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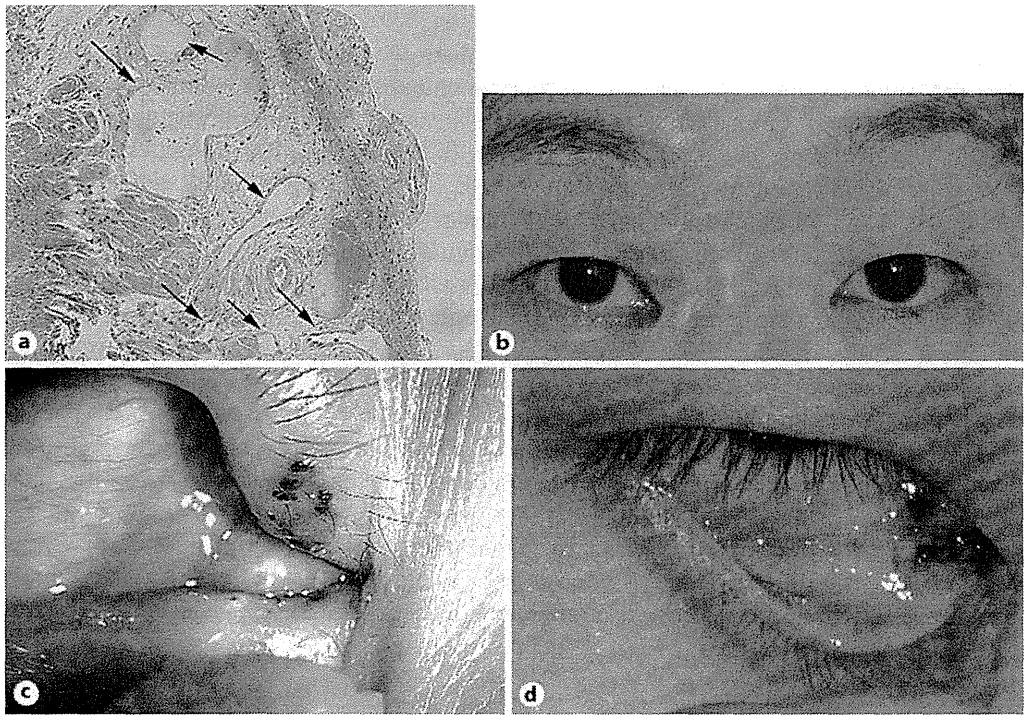

Fig. 1. **a** Histology of the biopsy sample. A lot of dilated capillaries were observed in the mucosa (arrows). ×100. **b** Facial appearance: almost no external lesions on the right eyelid. No proptosis can be seen. **c**, **d** Close-up view of the superficial lesion at the right medial ocular angle. Superficial tortuous blood vessels are visible.

Case Rep Ophthalmol 2014;5:60–65
DOI: 10.1159/000360392

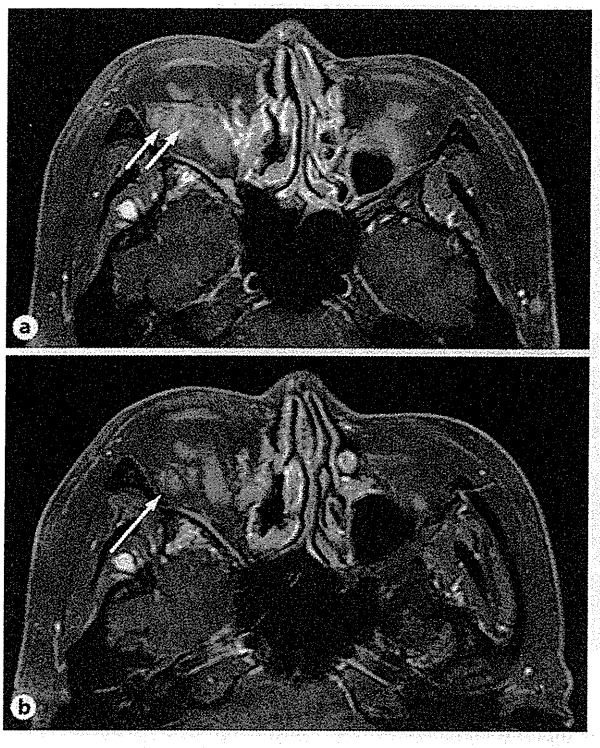

Fig. 2. a Gadolinium-enhanced MRI before treatment, with maximal dimensions of 16 × 11 mm. Internal signal voids (arrows) represent internal high-flow vessels. **b** After 1 year of topical timolol treatment, a reduction in size (12 × 8 mm, arrow) can be seen.

