 1 patient with sodium tetradecyl sulfate (STS), 1 with bleomycin. Average 3ml of foam sclerosants were used per session with an average of 8.7ml/patient. In high flow vascular malformations 4 were treated with Glue: lipiodol combinations and 1 with gel foam.

IX) Treatment Outcomes:-

a. Conservative group- Among the conservative groups most of the patients were in stable disease both symptomatically (79.1%) and radiologically (83.3%). Only 1 patient of cervical lymphatic malformation had shown marked reduction in the disease. 3(12.5%) patients had increase in the size of the disease during the course, however only 1(4%) patient had increased in symptom. None of the patient had complete resolution.

Table 14:-Symptomatic and radiological outcome in conservative group

CONSERVATIVE GROUP	SYMPTOMATIC OUTCOME	RADIOLOGICAL OUTCOME
Near complete/Complete response	0	0
Marked response	0	1(4.1%)
Mild response	4 (16.6%)	0
Stable disease	19(17.1%)	20(83%)
Worsened	1(4.1%)	3(12.5%)

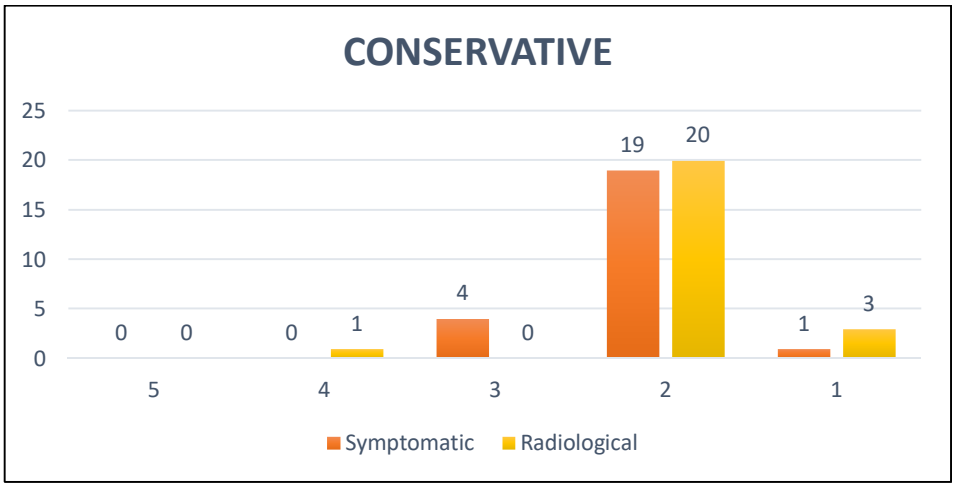


Figure 16:- Column chart depicting treatment outcome in conservative group

b. IR group- Among the patients who underwent sclerotherapy/embolization under interventional radiology, 38.6% marked reduction, 26% had mild reduction and 3% had near complete reduction on imaging. Majority (42%) had marked reduction in symptoms and 23% had near complete/complete reduction of symptoms. Only 1(3.8%) patient persisted with symptom and 6(23%) had radiologically stable disease. One patient had symptomatic worsening.

Table 15:- Symptomatic and radiological outcome in IR group

CONSERVATIVE GROUP	SYMPTOMATIC OUTCOME	RADIOLOGICAL OUTCOME
Near complete/Complete response	6(23%)	3(11.5%)
Marked response	11(42.3%)	10(38.46%)
Mild response	7(26.9%)	7(26.9%)
Stable disease	1(3.8%)	6(23%)
Worsened	1(3.8%)	0

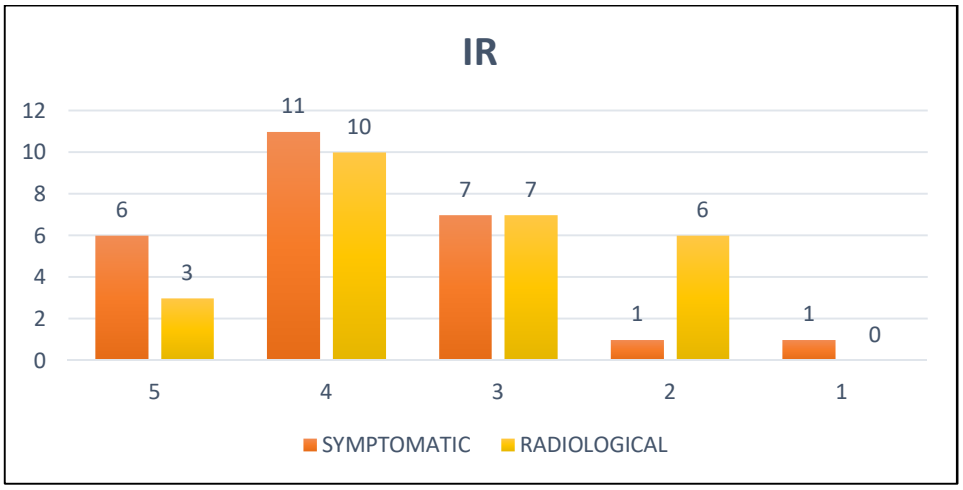


Figure 17:- Column chart depicting treatment outcome in IR group

c. Surgical and combination group- Among the patients who underwent surgery 66.6% had near complete reduction in the size and 66% had marked reduction in the symptoms. None of them showed worsening in a follow up period. Results were nearly similar in case of combined approach with slightly better symptomatic improvement when compared to surgical group.

Table 16:- Symptomatic and radiological outcome in surgical and combination modalities

	SURGERY		COMBINATION	
	SYMPTOMATIC OUTCOME	RADIOLOGICAL OUTCOME	SYMPTOMATIC OUTCOME	RADIOLOGICAL OUTCOME
Near complete/Complete response	1(16%)	4(66.6%)	2(33.3%)	4(66.6%)
Marked response	4(66.6%)	2(33.3%)	4(66.6%)	2(33.3%)
Mild response	1(16.6%)	0	0	0
Stable disease	0	0	0	0
Worsened	0	0	0	0

Table 17:- Summary of treatment outcome of different groups

	CONSERVATIVE		IR		SURGERY		COMBINATION	
	S*	R*	S*	R*	S*	R*	S*	R*
Near complete/Complete response	0	0	6 (23%)	3 (11.5%)	1 (16%)	4 (66.6%)	2 (33.3%)	4 (66.6%)
Marked response	0	1 (4.1%)	11 (42.3%)	10 (38.4%)	4 (66.6%)	2 (33.3%)	4(66.6%)	2 (33.3%)
Mild response	4 (16.6%)	0	7 (26.9%)	7 (26.9%)	1 (16.6%)	0	0	0
Stable disease	19 (17.1%)	20 (83%)	1 (3.8%)	6 (23%)	0	0	0	0
Worsened	1 (4.1%)	3 (12.5%)	1 (3.8%)	0	0	0	0	0

*S=Symptomatic outcome R=Radiological outcome

X) Other objective outcomes:-

Through IR modality there was 27% reduction in the overall size of the lesion. Surgery and Combined method were good at reduction of the overall size of the lesion. Only 3% reduction in total volumes were seen in conservative group. However, surgery and combination modalities had 91% and 98% reduction in volumes of VSMs respectively.

Table 18:-Difference in mean volumes of pre and post treatment volumes of VSMs in various treatment modalities

	PRE-TREATMENT SIZE (cc)	POST-TREATMENT SIZE (cc)	RESPONSE
Conservative	10921	10743	3% reduction
IR	1234.3	780.1	27% reduction
Surgery	237	22	91% reduction
Combination	687	16.9	98% reduction
TOTAL	13080.9	11562.22	22% reduction

Symptomatic reduction- According to GROC scale, the mean value was 3.4 which refers to moderate better in the overall symptoms. Surgery and Combined method had overall good means scores of 4.3 and 5.3 respectively.

Table 19:-GROC scale as symptomatic outcome measurement of VSMs

TREATMENT MODALITY	GROC scale	
	Mean	**S.D**
Conservative	0.6	1.2
IR	3.4	2.2
Surgery	4.3	1.6
Combination	5.3	1.2
Overall	2.6	2.4

Wilcoxon signed rank test was performed to look for significance of treatment response. Pre and Post pain scores were taken as symptomatic criteria. Pre and post treatment volumes were taken as radiological criteria. Interventional radiology method showed highly significant symptomatic and radiological reduction.

Table 20:-Statistical analysis of difference in treatment outcomes measured symptomatically and radiologically

WILCOXON SIGNED RANK TEST	SYMPTOMATIC REDUCTION (PAIN)		RADIOLOGICAL REDUCTION (VOLUME)	
	z	p value	z	p value
Conservative	-0.5	0.56	-1.3	0.57
IR	-4.2	**<0.001**	-4.03	**<0.001**
Surgery	-2.2	**0.03**	-2.2	**0.02**
Combination	-2.1	**0.02**	-2.2	**0.02**

XI) Complications: - Among interventional radiology, 53% had minor complications such as increase in severe pain and swelling mainly in the 1st week. It resolved with either an anti-inflammatory or analgesic medication. No major complications were seen in the present study. One person among surgical candidate who was operated for facial venolymphatic malformation developed facial nerve palsy (LMN) which persisted for more than 3 months.

XII) Predictors of Good radiological response of sclerotherapy in low flow vascular malformations

25 patients who underwent sclerotherapy were analysed using chi-square test for to predict the factors which may be responsible for radiological outcome. Variables like Age, Sex, Site, Size, duration, involvement of compartment, presence of phleboliths and number of sessions were taken into account. Radiological response was labelled as Good when there is more than 50% reduction in the total volume of the vascular malformation.