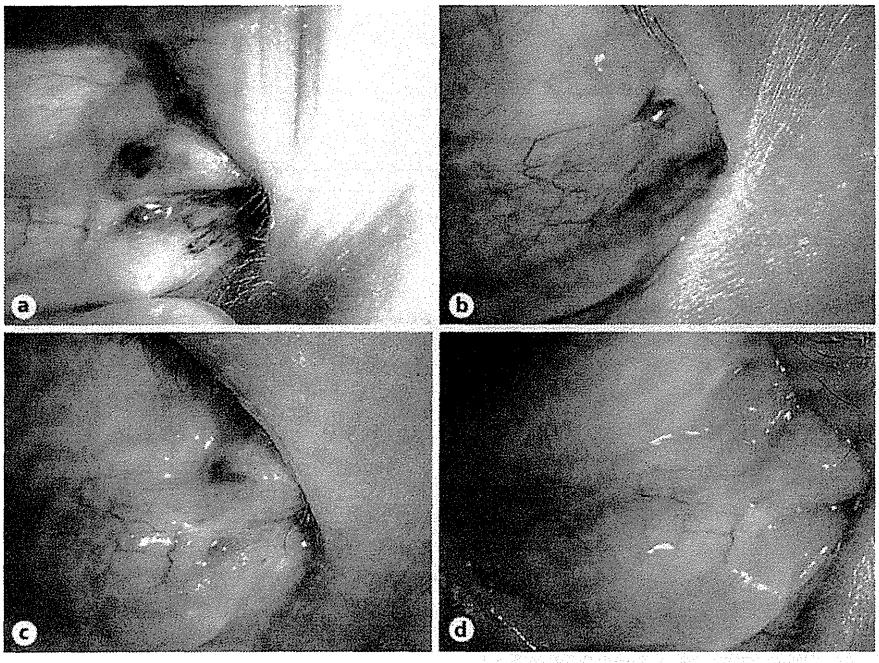

Fig. 3. Close-up view of the superficial lesions. **a** Photo at initial presentation. The lesions can be seen in the eyelids, conjunctiva and expanding into the subconjunctival space. **b** Four months later, the lesions were partially reduced. **c** Eight months later, a clear tendency toward regression can be seen. **d** After 1 year of treatment, the lesions were nearly absent.

IVR 会誌 Jpn J Intervent Radiol 29:062-067, 2014.

原著論文
Original Article

血管腫・血管奇形の全国実態調査に向けての予備調査結果の報告

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A National Epidemiological Survey of Vascular Anomalies in Japan: Results of a Pilot Survey

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● ***Abstract*** ●

No systemic epidemiological surveys have been performed on vascular anomalies in Japan. We planned to perform the first large, multicenter survey to assess the current status of medical practice for vascular malformations. In this study, we present the results of a pilot survey. This study focused on 343 patients from 5 institutions (130 men and 213 women; mean age, 27.4 years). The lesions had most commonly appeared at birth (23.3%) or by the age of 5 years (23.3%). The lower extremities were the most commonly involved area (36.0%), followed by the head and neck (35.5%). Pain and swelling were the most common symptoms (47.8 and 48.4%, respectively). Venous malformation was the most common subtype of vascular malformation (64.4%). Sclerotherapy, the most common treatment, was performed in 164 patients (47.8%). The symptoms were cured or alleviated in 82.6% of patients who underwent treatment.

Key words

- *Vascular anomalies*
- *Vascular malformations*
- *Epidemiological survey*

緒　言

体表・軟部組織の血管腫・血管奇形は，いずれも慣用的に「血管腫」と診断されることが多いが，国際血管腫・血管奇形学会（The International Society for the Study of Vascular Anomalies, ISSVA）の提唱している分類（Table 1）[1]では両者は病態の異なる疾患であり，この分類は国際的に標準化されつつある。この分類体系は，1982年に発表されたMulliken と Glowackiの研究[2]に基づいて作成された。Mullikenらによれば，血管病変は病理組織所見に基づき，血管性腫瘍（血管腫など）と血管奇形に区別される。すなわち，血管性腫瘍とは細胞（主に内皮）の腫瘍性増殖をきたす病変であるのに対し，血管奇形では内皮細胞のturnoverは正常であり，形態形成の局所的な異常と考えられる。

ISSVA分類によれば，一般に「血管腫」と診断されるもので最も頻度が高いのは乳児血管腫であり，小児期に自然退縮する。一方，血管奇形は自然退縮することはなく，疼痛，潰瘍，患肢の成長異常，機能障害，整容上の問題等をきたす。血管奇形は動脈，静脈，毛細血管，リンパ管といった構成要素により細分され，その混合型も存在する。血管奇形には，病変が小さく切除治療が可能なものから，多発性あるいは巨大で周囲組織に浸潤し治療に抵抗性を示すものまで幅広く含まれる。後者には長期にわたり患者の生活の質を深刻に損なう難治性血管奇形が含まれる。ISSVA分類により，これまで「血管腫」として一括りにされ混同されてきた病変が整理され，近年，血管腫・血管奇形の病因・病態や診断・治療法について，この分類に基づいた新たな知見が集積されつつある。

しかしながら，本邦においてはISSVA分類が未だ十分に認知されておらず，血管腫・血管奇形に関わる診療科も多岐にわたり，共通の用語を用いた標準的な診療体系が確立されているとは言い難い状況である。また，これまで本邦にて血管腫・血管奇形の体系的調査は行われたことがなく，病名が統一されていないこともあり，患者数・実態が把握できていない。このことは，治療法の保険認可や難治性疾患としての行政の事業を施行する上で問題となっている。そこで，厚生労働科学研究費補助金難治性疾患等克服研究事業（難治性疾患克服研究事業）「難治性血管腫・血管奇形についての調査研究班　患者実態調査および治療法の研究」（研究代表者：三村秀文）は，血管腫・血管奇形患者の症状・診断・治療の実態を把握する目的で，全国多施設協力体制の下，本邦初の血管腫・血管奇形患者の全国実態調査を行うことを計画した。今回は，本研究班の研究代表者・分担者が所属する施設を対象として，全国実態調査に向けた予備調査を実施したので，その結果を報告する。

対象と方法

本研究は各調査協力施設での倫理委員会の承認を経て施行した。

対象者は「難治性血管腫・血管奇形についての調査研究班」の研究代表者・分担者が所属する5施設（大阪大学医学部附属病院，長崎大学病院，川崎医科大学附属病院，川崎医科大学附属川崎病院，千葉大学医学部附属病院）を平成23年1月から12月の間に受診した血

Table 1　ISSVA classification of vascular anomalies (Updated version by Enjolras et al.)[1]

Vascular tumors	Vascular malformations
Infantile hemangiomas	**Slow-flow vascular malformations:**
Congenital hemangiomas (RICH and NICH)	Capillary malformation (CM)
Tufted angioma (with or without Kasabach-Merritt syndrome)	Port-wine stain
Kaposiform hemangioendothelioma (with or without Kasabach-Merritt syndrome)	Telangiectasia
Spindle cell hemangioendothelioma	Angiokeratoma
Other, rare hemangioendotheliomas (epithelioid, composite, retiform, polymorphous, Dabska tumor, Lymphangioendotheliomatosis, etc.)	Venous malformation (VM)
Dermatologic acquired vascular tumors (pyogenic granuloma, targetoid hemangioma, glomeruloid hemangioma, microvenular hemangioma, etc.)	Common sporadic VM
	Bean syndrome
	Familial cutaneous and mucosal venous malformation (VMCM)
	Glomuvenous malformation (GVM) (glomangioma)
	Maffucci syndrome
	Lymphatic malformation (LM)
	Fast-flow vascular malformations:
	Arterial malformation (AM)
	Arteriovenous fistula (AVF)
	Arteriovenous malformation (AVM)
	Complex-combined vascular malformations:
	CVM, CLM, LVM, CLVM, AVM-LM, CM-AVM

C = capillary; V = venous; L = lymphatic; AV = arteriovenous; M = malformation
RICH = rapidly involuting congenital hemangioma; NICH = noninvoluting congenital hemangioma

管奇形患者である。尚，今回の検討では乳児血管腫を含む血管性腫瘍の患者と毛細血管奇形（いわゆる単純性血管腫）の患者は対象外とした。症例登録期間は平成24年11月から12月で，本調査のために構築したweb登録システムを使用し，各調査協力施設にて診療録の記載内容に基づいて該当患者の情報を登録した。尚，登録情報については連結可能匿名化を行った。