Table 21:-Statistical analysis of factors responsible for good radiological response

		RADIOLOGICAL OUTCOME		FISHERS EXACT TEST
		GOOD	NO GOOD	
AGE (years)	<20	9	9	0.49
	>20	3	4	
SEX	M	8	10	0.6
	F	4	3	
LOCATION	EXTREMITIES	6	10	0.2
	NON EXTREMITIES	6	3	
SIZE	<5cm	5	0	**0.015**
	>5cm	7	13	
CONGENITAL	Yes	1	5	0.18
	No	11	8	
COMPARTMENT INVOLVEMENT	Single	2	2	1
	Multiple	10	11	
PHLEBOLITHS	Yes	1	6	0.07
	No	11	7	
SCLEROTHERAPY SESSIONS	1	6	5	0.65
	>1	6	8	

Among these only sizes of the lesion had impact on response of sclerotherapy. Maximum diameter less than 5cm showed good response which was statistically significant (p=0.015). Presence of phlebolith showed poor response to sclerotherapy in respect to the overall reduction of the volume however it was not statistically significant.

DISCUSSION

DISCUSSION

1) Sex distribution

In our study 61.3% were males and 38.7% were females. It was slightly different as compared to study of Lidsky et al.(32) and Verajankorva et al.(45) had female dominance and consistent with male dominance as seen in Tahir et al.(34). However there is no significant difference between the incidence of vascular malformation between the male and female in most of the literatures. This male dominance was probably due to less awareness about disease among females in this areas.

Table 22:-Gender distributions of VSM in different studies

	Male	Female
Our study	61.3%	38.7%
Lindsky et al.	43.7%	56.3%
Esko Veräjänkorva et al.	37%	63%
Tahir et al.	53%	46%

2) Age distribution:-

More than 87% patients belonged to less than 30 years of age, indicating the vascular malformations mainly affects the younger population. Mean age of presentation was 18 years. Approximately 8% of the patients presented to us at 30-40 years of age who had chronic symptoms.

These findings were consistent with all the other studies. This peak of VSM in 2nd decade (mean age of 18 years) can be explained by the surge in hormones in adolescent age groups, which are present congenitally and manifest symptoms at this age.

3) Location of Vascular malformation:-

Vascular malformations were mainly found in extremities, head and neck region and less commonly in trunk. Similar results were seen in the other studies, with truncal involvement in less than 10 % of cases as shown in the table below.

Table 23:-Percentage distribution of VSM in the body in different studies

	Head and neck	Upper limb	Lower Limb	Trunk
Our study	37%	21%	36%	6%
Esko Veräjänkorva et al.	13%	24%	57%	4%
Lindsky et al.	22.7%	16.6%	49.9%	10.8%
Tahir et al.	40%	26.6%	33.3%	0

4) Presenting symptoms:-

Swelling was the most common presenting symptom in 90% of the cases followed by pain accounting for 50%. This was similar with the study conducted by Rautio et al(46) where 95% patients had swelling as their chief complaint. Patients usually present with abnormal swelling or minor pain.

5) Types of Vascular Malformations:-

Our study consisted of 88.7% of low flow vascular malformations and 11.3% high flow vascular malformations. This is comparable to the study conducted by Lidsky et al.(32) which consisted 77.1% low flow and 22.9% high flow vascular malformation. VM was the most common type of VSM like other studies. However, according to Erola et al.(47) it is the capillary malformation which are more common than the venous malformation, but often overlooked as most of them are asymptomatic. Few studies demonstrated lymphatic malformation as the most common amongst the paediatric group similar to the study of Benzar et al.(48). We had encountered 3 cases of FAVA. FAVA is a new addition to the unclassified group of vascular malformation, which is being increasingly recognised due to increased awareness about this entity. Rare syndromes such as Parkes weber syndromes, CLOVES syndrome, Primary lymphedema and Servelle-Martorell syndrome were also identified in our study.

6) Phleboliths in Venous malformation:-

Role of phleboliths in diagnosing VM is already an established entity in many studies(49). Phleboliths mainly occur as a result of stasis of slow flowing blood with formation of

thrombus with fibrosis and eventual deposition of calcium phosphate, calcium carbonate at the centre followed by peripheral mineralisation and concentric lamination(50). Although phleboliths are said to be pathognomic of VM, they can also be seen physiologically in lower abdomen- pelvis veins due to significant stasis. Hence, in our study we specifically studied the sensitivity and specificity of phleboliths in detecting the simple VM amongst the lesions suspected to have VSM.

We reported the incidence of phleboliths in 27% of VSMs and 45% of VMs. This was slightly more than when compared to 28.6% incidence of phleboliths in VM in the study by Eivazi et al.(51). Our study showed detection of phleboliths to have a high specificity (96.3%), negative predictive value (99.2%) and accuracy for VM (95.5%) with sensitivity of 45.7%.

7) <u>Treatment outcomes:-</u>

Conservative treatment did not alter the clinical course of the patients and majority of the patients were in "Unchanged" category both symptomatically and radiologically. This is comparable with the study conducted by Lidsky et al.(32) where patients in all groups were managed conservatively had minimal alteration in clinical status. This is because most of the VSMs do not tend to subside on their own, barring few lymphatic malformations which can sometime regress. However, there is high chance of recurrence rates.

Interventional radiology treatment offered satisfactory clinical response with 11.5% patients having near complete response, 38.4% having marked response and 26 % mild response radiologically. 65% of the patients had marked symptomatic response. Radiological worsening was seen in none of the patients in IR group and only one patient had clinical worsening of symptoms. Nearly 75% of the patients had responded to sclerotherapy which was comparable to the study conducted by Lidsky et al.(32) (improvement in 84.2% by sclerotherapy). It is fair to assume that IR methods alone are usually sufficient to alleviate the symptoms and lead to significant reduction in the size of the lesion. However, complete resolution of VSM is often not possible.

In both surgical and combination groups majority of the patients had both radiological and symptomatic resolution. The results are consistent with study of Lidsky et al.(32). However, there were only few patients in the surgical and combined treatment group which was a

limitation in our study. But surgery is more invasive as compared to IR approach, and can be reserved for those who fail to respond with IR treatments. Combination therapy is better than surgery alone in alleviating the symptoms.

8) Predictors of response of treatment outcome in LFVM:-

Patient's demographic and clinical details aid in prognosis. In our study we found that size less than 5cm, was an independent predictor of good treatment response to sclerotherapy in low flow vascular malformations (p value-0.015). This was comparable to the study conducted by Mimura et al.(52) and Goyal et al.(53). Similarly, Vollherbst et al.(54) study also supported this theory of small VMs responding better than the large VMs. However exact reason is not yet known, but it may be due to the technical feasibility of handling and deciding amount of sclerosant to be given. However, further studies are needed to validate this concept. We found that presence of phleboliths have shown "no good response" in the practice, however it was found to be statistically insignificant.

No association of gender was seen with respect to "good response" prediction similar to the study of Berenguer et al.(55). However, Yun et al (35) showed female sex being predictor of "good response".

There is no predilection for good response to sclerotherapy on the basis of location as per our study, which was also validated by the study conducted by Yun et al.(35) . Yun et al.(35) and bagga et al.(41) showed presence or absence of fast draining vein is an important predictor of response to sclerotherapy, secondary to increase sclerosant wash off and reduced effective dwell time. Age, onset since birth, number of sclerotherapy did not influence on the outcome in our study.

9) Complications: -

No major complications were seen in the conservative and interventional radiology groups. One patient had facial nerve palsy as major complication in surgical group, as the venolymphatic malformation was involving whole of the parotid gland. Among interventional radiology group majority of the patients experienced postoperative pain which lasted for not more than 3 days after the 1st sclerotherapy setting. However, it was diminished by using anti-inflammatory medications.

CONCLUSION

CONCLUSION

1. Vascular malformations are the rare disorders which primarily affects the children and young adults causing significant morbidity.
2. Most of the vascular malformations are mislabelled in the current practice, hence correct terminologies to be used as per latest guidelines of ISSVA classification.
3. Venous malformations are the most common vascular malformations among all followed by the lymphatic malformation.
4. USG with colour doppler to be considered in the initial evaluation of the suspected vascular malformation. Addition of non-contrast MRI along with USG will not increase the diagnostic accuracy much, however lesion location and extensions are better appreciated in MRI than USG. Addition of contrast MRI along with TRICKS will certainly help in diagnosing the vascular malformation more accurately. Identifying the phlebolith in case of suspected VSM has high specificity, accuracy, and negative predictive value for detecting simple VMs.
5. Treating the vascular malformation is necessary when it is symptomatic
    - Conservative treatment including observation and stockings will not help much in reducing patient's symptoms or the lesion.
    - Interventional radiology treatment like sclerotherapy has shown statistically significant results in reducing the overall volume of the low flow venous malformation and good symptomatic response.
    - Surgical approach certainly gives better radiological outcome however, more invasiveness, post-operative recovery phases limits its role as the sole management modality.
    - Combined approach usually results in best radiological and symptomatic outcome.
6. Size of the LFVM is one of the important predictor of treatment outcome of sclerotherapy response.

LIMITATION

LIMITATIONS

1) No single standard outcome measurement scale available so far for outcome analysis of vascular malformation. Hence, it was very difficult to compare among the different studies.
2) The study design was being descriptive, comparison of treatment outcome between the different subgroups was limited.
3) Short term follow up of our study does not exactly state the outcome most of the time. It may further reduce at the end or recurring during these time period.
4) COVID pandemic has hampered the process of regular treatment and follow ups of patients in the study.