調査内容は，患者基本情報，病変部位情報，症状情報，診断情報，治療情報に大別される。患者基本情報としては，生年月，性別，初発時期，併存疾患・既往歴，血管奇形に関わる家族歴を含む。病変部位情報としては，病変の主な占居部位，深さ，大きさ（長径）を含み，多部位に病変を有する症例の場合は最多で5部位まで登録可能とした。症状情報は，受診時および既往症状，機能的障害，動静脈奇形（arteriovenous malformation, AVM）のSchöbinger病期分類[9]を含む。診断情報は，診断名，診断の根拠，診断に有用であった画像診断を含む。治療情報としては他院での治療の有無，該当施設での切除（再建）術・硬化療法・塞栓術・レーザー治療の回数，保存的治療（薬物・圧迫療法）の有無，治療の転帰（該当施設で治療歴のある患者のみ），入院回数を含む。登録は主に選択肢選択方式で行った。各調査項目の選択肢の具体的な内容は結果と共に示す。

結　果

5施設で計343症例が登録された。

患者基本情報

登録患者の平均年齢は27.4歳（標準偏差20.7，中央値21.0歳，範囲1～88歳）であった。

性別は，男性130例（37.9%），女性213例（62.1%）であった。

初発時期については232例で明らかであった。その集計結果をFig.1に示す。生下時あるいは5歳未満での発症がそれぞれ54例（23.3%）で最も多く，高齢になるほど少ない傾向であった。

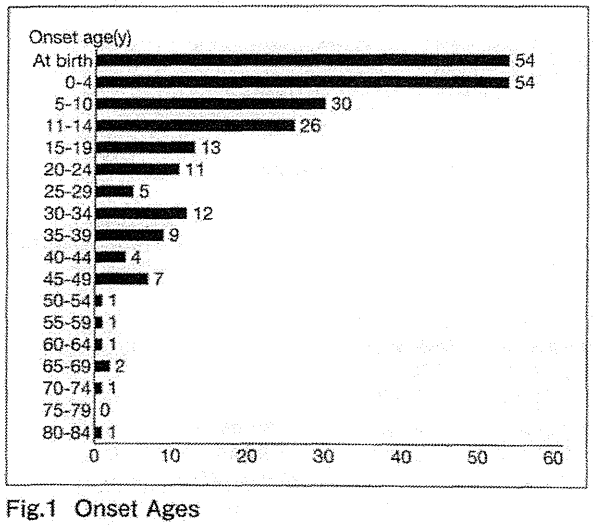

Fig.1 Onset Ages

併存疾患・既往歴は31例（9.0%）で認められ，複数患者で認められた既往症としては子宮筋腫（3例），腎不全（2例），喘息（2例）があった。

血管奇形に関わる家族歴は4例（1.2%）で認められ，父親にAVM，弟に静脈奇形（venous malformation, VM），子にVM，祖母に多発するあざ（詳細不明）がそれぞれ1例ずつであった。

病変部位情報

病変部位は1箇所のみの症例が326例，2箇所が11例，3箇所が1例，4箇所が4例，5箇所以上が1例で，登録された病変の総数はのべ372病変であった。

病変の主な占居部位，病変の深さ，病変の大きさの集計結果をTable 2に示す。占居部位は下肢が最も多く（36.0%），次いで頭頸部が多かった（35.5%）。病変の深さについては，筋肉骨靭帯などに進展する病変が多かった（67.5%）。病変の大きさについては，10㎝以上の病変が多く（42.7%），次いで5㎝未満が多かった（32.5%）。

症状情報

受診時及び既往症状は321例（93.6%）で認められ，機能的障害は38例（11.1%）で認められた。症状および機能的障害（複数選択可）の集計結果の詳細をTable 3に示す。症状は疼痛・腫脹を呈した患者が多く（それぞれ47.8%，48.4%），機能的障害については下肢機能（膝関節以下）の障害が多かった（2.6%）。

AVM患者のうち，Schöbinger病期分類は61例で明らかであり，Ⅰ期が6例（9.8%），Ⅱ期が17例（27.9%），Ⅲ期が37例（60.7%），Ⅳ期が1例（1.6%）であった。

診断情報

診断は，単純型血管奇形が316例（92.1%），混合型血管奇形（Klippel-Trenaunay症候群・Parkes Weber症候群を含む）が27例（7.9%）であった。単純型・混合型それぞれの診断名ごとの症例数をTable 4に示す。単純