IMAGE GALLERY

IMAGE GALLERY

CASE 1:- ARTERIOVENOUS MALFORMATION

A 27 year male with insidious onset swelling in lateral aspect of left knee - gradually progressive in nature over 1 year with subsequent ulcer formation over the swelling. On examination- increased warmth, pulsation/ bruits

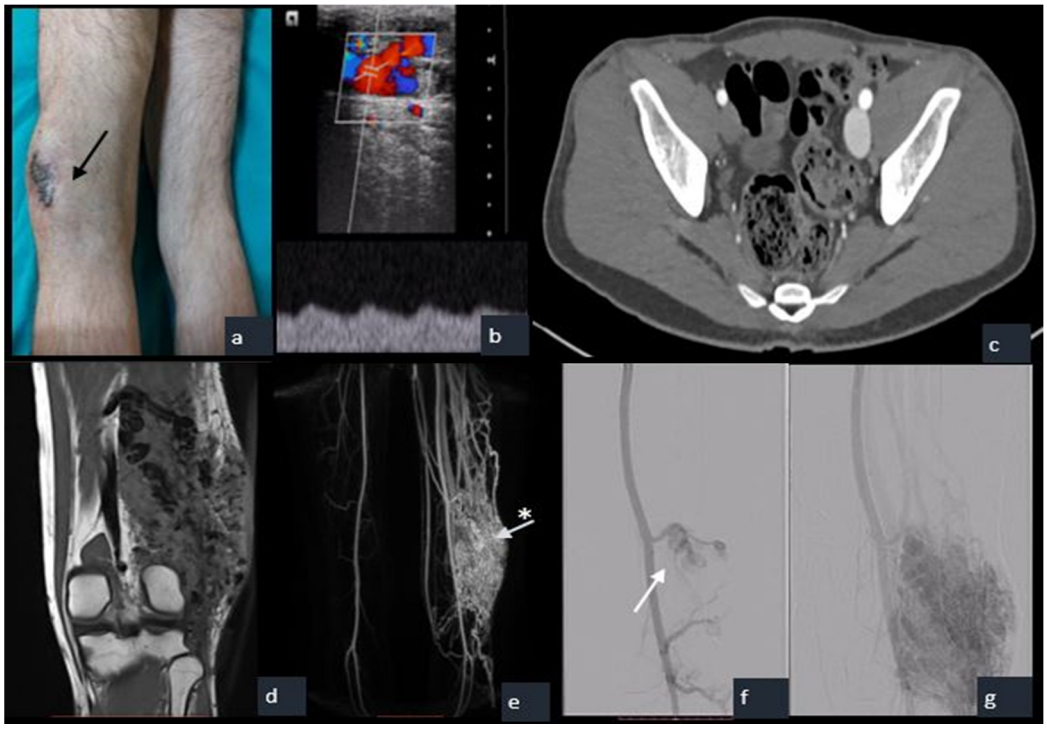


Figure (a) - Left posterolateral aspect of knee shows an indurated lesion which on palpation/auscultation demonstrated pulsations and bruit. Figure (b) - transverse ultrasound image exhibiting low resistance arterial flow within the tubular anechoic spaces of lesion. Figure (c) - Axial CT Angiogram image at the level of pelvis with dilated left external femoral vein, likely the early draining vein. Figure (d) - Coronal T1W image shows multiple flow voids corresponding to the multiple arterial feeders, nidus & draining veins. Figure (e) Late arterial phase of TR-MRA shows the nidus (asterisk) and multiple early draining veins (arrow shows one of them). Figure (f) and (g) demonstrates the early and late arterial phase of digital subtracted angiogram confirming the aforementioned findings with clear demonstration of intranidal aneurysms within the lesion. The lesion was treated with glue embolization.

CASE 2:- VENOUS MALFORMATION

4 year old male with gradual onset of swelling over lateral aspect of left thigh with occasional pain. Past history of surgical attempt without excision.

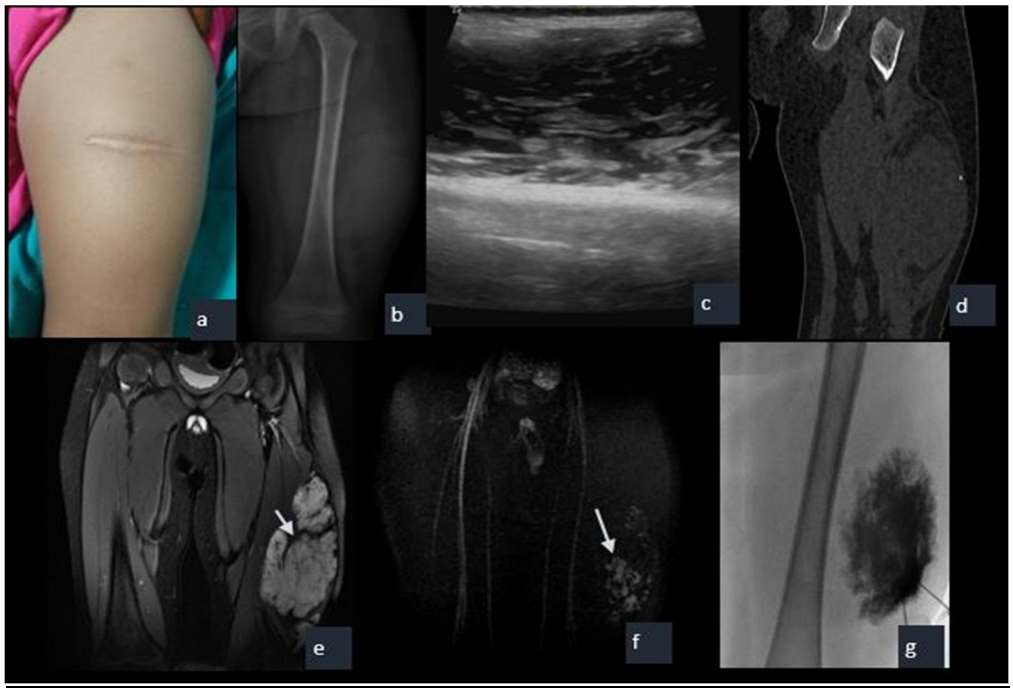


Figure (a) shows a swelling involving the left thigh with a swelling. Figure (b) - AP radiograph of the left femur depicting a soft tissue swelling and doubtful calcific focus. Figure (c) - Transverse ultrasound image shows an intramuscular hypoechoic lesion. Lesion also demonstrated compressibility. Figure (d) Coronal reformatted image of left thigh confirmed the small focus of calcification within the swelling - phlebolith. Figure (e) - Coronal T2FS image shows a large lobulated multi compartmental hyperintense intramuscular swelling showing delayed filling on the late venous phase of TR-MRA (figure f). Figure g - direct percutaneous phlebography showing the typical spongiform appearance of lesion. Lesion was treated with sclerotherapy successfully.

CASE 3:- LYMPHATIC MALFORMATION OF THE TONGUE:-

Infant with swelling of the tongue since birth, slowly growing over the time. Sudden onset of swelling and difficulty in feeding

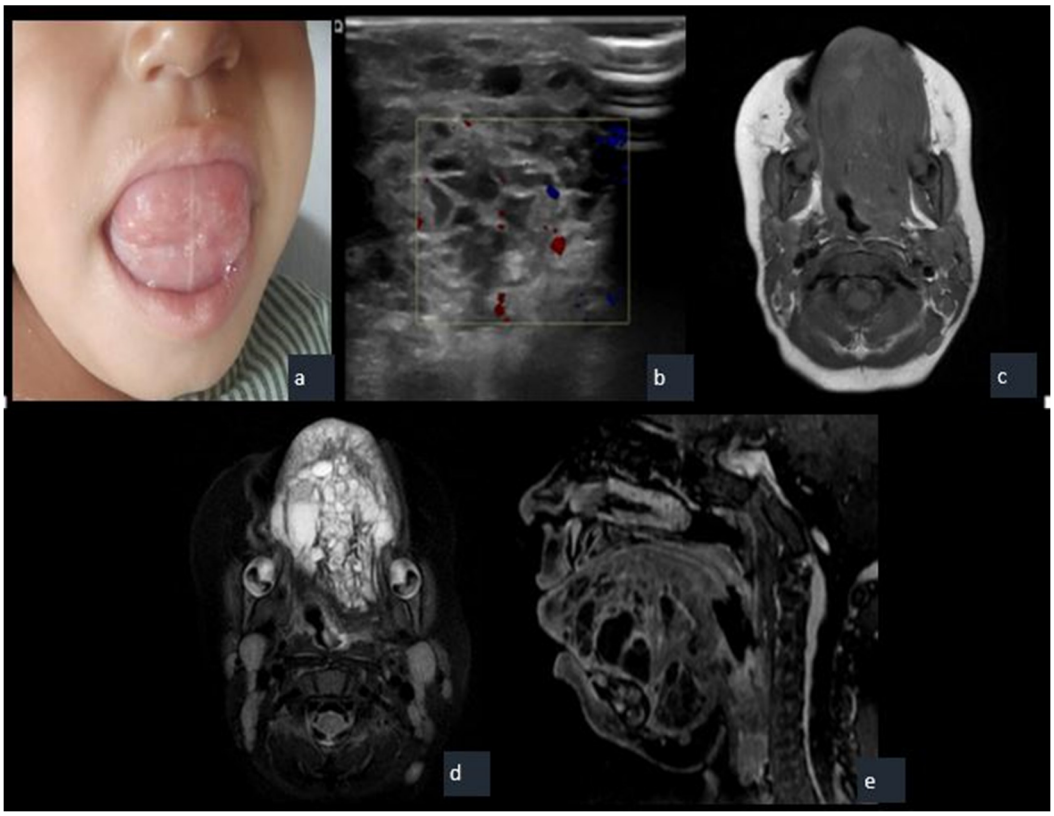
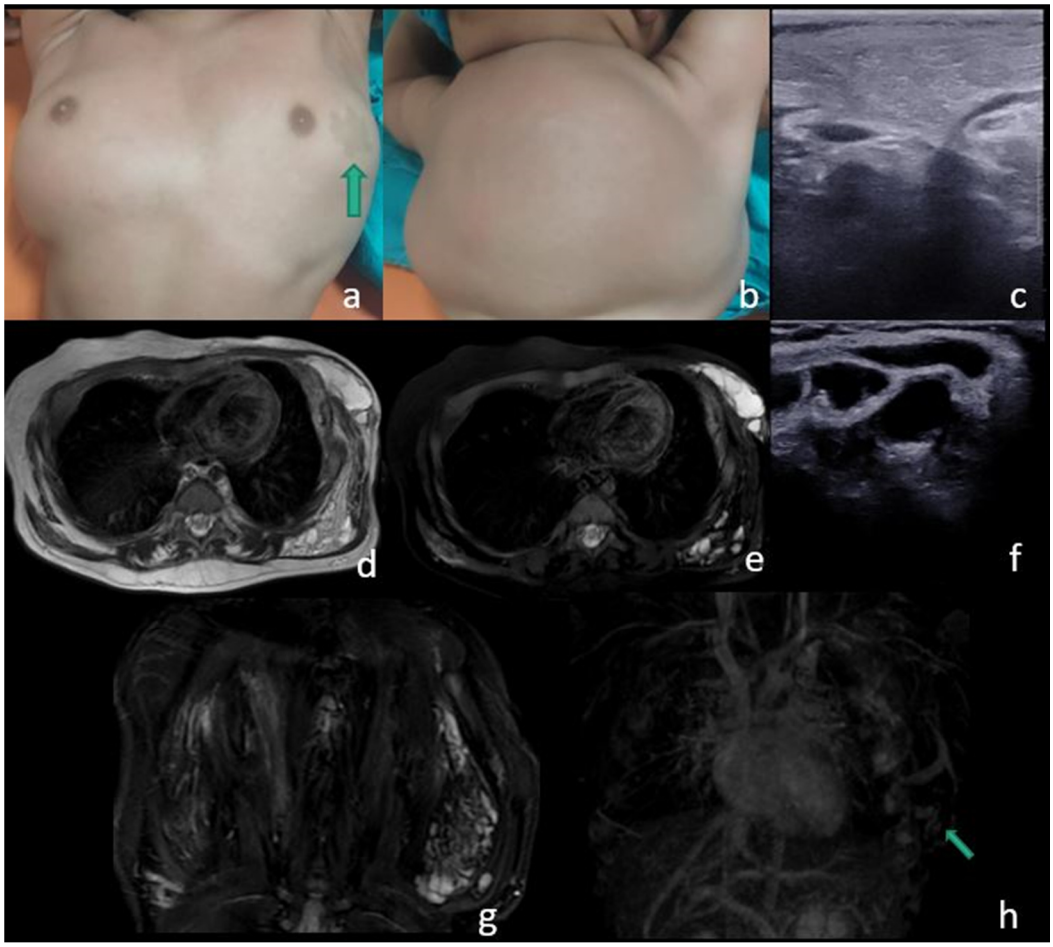


Figure (a) - shows a swelling involving the tongue. Figure (b) transverse ultrasound image shows multiple anechoic cystic areas with vascularity along the septations. Figure (c) and (d)- axial T1W and T2FS images show a macrocystic lesion involving the intrinsic and extrinsic muscles of tongue, extending into the base with post contrast septal enhancement in the sagittal post contrast T1W image: Figure (e). No laryngeal involvement was noted. Findings consistent with type -3 lymphatic malformation of tongue (Weigand classification)

CASE 4:- CLOVES SYNDROME

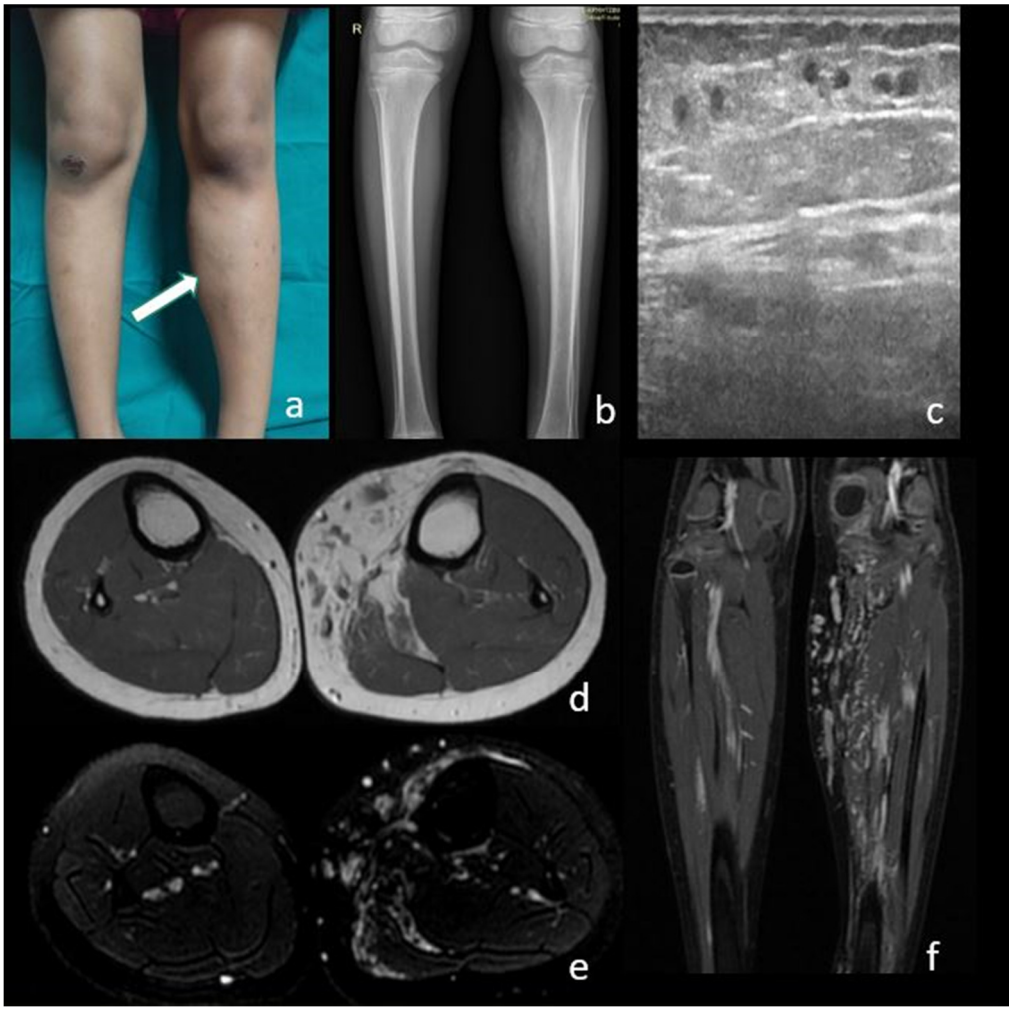
4 months male child with swelling over chest since birth



Clinical photographs showing swelling in the entire chest (a and b) with a nevus over left chest which is pathognomic. Grey scale USG images showing lipomatous growth(c) and macrocystic LM (f). MRI images (d,e,g) confirms the lipomatous hypertrophy and macrocystic LM over left anterior chest wall and TRICKS(h) demonstrating component of VM in the left posterior chest wall.