Table 2 Location, depth, and size of the lesions

	n	%
Location		
Head and Neck	132	35.5
Upper extremities	56	15.1
Lower extremities	134	36.0
Trunk	50	13.4
Depth		
Superficial*	117	31.5
Deep**	251	67.5
Not entered	4	1.1
Size		
≥10 cm	159	42.7
5-10 cm	87	23.4
<5 cm	121	32.5
Unknown	2	0.5
Not entered	3	0.8

*Lesions in the skin or subcutaneous tissue
**Lesions involving muscle, bone, or ligament

Table 3 Symptoms and functional disorders

	n	%
Symptoms		
None	22	6.4
Pain	164	47.8
Swelling	166	48.4
Ulcer	14	4.1
Local bleeding	29	8.5
Cosmetic disorders	103	30.0
Infection	7	2.0
Functional disorders		
Central or peripheral nerve function	0	0.0
Eyelid or eye function	4	1.2
Respiratory or cardiac function	3	0.9
Mastication or swallowing function	3	0.9
Articulation or nasal function	4	1.2
Auditory function	1	0.3
Hand and upper extremity function	5	1.5
Lower extremity function (below knee)	9	2.6
Lower extremity function (above knee)	2	0.6
Trunk or genital function	1	0.3
Systemic bleeding tendency	3	0.9
Others	3	0.9

Table 4 Diagnosis

Diagnosis	n	%
Simple type		
VM	221	64.4
AVM	71	20.7
LM	22	6.4
VM and AVM	1	0.3
VM and LM	1	0.3
Complex-combined type		
CVM	2	0.6
CLM	0	0.0
LVM	4	1.2
CLVM	3	0.9
AVM-LM	1	0.3
CM-AVM	3	0.9
Klippel-Trenaunay syndrome	9	2.6
Parkes Weber syndrome	5	1.5

Table 5 Basis of diagnosis and valuable diagnostic imaging modalities

	n	%
Basis of diagnosis		
Clinical diagnosis	285	83.1
Imaging diagnosis	301	87.8
Pathological diagnosis	10	2.9
Valuable diagnostic imaging modalities		
Ultrasonography	236	68.8
MRI	301	87.8
CT	35	10.2
Scintigraphy	0	0.0
Angiography	81	23.6
Plain X-ray photography	3	0.9

型血管奇形ではVMが221例(64.4%)と最も多かった。混合型血管奇形では，Klippel-Trenaunay症候群が9例(2.6%)と最も多かった。

診断の根拠および診断に有用であった画像診断(複数選択可)の集計結果をTable 5に示す。画像診断，臨床診断が診断の根拠となった症例が多く(それぞれ87.8%，83.1%)，診断に有用な画像診断としてはMRIおよび超音波が多かった(それぞれ87.8%，68.8%)。

治療情報

他院での治療は114例(33.2%)で施行されており，当該施設での治療は218例(63.6%)で施行されていた。当該施設で施行された各治療別の症例数をTable 6aに示す。硬化療法が164例(47.8%)で施行されており，最も多かった。治療の転帰の集計結果をTable 6bに示す。全ての治療を含めた転帰として，治癒または改善が合わせて82.6%で認められた。

入院回数は，なしが166例(48.4%)，1～2回が134例(39.1%)，3～5回が33例(9.6%)，6回以上が9例(2.6%)，回数不明が1例(0.3%)であった。

Table 6a Treatments performed at the surveyed institutions

	Number of the treatment sessions				
	1～2	3～5	6	Unknown	Total
Resection, n (%)	31 (75.6)	9 (22.0)	0 (0)	1 (2.4)	41
Sclerotherapy, n (%)	125 (76.2)	30 (18.3)	9 (5.5)	0 (0)	164
Embolization, n (%)	11 (84.6)	2 (15.4)	0 (0)	0 (0)	13
Laser, n (%)	0 (0)	0 (0)	6 (85.7)	1 (14.3)	7
Conservative treatment	—	—	—	—	58