CASE 5:- FIBROADIPOSE VASCULAR MALFORMATION (FAVA)

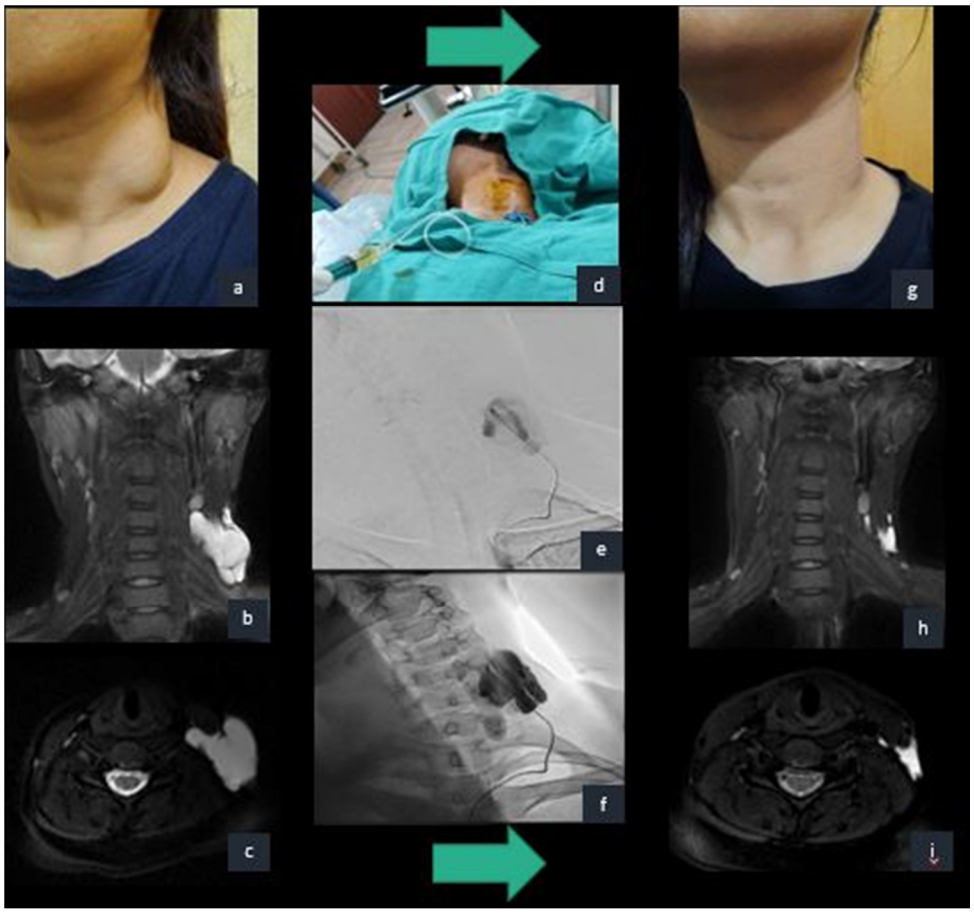
8y/F with complaints of pain and swelling in medial aspect of left leg since the age of 2 years.



Swelling is seen in the posteromedial aspect without any overlying cutaneous pigmentation (a). Radiographs showing soft tissue swelling without bony abnormality (b). B mode USG (c) shows fibrofatty replacement of underling gastrocnemius muscle with dilated venous channels s/o phlebectasia which were confirmed in the CEMRI (d,e,f).

CASE 6:- TREATMENT RESPONSE OF LYMPHATIC MALFORMATION TO THE PERCUTANEOUS SCLEROTHERAPY

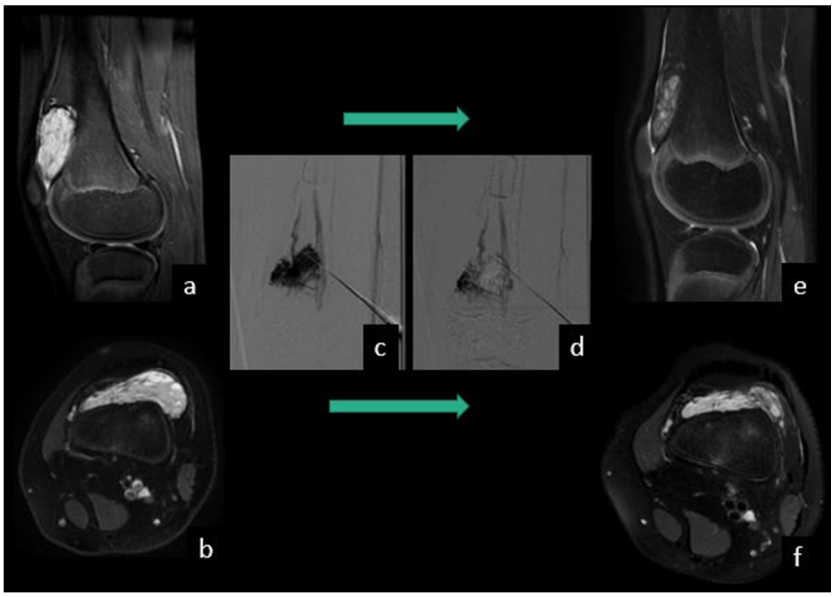
16 year female with history of swelling in left neck since 2 years



Swelling in the left side of neck (a) since birth with intermittent increase in pain in a young female. Coronal STIR (b) and Axial T2FS(c) shows cystic swelling with multiple septations within it corresponding to lymphatic malformation. The patient underwent image guided aspiration (d) which shows straw coloured lymphatic fluid with a communicating cavity as shown in a contrast fluoroscopy run (e). After confirmation of the needle position 15U of bleomycin was injected. On 3rd month follow up, the external swelling was completely disappeared with disappearance of pain. On follow-up MRI (h and i), the lesion had shown significant reduction in the volume suggestive of near complete response.

CASE 7:- TREATMENT RESPONSE OF VENOUS MALFORMATION TO THE PERCUTANEOUS SCLEROTHERAPY

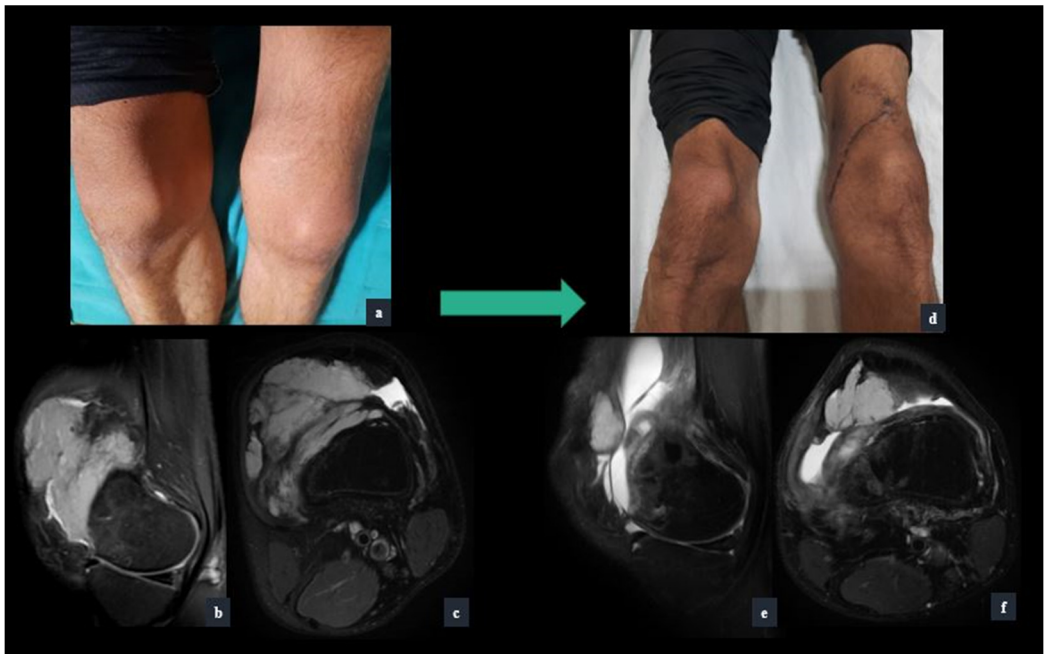
11 year old boy with swelling, pain and limitation of movement since 5 years of age.



Sagittal STIR (a) and axial T2FS (b) images show hyperintense lobulated lesion involving the vastus intermediaus muscle and patellofemoral joint with fluid-fluid level. The lesion had delayed venous phase enhancement on TRICKS images (not shown here)-s/o venous malformation. On percutaneous direct puncture phlebography the venous malformation had spongiform pattern with two draining veins(c). With double needle technique and proximal compression polidocanol sclerotherapy was performed (d). Patient underwent a total of 4 sessions of sclerotherapy. After 3 months from the last session the patient was totally relived of his symptoms (Grade 5). The follow-up MRI shows significant reduction of the lesion corresponding to marked reduction of the volume category (Grade 4).

CASE 8:- TREATMENT OUTCOME IN A SURGICALLY OPERATED VENOUS MALFORMATION

18 year old male patient presented with swelling and pain for 4 years. He was a poor responder to sclerotherapy underwent surgery. Post-surgery his symptoms were relieved



There is swelling in the anteromedial aspect of left knee. The corresponding sagittal T2FS (b) and axial TFS (c) shows hyperintense lobulated lesion seen in the pre fermoral region with extension into patellofemoral joint, which was proven to be venous malformation on further dynamic contrast images and phlebography (not shown here). The patient underwent surgery as he did not show any response to sclerotherapy even after 5 sessions. Post-surgery the patient scar mark can be seen in image (d). 3 months follow up MR shows a small residual lesion with surrounding joint effusion. Patient had marked symptomatic and radiological improvement.

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ANNEXURES

ANNEXURE-1

ETHICAL CLEARANCE CERTIFICATE

अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर
All India Institute of Medical Sciences, Jodhpur
संस्थागत नैतिकता समिति
Institutional Ethics Committee

No. AIIMS/IEC/2020/2031 **Date: 01/01/2020**

ETHICAL CLEARANCE CERTIFICATE

Certificate Reference Number: **AIIMS/IEC/2019-20/989**

Project title: **"Clinicoradiological assessment and treatment outcomes of non-visceral vascular malformations"**

Nature of Project:	**Research Project**
Submitted as:	**M.D. Dissertation**
Student Name:	**Dr.Adarsh Ishwar Hegde**
Guide:	**Dr.Pawan Kumar Garg**
Co-Guide:	**Dr.Pushpinder Singh Khera, Dr.Daisy Khera, Dr.Kirti Kumar J Rathod, Dr. Prakash Chandra Kala, Dr.Darwin & Dr.Sarbesh Tiwari**

This is to inform that members of Institutional Ethics Committee (Annexure attached) met on **23-12-2019** and after through consideration accorded its approval on above project. Further, should any other methodology be used, would require separate authorization.

The investigator may therefore commence the research from the date of this certificate, using the reference number indicated above.

Please note that the AIIMS IEC must be informed immediately of:

- Any material change in the conditions or undertakings mentioned in the document.
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The Principal Investigator must report to the AIIMS IEC in the prescribed format, where applicable, bi-annually, and at the end of the project, in respect of ethical compliance.

AIIMS IEC retains the right to withdraw or amend this if:

- Any unethical principle or practices are revealed or suspected
- Relevant information has been withheld or misrepresented

AIIMS IEC shall have an access to any information or data at any time during the course or after completion of the project.

On behalf of Ethics Committee, I wish you success in your research.

Dr. Praveen Sharma
Member secretary
Institutional Ethics Committee
AIIMS,Jodhpur

Enclose:
1. Annexure 1

Page 1 of 2

Basni Phase-2, Jodhpur, Rajasthan-342005, **Website:** www.aiimsjodhpur.edu.in, **Phone:** 0291-2740741 Extn. 3109
Email: ethicscommittee@aiimsjodhpur.edu.in

Annexure 1

Institutional Ethics Committee
All India Institution of Medical Sciences, Jodhpur

Meeting of Institutional Ethics committee held on **23-12-2019 at 10:00** AM at Committee Room, Admin Block AIIMS Jodhpur.

Following members were participated in the meeting:-

S/No.	Name of Member	Qualification	Role/Designation in Ethics Committee
1.	Dr. F.S.K Barar	MBBS, MD (Pharmacology)	**Chairman**
2.	Justice N.N Mathur	LLB	Legal Expert
3.	Dr. Varsha Sharma	M.A (Sociology)	Social Scientist
4.	Mr. B.S.Yadav	B.Sc., M.Sc. (Physics), B.Ed.	Lay Person
5.	Dr. K.R.Haldiya	MD (General Medicine)	Clinician
6.	Dr. Arvind Mathur	MBBS, MS (General Medicine)	Clinician
7.	Dr. Surajit Ghatak	MBBS, MS (Anatomy)	Basic Medical Scientist
8.	Dr. Vijaya Lakshmi Nag	MBBS, MD (Microbiology)	Basic Medical Scientist
9.	Dr. Sneha Ambwani	MBBS, MD (Pharmacology)	Basic Medical Scientist
10.	Dr. Kuldeep Singh	MBBS, MD (Paediatric), DM (General Medicine)	Clinician
11.	Dr. Abhinav Dixit	MBBS, MD (Physiology), DNB (Physiology)	Basic Medical Scientist
12.	Dr. Pradeep Kumar Bhatia	MBBS, MD (Anaesthesiology)	Clinician
13.	Dr. Tanuj Kanchan	MBBS, MD (Forensic Medicine)	Basic Medical Scientist
14.	Dr. Pankaj Bhardwaj	MBBS, MD (CM&FM)	Clinician
15.	Dr. Praveen Sharma	M.Sc., Ph.D. (Biochemistry)	Member Secretary

Dr. Praveen Sharma

Member secretary
Institutional Ethics Committee
AIIMS,Jodhpur

ANNEXURE-2

All India Institute of Medical Sciences, Jodhpur, Rajasthan

Informed Consent Form (ENGLISH)

Title of the project : Clinicoradiological assessment and treatment outcomes of nonvisceral vascular malformations

Name of the Principal Investigator : Dr. Adarsh Ishwar Hegde Tel. No.9902196247

Patient/Volunteer Identification No. : _____

I _____ S/o or D/o _____

R/o _____

give my full, free, voluntary consent to be a part of the study "Clinicoradiological assessment and treatment outcomes of nonvisceral vascular malformations" the procedure and nature of which has been explained to me in my own language to my full satisfaction. I confirm that I have had the opportunity to ask questions.

I understand that my participation is voluntary and am aware of my right to opt out of the study at any time without giving any reason.

I understand that the information collected about me and any of my medical records may be looked at by responsible individual from AIIMS Jodhpur. I give permission for these individuals to have access to my records.

Date : _____ _____

Place : _____ Signature/Left thumb impression

This to certify that the above consent has been obtained in my presence.

Date : _____ _____

Place : _____ Signature of Principal Investigator/PG student

Witness 1 Witness 2

_____ _____

Signature Signature

Name: _____ Name: _____

Address : _____ Address : _____

ANNEXURE-3

All India Institute of Medical Sciences, Jodhpur, Rajasthan

Informed Consent (Hindi)

- थीसिस / निबंध का शीर्षक: **संवहनी विकृतियों के क्लिनिकोरैडोलॉजिकल मूल्यांकन और उपचार के परिणाम**
- पीजी छात्र का नाम: डॉ। आदर्श ईश्वर हेगड़े टेल न:9902196247
- रोगी / स्वयं सेवक पहचान संख्या: _____

मैं, _____ एस / ओयाडी / ओ _____

आर / ओ _____

अध्ययन "**संवहनी विकृतियों के क्लिनिकोरैडोलॉजिकल मूल्यांकन और उपचार के परिणाम** " का एक भाग बनने के लिए मेरी पूर्ण, स्वतंत्र, स्वैच्छिक सहमति दें, जिसकी प्रक्रिया और प्रकृति मुझे अपनी पूरी संतुष्टि के लिए अपनी भाषा में समझाई गई है। मैं पुष्टि करता हूं कि मुझे प्रश्न पूछने का अवसर मिला है।मैं समझता हूं कि मेरी भागीदारी स्वैच्छिक है और मुझे किसी भी कारण दिए बिना किसी भी समय अध्ययन से बाहर निकलने के मेरे अधिकार की जानकारी है। मैं समझता हूं कि मेरे और मेरे मेडिकल रिकॉर्ड के कत्रित की गई जानकारी को एम्स मैं वन व्यक्तियों को अपने अभिलेखों तक पहुंच के लिए अनुमति देता हूं

तारीख : _____

जगह: _____ हस्ताक्षर / बाएं अंगूठे का छाप_____

यह प्रमाणित करने के लिए कि मेरी उपस्थिति में उपरोक्त सहमति प्राप्त की गई है

तारीख : _____

गवाह1: : _____

हस्ताक्षर: _____

तारीख : _____

जगह: _____ पीजी छात्र के हस्ताक्षर_____

गवाह1: : _____

हस्ताक्षर: _____

तारीख : _____

गवाह2: : _____

हस्ताक्षर: _____

तारीख : _____

ANNEXURE-4

PATIENT INFORMATION SHEET

1. Risks to the patients: There's no risk of death or any disability resulting directly due to imaging.

2. Confidentiality: Your participation will be kept confidential. Your medical records will be treated with confidentiality and will be revealed only to doctors/ scientists involved in this study. The results of this study may be published in a scientific journal, but you will not be identified by name.

3. Provision of free treatment for research related injury. Not applicable

4. Compensation of subjects for disability or death resulting from such injury. Not Applicable

5. Freedom of individual to participate and to withdraw from research at any time without penalty or loss of benefits to which the subject would otherwise be entitled.

6. You have complete freedom to participate and to withdraw from research at any time without penalty or loss of benefits to which you would otherwise be entitled.

7. Your participation in the study is optional and voluntary.

8. The copy of the results of the investigations performed will be provided to you for your record.

9. You can withdraw from the project at any time, and this will not affect your subsequent medical treatment or relationship with the treating physician.

10. Any additional expense for the project, other than your regular expenses, will not be charged from you.

ANNEXURE-5

रोगी सूचना पत्रक

1. रोगियों के लिए जोखिम: □मेजिंग के कारण सीधे मौत या कोई □िकलांगता का कोई खतरा नहीं है। कोई हस्तक्षेप या जी□न-धम की प्रक्रिया नहीं की जाएगी।

2.गोपनीयता: आपकी भागीदारी को गोपनीय रखा जाएगा। आपके मेडिकल रिकॉर्ड को गोपनीयता के साथ □लाज किया जाएगा और के□ल □स अध्ययन में शामिल डॉक्टरों / □ैज्ञानिकों को पता चलेगा। □स अध्ययन के परिणाम एक □ैज्ञानिक पत्रिका में प्रकाशित हो सकते हैं, लेकिन आपको नाम से पहचाना नहीं जाएगा।

3.अनुसंधान संबंधी चोट के लिए नि: शुल्क उपचार की व्य□स्था। लागू नहीं।

4. ऐसी चोट से उत्पन्न □िकलांगता या मृत्यु के लिए □िषयों का मुआ□जा लागू नहीं है

5.किसी भी समय दंड या लाभों के नुकसान के बिना किसी भी समय भाग लेने के लिए व्यक्ति को स्वतंत्रता लेने और अनुसंधान से □ापस लेने के लिए स्वतंत्रता, जिसके तहत □िषय अन्यथा हकदार होगा

6.आपको जुर्माना या लाभ के नुकसान के बिना किसी भी समय भाग लेने और अनुसंधान से □ापस लेने की पूरी आजादी है, जिस पर आप अन्यथा हकदार होंगे।

7. अध्ययन में आपकी भागीदारी □ैकल्पिक और स्वैच्छिक है।

8. प्रदर्शन की जांच की परिणामों की प्रति आपके रिकॉर्ड के लिए आपको उपलब्ध कराई जाएगी।

9.आप किसी भी समय परियोजना से □ापस ले सकते हैं, और यह आपके बाद के चिकित्सा उपचार या उपचार चिकित्सक के साथ संबंध को प्रभा□ित नहीं करेगा।

10. परियोजना के लिए कोई भी अतिरिक्त व्यय, आपके नियमित खर्चों के अला□ा, आप से शुल्क नहीं लिया जाएगा।

ANNEXURE-6

Declaration by the PG Student

All India Institute of Medical Sciences, Jodhpur, Rajasthan

I hereby declare that:

1. The study will be done as per ICMR/ GCP guidelines.
2. The study has not been initiated and shall be initiated only after ethical clearance
3. Voluntary written consent of the volunteers/patients will be obtained.
4. In case of children and mentally handicapped volunteers/patients, voluntary written informed consent of the parents/guardians will be obtained.
5. The probable risks involved in the study will be explained in full to the subjects/parents/guardians in their own language.
6. Volunteers/patients/parents/guardians will be at liberty to opt out of the study at any time without assigning reason.
7. I will terminate the study at any stage, if I have probable cause to believe, in the exercise of the good faith, skill and careful judgement required for me that continuation of the study/experiment is likely to result in injury/disability/death to the volunteers/subject.