Table 6b Outcomes of the treatments

	Cure	Improvement	No change	Deterioration	Unknown	Not entered
Resection, n (%)	4 (9.8)	33 (80.5)	2 (4.9)	2 (4.9)	0 (0)	0 (0)
Sclerotherapy, n (%)	3 (1.8)	139 (84.8)	17 (10.4)	4 (2.4)	1 (0.6)	0 (0)
Embolization, n (%)	0 (0)	10 (76.9)	3 (23.1)	0 (0)	0 (0)	0 (0)
Laser, n (%)	0 (0)	6 (85.6)	1 (14.3)	0 (0)	0 (0)	0 (0)
Conservative treatment, n (%)	3 (5.1)	35 (60.3)	17 (29.3)	1 (1.7)	1 (1.7)	1 (1.7)
Overall, n (%)	7 (3.2)	173 (79.4)	31 (14.2)	4 (1.8)	2 (0.9)	1 (0.5)

考　察

血管腫・血管奇形の有病率は1.5～4.5％と報告されており，その頻度は地域によっても異なるとされる[4,5]。本邦における血管腫・血管奇形の患者数や有病率は明らかではない。また，血管腫・血管奇形の実態についてISSVA分類に基づいて疫学的事項を調査した報告は，世界的にみても単施設での研究が散見されるのみである[6~9]。従って，我々が計画している全国実態調査は，世界初の大規模な多施設共同研究となる。今回の調査は，全国調査を行うにあたってその調査項目や調査方法の妥当性を検証するための予備調査であり，対象症例は「難治性血管腫・血管奇形についての調査研究班」の研究代表者・分担者が所属する5施設の症例（うち3施設が放射線科，2施設が形成外科の症例）に限られた。従って，施設あるいは診療科の偏りによるバイアスが存在していると考えられ，結果の解釈にあたってはこの点に留意する必要がある。しかし，この予備調査自体も多施設の血管奇形患者を対象とした本邦初の疫学的調査であり，これまで明らかでなかった本邦における血管奇形患者の患者背景や診断・治療の実態について，一定の傾向を把握することができた。

血管奇形患者の男女比については，Enjolrasらの成書によればほぼ1：1とされており[1]，これに合致する報告も認められる[5,7]。一方，我々の検討では女性にやや多い傾向が示された。Leeの報告でも我々の結果と同様にやや女性の方が多く[8]，血管奇形患者の男女比については未だ検討の余地があるものと考えられる。

Mathesらの報告では，血管奇形患者のうち57％が生下時に発症し，これに10歳までに発症した症例も加えると約70％を占める[9]。Yeらの報告では，29％が生下時に発症しており，これに10歳までに発症した症例も加えると約85％を占める[6]。我々の調査では，初発時期が明らかであった症例のうち23％が生下時に発症しており，10歳までに発症した患者を合計すると約60％を占めており，過去の報告と同様に生下時～若年での発症が多いことが示された。

遺伝性の血管奇形は存在するが比較的稀であり，血管奇形の大部分は孤発性とされる[10]。今回の調査でも血管奇形関連の家族歴が認められた症例は1.2％のみであり，大部分は孤発性と考えられた。既往症については様々であり，血管奇形との関連を積極的に疑う特定の既往症は認めなかった。

病変の占居部位については，過去の複数の報告で頭頸部あるいは下肢が最も多く，上肢，体幹がそれに続くという傾向が示されており[6,8,9]，今回の調査でも同様の結果が得られた。また，今回の調査では，深部（筋肉骨靱帯など）に進展する病変が70％近くあり，大きさについては10㎝を超える病変が40％程度認められた。血管奇形の治療において，病変の大きさや広がりが治療効果・予後に関わることが知られており[4,11,12]，難治性や重症度との関連を検討する上でもこれらの情報の把握は重要と思われる。

今回の調査では受診時及び既往症状が認められた症例は94％にのぼり，疼痛および腫脹が最も多くそれぞれ半数近くの症例で認められた。また，機能的障害は11％で認められた。Mathesらは，血管腫・血管奇形患者の症状として，疼痛が51.4％，腫脹が24.0％，整容障害が21.0％，感染が6.9％，出血が11.4％に認められ，機能的障害が27.4％の患者に認められたとしている[9]。これは乳児血管腫をはじめとする血管性腫瘍も含むデータであるため，我々の調査結果と一概に比較はできないが，腫脹を呈した症例の割合が異なる他は概ね同様の傾向と言える。

Schöbinger分類は，AVMの病期分類として広く用いられている。小児期にⅠ期であった症例の4割程度が成人までにⅢ期以上に進行するとの報告がある[13]。我々の調査ではⅢ期の症例が約60％を占めていた。病期ごとの割合については報告によって異なるが[12,14]，これは施設や診療科による対象患者の違いを反映している可能性がある。