Date: _____

(Signature of PG Student) **Department _____**

(Signature of Guide/Supervisor/s) **Department _____**

ANNEXURE-7

PATIENT PROFORMA

Date: Name: Age: Gender: AIIMS ID :	Occupation: Contact number: Address:

History:

Clinical examination:

Radiological Imaging

USG Doppler:

MRI/CT ANGIO/DSA:

FINAL DIAGNOSIS:-

Treatment: Conservative/ Interventional Radiology/ Surgical/ Combined

Post Intervention Status:

- Complications(if any)

Follow-up visit (immediate post op/1 week/1month):

SYMPTOMATOLOGY	RADIOLOGICAL FINDING

Follow-up visit (3 months):

SYMPTOMATOLOGY	RADIOLOGICAL FINDING

Final outcome:

SYMPTOMATIC OUTCOME	RADIOLOGICAL OUTCOME
1 = Worsened 2 = Unchanged 3 = Mildly response 4 =Markedly response 5= Near complete/ Complete response	1 = Worsened 2 = Unchanged 3 = Mild response 4 = Marked response 5= Near complete/ Complete response

ANNEXURE-8

THESIS APPROVAL LETTER

This is to approve that the thesis titled "**Clinicoradiological assessment and treatment outcomes of non-visceral vascular malformations**" is a bonafide work of Dr. Adarsh Ishwar Hegde carried out under our guidance and supervision, in the department of diagnostic and interventional Radiology, All India Institute of Medical Sciences, Jodhpur.

Dr. Darwin Kaushal
Associate professor
Department of Otorhinolaryngology
AIIMS, Bilaspur
[Co-guide]