血管奇形の中で，VMが一般的に最も頻度が高いとされる。その割合は血管奇形患者の約37～66％と報告されている[4,6~9]。今回の調査対象患者の中でもVMが約64％で最も多く，過去の報告に一致する結果であった。ただし，今回の調査では単純型の毛細血管奇形が含まれていない。また，混合型血管奇形の割合は約8～19％と報告されており[6~8]，これについても今回調査では約8％と類似の結果であった。

血管腫・血管奇形は，病歴と身体所見のみで診断可能な症例も多いとされるが[15]，今回の調査では約88％の症例で画像診断が施行されていた。画像診断が用いられる場合，病変の種類や臨床的状況に応じてモダリティを選択することが重要であり，超音波とMRIが最もよく用いられる[15,16]。今回の調査でも超音波・MRIが有用であった症例が多いことが示された。

血管奇形の治療については，VMに対する硬化療法や四肢のAVMに対する塞栓術が未だ保険適応外であるにもかかわらず，今回の調査により比較的多数の患者が硬化療法や塞栓術を受けており，治療を受けた患者の多くで良好な治療効果（治癒または改善）が得られている実態が明らかになった。全国調査でのより詳細な現状の把握が待たれる。

尚，今回の予備調査において，血管奇形の重症度と難治性についても同時に調査を行ったが，その解析は本研究班にて別途施行し，報告している[17]。

結　語

今回の予備調査により，多施設の血管奇形患者を対象として，これまで明らかでなかった疫学的情報を得ることができた。また，今回構築したweb登録システムを用いて全国調査を行うことにより，本邦における血管奇形患者の実態を把握できる見通しが示された。

謝　辞

本研究は，平成24年度厚生労働科学研究費補助金

難治性疾患等克服研究事業（難治性疾患克服研究事業）「難治性血管腫・血管奇形についての調査研究班　患者実態調査および治療法の研究」の資金を得て施行した。

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Jpn J Radiol (2013) 31:775–785
DOI 10.1007/s11604-013-0249-x

PICTORIAL ESSAY

Imaging of vascular tumors with an emphasis on ISSVA classification

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Received: 17 June 2013 / Accepted: 12 September 2013 / Published online: 18 October 2013

Abstract The International Society for the Study of Vascular Anomalies (ISSVA) classification is becoming the international standard classification system for vascular tumors and vascular malformations. The ISSVA classification strictly distinguishes vascular tumors (neoplastic lesions) from vascular malformations (non-neoplastic lesions) based on whether there is a proliferation of vascular endothelial cells present, and it is an extremely useful classification system for determining therapeutic measures. For vascular tumors, it is clinically significant in terms of discriminating infantile hemangioma and rapidly involuting congenital hemangioma, which are expected to spontaneously regress, from other vascular tumors requiring treatment. Needless to say, clinical courses are important for diagnosis, and it is also important for radiologists to understand imaging findings on vascular tumors because such tumors have unique findings on diagnostic images. In this paper, vascular tumors are classified based on the ISSVA classification, and clinical and imaging findings are reviewed.

Keywords Vascular tumors · Hemangioma · ISSVA classification

Introduction

Vascular tumors and malformations may occur at any site in the body, and various specialists from different fields treat them depending on the location of occurrence. Traditionally, different names have been applied in describing these lesions, resulting in confusion. In the WHO classification, two sections are related to vascular tumors and malformations: "bone and soft tissue tumors" and "skin tumors" (Tables 1, 2) [1]. The term "hemangioma" in these descriptions includes both vascular neoplasms and malformations in the WHO classification.

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Table 1 WHO classification of vascular tumors of soft tissue and bone

Benign	Hemangiomas
	Synovial hemangioma
	Intramuscular angioma
	Venous hemangioma
	Arteriovenous malformation/hemangioma
	Epithelioid hemangioma
	Angiomatosis
	Lymphangioma
Intermediate	Kaposiform hemangioendothelioma
	Retiform hemangioendothelioma
	Papillary intralymphatic angioendothelioma
	Composite hemangioendothelioma
	Kaposi sarcoma
	Pseudomyogenic hemangioendothelioma
	Other intermediate vascular neoplasms
Malignant	Epithelioid hemangioendothelioma
	Angiosarcoma of soft tissue