DATE- 08.02.2022

S.N	AGE	SEX	FAMILY HISTORY	CHIEF COMPLAINT	SITE	SIZE	DURATION		DIAGNOSIS	Mislabelled	Involvement	Phleboliths	TREATMENT									COMPLICATIONS							FOLLOW UP SCAN	Pre tx- Size	Post tx size	Reduction in the size	RADIOLOGICAL OUTCOME	RECURRENCE
							Years	Since birth			Localised/ Multicompartmental		Conservative alone		Percutaneous interventions			Surgical resection		COMBINED	Perioperative	1week	1 month	3 months	Pain		3 months			cc	cc			
						(max size)			(USG,MRI, DSA)					Stockings	only	Sessions	Agent	Quantity (ml)	only	Sessions						Post	GROC	5 scale				(after 3 months from last intervention)		(3 months follow up period)
						cm																			Pre								
1	21	F	No	Swelling	Face	3	4	no	Venous	yes	L	No	no	no	no	2	Polidocanol	6	no	1	yes	None	Pain, Swelling	none	none	0	0	5	4	USG	7	0.7	90	5	No
2	18	M	No	Swelling, Pain	Leg	8.2	10	no	Venous	No	L	No	no	no	yes	4	Polidocanol	16	no	NA	no	None	Pain, Swelling	none	none	7	2	4	4	USG, MRI	7.5	3.5	44	3	**No**
3	38	M	No	Swelling	Face	5.9	2	no	Venous	No	M	No	no	no	no	1	None	0	yes	1	no	None	none	none	none	2	0	5	4	USG, MRI	50	1	98	4	No
4	3	M	No	Swelling	Neck	4.8	2.5	yes	Lymphatic	yes	M	No	yes	no	no	0	NA	0	no	NA	no	None	none	none	none	1	1	2	2	USG, MRI	28	28	0	2	No
5	7	M	No	Swelling	Neck	7	7	yes	Lymphatic	yes	M	No	no	no	yes	1	Polidocanol	4	no	NA	no	None	none	none	none	2	0	6	5	USG	98	12	88	4	No
6	1	F	No	Swelling, Limitation of activity	Tongue	4.2	1	yes	Lymphatic	yes	M	No	yes	no	no	0	NA	0	no	NA	no	None	none	none	none	7	7	0	2	USG	32	32	0	1	No
7	26	M	No	Swelling, Ulcer, Limitation of activity	Knee	15	5	no	AVM	No	M	No	no	no	no	2	Glue:Lipiodol	5	no	2	yes	None	none	none	none	8	2	3	4	USG	480	9	99	5	**Yes**
8	25	M	No	Swelling	Neck	4.2	5	no	Malformation along major vessels-venous ectasia	No	M	No	no	no	no	0	NA	0	yes	1	no	None	none	none	none	2	1	6	4		24	0	100	5	No
9	11	M	No	Swelling, Pain	Upper back	7.2	4	no	Venous	yes	M	No	no	no	yes	5	Polidocanol	18	no	NA	no	None	none	none	none	7	1	5	5	USG, MRI	35	9	75	4	No
10	18	M	No	Swelling, Pain	Knee	10.4	5	no	Venous	yes	M	Yes	no	no	yes	7	Polidocanol	26	no	NA	no	None	Pain, Swelling	none	none	7	1	1	3	MRI	140	105	25	2	No
11	28	F	No	Swelling	Scalp	4	2	no	AVF	No	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	4	4	0	3	USG	12	12	0	2	NA
12	31	F	No	Swelling, Pain	Hand	2	10	no	Venous	yes	M	No	no	no	no	0	NA	0	yes	1	no	None	none	none	none	6	1	3	4	USG	1.6	0.12	93	5	No
13	18	F	No	Swelling, pain	Face	3	1	no	AVF	No	M	No	no	no	yes	1	Glue:Lipiodol	1	no	NA	no	None	none	none	none	6	2	3	3	USG	9	4	56	4	No
14	35	F	Yes	Skin discolouration	Buttock	6	35	yes	Capillary	No	L	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	1	1	0	2	USG	2.4	2.4	0	2	No
15	37	M	No	Swelling, Pain	Hand	5.4	5	no	Venous	No	M	Yes	yes	yes	No	0	NA	0	no	NA	no	None	none	none	none	6	4	2	3	USG, MRI	30	30	0	1	No
16	14	F	No	Swelling, Pain	Leg	6.7	25	no	FAVA	No	M	No	yes	yes	No	0	NA	0	no	NA	no	None	none	none	none	8	8	0	2	USG, MRI	360	360	0	2	NA
17	28	M	No	Pain	Thigh	8.5	0.5	no	Venous	yes	M	Yes	no	no	yes	1	Polidocanol	3	no	NA	no	None	Pain and skin discolouraration	none	none	6	3	3	3	USG, MRI	114	84	37	3	NA
18	8	F	No	Swelling, Pain	Leg	15	2	no	FAVA	No	M	No	yes	yes	No	0	NA	0	no	NA	no	None	none	none	none	6	6	0	2	USG, MRI	205	205	0	2	NA
19	44	M	No	Swelling	Neck	2.4	2	no	Venous	No	L	No	no	no	no	0	NA	0	yes	1	no	None	none	none	none	4	0	6	5	USG	2.1	0	100	5	No
20	23	F	No	Pain	Thigh	5.8	2	no	Venous	yes	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	6	7	0	2	MRI,USG	14	14	0	2	No
21	9	F	No	Swelling	Lower limb and perineum	65	9	yes	KTS	No	M	No	yes	yes	No	0	NA	0	no	NA	no	None	none	none	none	6	6	-2	1	MRI, USG	1500	1500	0	2	NA
22	21	M	No	Swelling, Pain	Thigh	5	2	no	Venous	yes	L	No	no	no	yes	1	Polidocanol	4	no	NA	no	None	none	none	none	8	2	6	5	USG	2.5	0	100	5	NA
23	27	M	NO	Swelling, Pain	Thigh	8.2	8	no	Venous	No	L	No	no	no	yes	3	Polidocanol	10	no	NA	no	None	Pain, Swelling	none	none	7	2	4	4	USG	86	62	38	3	NA
24	20	F	No	Swelling, Cosmetic	Lip	4.8	20	yes	Venous	yes	M	Yes	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	4	4	0	2	MRI,USG	16	16	0	2	NA
25	4	M	No	Swelling	Face	6.9	4	yes	Lymphaic	yes	M	No	no	no	no	0	NA	0	yes	1	no	None	Facial nerve palsy	Facial nerve palsy	Facial nerve palsy	6	3	2	4	USG	126	15	89	5	NA
26	17	M	No	Swelling, Pain	Knee	9.7	4	no	Venous	No	M	Yes	no	no	no	5	Polidocanol	24	no	1	yes	None	none	none	none	6	2	6	5	MRI	151	6	97	4	No
27	64	F	No	Swelling, Pain	Scalp	12	4	no	AVM	No	M	No	no	no	no	1	Glue:lipidiol	32	no	1	yes	None	none	none	none	6	2	6	4	USG	4.8	0	100	4	No
28	18	F	No	Swelling, Pain	Elbow	5.7	4	no	Venous	yes	M	No	no	no	yes	4	Polidocanol	18	no	NA	no	None	Pain, Swelling	none	none	7	2	5	4	USG,MRI	28	13	54	4	No
29	29	M	No	Swelling, Pain	Thigh	6.8	15	no	Venous	No	L	Yes	yes	yes	No	0	NA	0	no	NA	no	None	none	none	none	6	6	1	2	USG,MRI	38	38	0	2	No
30	7	M	No	Swelling	Neck	8.3	7	yes	Lymphatic	No	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	2	1	3	3	USG	160	34	79	4	No
31	11	M	No	Swelling, Pain	Knee	4.8	5	no	Venous	yes	M	No	no	no	yes	2	Polidocanol	8	no	NA	no	None	Pain, Swelling	none	none	7	1	7	5	USG	**18**	**4.6**	75	4	No
32	6	M	No	Swelling	Lower limb	60	6	yes	Primary lymphadema	yes	D	No	yes	yes	No	0	NA	0	no	NA	no	None	none	none	none	4	4	0	2	USG	1420	1420	-15	1	No
33	21	M	No	Swelling, Pain	Leg	5.3	4	no	FAVA	yes	M	No	yes	yes	No	0	stocking	0	no	NA	no	None	none	none	none	6	6	1	2	MRI,USG	6	6	0	2	No
34	13	M	No	Swelling, Pain	Chest and abdomen	17	13	yes	Venous	No	M	Yes	yes	no	no	0	NA	0	no	NA	no	None	none	none	none	5	6	3	3	MRI, USG	311	259	17	2	No
35	10	M	No	Swelling and deformity	Lower limb and perineum	55	10	yes	Servelle Martorell syndrome	No	M	Yes	yes	yes	No	0	stocking	0	no	NA	no	None	none	none	none	4	4	0	2	MRI, USG	1980	1980	0	2	No
36	18	M	No	Pain, Swelling	Abdominal wall	5	2	no	Venous-lymphatic	No	M	Yes	no	no	yes	1	Polidocanol	4	no	NA	no	none	Pain, Swelling	none	none	8	2	4	5	MRI, USG	19	2	90	5	
37	0.4	M	No	Swelling	Chest	5.2	0.4	yes	CLOVES syndrome	No	M	No	no	no	yes	2	STS	2	no	NA	no	None	none	none	none	2	2	1	2	USG	33	37	5	2	No
38	8	M	No	Swelling, Pain	Hand	5.3	8	yes	Venous	yes	M	Yes	no	no	yes	1	Polidocanol	3	no	NA	no	None	none	none	none	6	4	3	4	MRI	18	12.6	30	3	No
39	13	F	No	Swelling, Pain	Thigh	23	5	no	Venous	No	M	No	no	no	yes	4	Polidocanol	20	no	NA	no	None	none	none	none	6	5	1	3	MRI	288	267	8	2	No
40	14	M	No	Swelling, Pain	Wrist	3.8	2	no	Venous	yes	M	Yes	no	no	yes	1	Polidocanol	3	no	NA	no	None	Swelling	none	none	6	2	3	4	USG	10	4.7	53	4	No
41	19	F	no	Swelling, cosmetic	Face and tongue	12.5	19	yes	Venous	No	M	Yes	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	5	5	0	2	MRI	270	270	0	2	No
42	27	M	no	Swelling, Pain	Knee	6.6	5		Venous	No	M	No	no	no	yes	1	Polidocanol	4	no	NA	no	None	none	none	none	7	2	0	3	USG	17	17	0	2	No
43	5	M	no	Swelling	Hand	6.5	5	yes	Venous	yes	M	Yes	no	no	no	2	NA	0	yes	1	no	None	none	none	none	5	2	4	3	MRI	34	6	83	4	No
44	11	F	no	Swelling, Pain	Hands and fingers	7.3	2	no	Venous	No	M	Yes	no	no	yes	1	Polidocanol	3	no	NA	no	None	none	none	none	7	3	4	4	USG	46	32	30	3	No
45	18	M	no	Swelling, Pain, Ulceration	Scalp	5.5	18	yes	AVM	No	M	No	no	no	no	1	Glue:Lipiodol	22	no	1	yes	None	none	none	none	6	2	6	3	USG	40	1	97	5	No
46	3	M		Swelling, Limitation of activity	Tongue	6	3	yes	Venous	yes	M	No	no	no	yes	2	Polidocanol	6	no	NA	no	None	none	none	none	4	5	-3	1	USG	48	48	0	2	No
47	15	F	No	Swelling, Pain	Hand	5.3	5	no	Venous	No	M	Yes	no	no	yes	2	Polidocanol	6	no	NA	no	None	Pain, Swelling	none	none	6	3	3	4	MRI	12	9	35	3	No
48	22	M	No	Swelling, Pain	Face	9	22	yes	Venous-Lymphatic	No	M	No	no	no	yes	2	Polidocanol	6	no	NA	no	None	none	none	none	7	2	4	3	MRI	33	13	40	3	No
49	12	F	Yes	Swelling, Pain	Parotid region	4.5	4	no	Venous	yes	M	No	no	no	yes	2	Polidocanol	8	no	NA	no	None	Pain, Swelling	none	none	7	2	4	4	MRI, USG	12	4.5	62	4	No
50	35	M	No	Swelling	Foot	2.8	2	no	Venous	No	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	6	6	2	2	USG	5.5	5.5	0	2	No
51	1	F	No	Swelling	Forehead, Orbit, Maxilla	4.7	1	yes	Venous	yes	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	4	4	1	2	MRI	14	14	0	2	No
52	19	F	No	Swelling, Pain	Finger (middle)	2.2	2	no	Venous	yes	M	No	no	no	yes	1	Polidocanol	3	no	NA	no	None	none	none	none	6	2	4	4	USG	1.3	0.6	54	4	No
53	15	M	No	Swelling, Ulcer	Foot	21	15	yes	AVM	No	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	6	6	0	2	MRI	230	230	0	2	No
54	20	F	No	Swelling	Neck	4.2	1	no	Lymphatic	No	M	No	no	no	yes	1	Bleomycin	4	no	NA	no	None	Pain, Swelling	none	none	6	2	6	5	USG	20	2.5	87	4	No
55	13	F	No	Swelling	Hand	7	10	yes	Lymphatic	yes	L	No	no	no	no	0	NA	0	no	NA		None	none	none	none	3	3	2	3	USG, MRI	10	10	0	2	
56	11	F	No	Swelling	Face	7.5	11	yes	Venous	yes	M	Yes	yes	no	No	0	None	0	no	NA	no	None	none	none	none	2	2	1	2	MRI, USG	68.5	68.5	0	2	No
57	11	M	No	Swelling	Arm	15	6	no	Lymphatic	No	L	No	no	no	yes	2	Polidocanol	8	no	NA	no	None	none	none	none	4	1	6	4	USG	107	10	90	4	No
58	10	M	No	Bluish discouration, Pain	Thigh	11	5	no	Venous	No	M	Yes	no	no	yes	1	Polidocanol	4	no	NA	no	None	none	none	none	4	3	1	3	USG	20	17.5	13	2	No
59	22	M	No	Swelling	Forehead	5	4	no	Venous	No	M	No	no	no	yes	2	Polidocanol	8	no	NA	no	None	Pain, Swelling	none	none	4	1	4	4	USG	12	5.6	54	4	No
60	26	F	No	Pain, swelling, ulceration, Bleeding	Upper limb	70	26	yes	PWS	No	M	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	6	6	-1	2	MRI	4200	4200	0	2	No
61	17	M	No	Cosmetic	Arm	15	1	yes	Capillary-Venous	yes	L	No	yes	no	No	0	NA	0	no	NA	no	None	none	none	none	0	0	0	2	MRI	8.7	8.7	0	2	No
62	20	M	No	Swelling, Bleeding	Tongue	3	0.1	no	Venous-lymphatic	No	L	No	no	no	no	1	Gelfoam	10	no	1	yes	None	none	none	none	6	2	6	4	MRI	5	0.2	96	5	No

Department of Diagnostic and Interventional Radiology
All India Institute of Medical Sciences, Jodhpur

Letter No. – Radio/2022/02/30 Dated:

THROUGH PROPER CHANNEL

8103
14/12/22

To,

The Dean (Academics)
All India Institute of Medical Sciences, Jodhpur
Jodhpur- 342005

Subject: Submission of thesis in partial fulfilment of the requirement for the degree of MD Radiology

Respected Sir,

I, Dr. Adarsh Ishwar Hegde, Academic Junior Resident in the Department of Diagnostic and Interventional Radiology for the session starting August 2019, hereby submit my thesis in partial fulfilment of the requirement for the degree of MD Radiology.

Kindly find enclosed 05 copies of thesis titled "**Clinicoradiological assessment and treatment outcomes of non-visceral vascular malformations**" and accept the same. I shall be obliged.

Thanking you,

Yours sincerely,

Dr. Adarsh Ishwar Hegde
Academic Junior Resident (August 2019 Batch)
Department of Diagnostic and Interventional Radiology
AIIMS Jodhpur

Forwarded & recommended.

14/12/22