Table 2 WHO classification of vascular and lymphatic tumors of skin

Vascular tumors	Hemangioma of infancy
	Cherry hemangioma
	Sinusoidal hemangioma
	Hobnail hemangioma
	Glomeruloid hemangioma
	Microvenular hemangioma
	Angiolymphoid hyperplasia with eosinophilia
	Spindle cell hemangioma
	Tufted angioma
	Bacillary angiomatosis
	Reactive angioendotheliomatosis
	Verrucous hemangioma
	Pyogenic granuloma
	Cavernous hemangioma
	Angiokeratomas
	Arteriovenous hemangioma
	Cutaneous angiosarcoma
Lymphatic tumors	Lymphangioma circumscriptum
	Progressive lymphangioma
	Lymphangiomatosis

In recent years, the ISSVA classification, in which vascular tumors are distinguished from vascular malformations, is gaining traction as the international standard. This classification system distinguishes between vascular tumors and vascular malformations based on whether neoplastic proliferation of vascular endothelial cells is present (i.e. vascular tumors are defined as those having neoplastic proliferation while vascular malformations lack neoplastic proliferation) (Table 3) [2].

Several recent review articles have focused on vascular anomalies, because their diagnosis and treatment has progressed with the advent of new drug therapies such as propranolol and sirolimus. However, these articles include breadth without depth, detailing vascular anomalies overall, including neoplasms and malformations. To the best of our knowledge, no pictorial essay has simply focused on the clinical and imaging features of vascular neoplasms based on the ISSVA classification. This paper outlines the clinical and imaging features of vascular tumors in soft tissues based on the ISSVA classification. We also compare and contrast the ISSVA classification with the classical classification systems, including the latest WHO classification.

ISSVA classification versus classical classification systems

In the WHO classification of tumors of soft tissue and bone (4th edition, 2013), "hemangiomas" include synovial hemangioma, intramuscular angioma, venous hemangioma and arteriovenous hemangioma. They assert that these "hemangiomas" are likely vascular malformations and that the early presentation/congenital nature and pathologic architectural features of "lymphangioma" favor a developmental malformation. On the other hand, the WHO classification of tumors of pathology and genetics of skin tumors (3rd edition, 2006) asserts that the term "cavernous hemangiomas" was erroneously considered neoplastic, when in reality it is a vascular malformation, and "lymphangioma" is either a vascular malformation or a neoplasm. Thus, the term "hemangioma" and "lymphangioma" may refer to either vascular malformations or vascular neoplasms in the latest WHO classifications.

In contrast, the ISSVA classification (1996) is simpler, emphasizing the presence or absence of neoplastic cells (i.e., tumor or malformation). Thus, "venous malformation" refers to a venous vascular anomaly without neoplastic cells and corresponds approximately to "cavernous hemangioma", "venous hemangioma" and "intramuscular hemangioma" in the WHO classification; "capillary malformation" corresponds approximately to "port-wine stain", "hemangioma simplex", and "angiokeratoma" in the WHO classification; and "lymphatic malformation" corresponds approximately to "cystic hygroma" and "cavernous lymphangioma" in the WHO classification. Mixed vascular lesions are represented as well, with "arteriovenous malformation" in the ISSVA classification corresponding to "arteriovenous hemangioma" in the WHO classification. "Infantile hemangioma" and "congenital hemangioma" in the ISSVA classification corresponds

Table 3 ISSVA classification of vascular tumors and malformations

Vascular tumors	Vascular malformations	
Infantile hemangiomas	Slow-flow	Capillary malformation (CM)
Congenital hemangiomas (RICH and NICH)		Port-wine stain
Tufted angioma		Telangiectasia
Kaposiform hemangioendothelioma		Angiokeratoma
Spindle cell hemangioendothelioma		Venous malformation (VM)
Other, rare hemangioendotheliomas (epithelioid, composite, retiform, polymorphous, Dabska tumor, lymphangioendotheliomatosis, etc.)		Common sporadic (VM)
Dermatologic acquired vascular tumors (pyogenic granuloma, targetoid hemangioma, glomeruloid hemangioma, microvenular hemangioma, etc.)		Bean syndrome
		Familial cutaneous and mucosal
		Venous malformation (VMCM)
		Glomuvenous malformation (GVM)
		(Glomangioma)
		Maffucci syndrome
		Lymphatic malformation (LM)
	Fast-flow	Arterial malformation (AM)
		Arteriovenous fistula (AVF)
		Arteriovenous malformation (AVM)
	Complex-combined	CVM, CLM, LVM,CLVM,
		AVM-LM, CM-AVM

Table 4 ISSVA classification versus classical classification

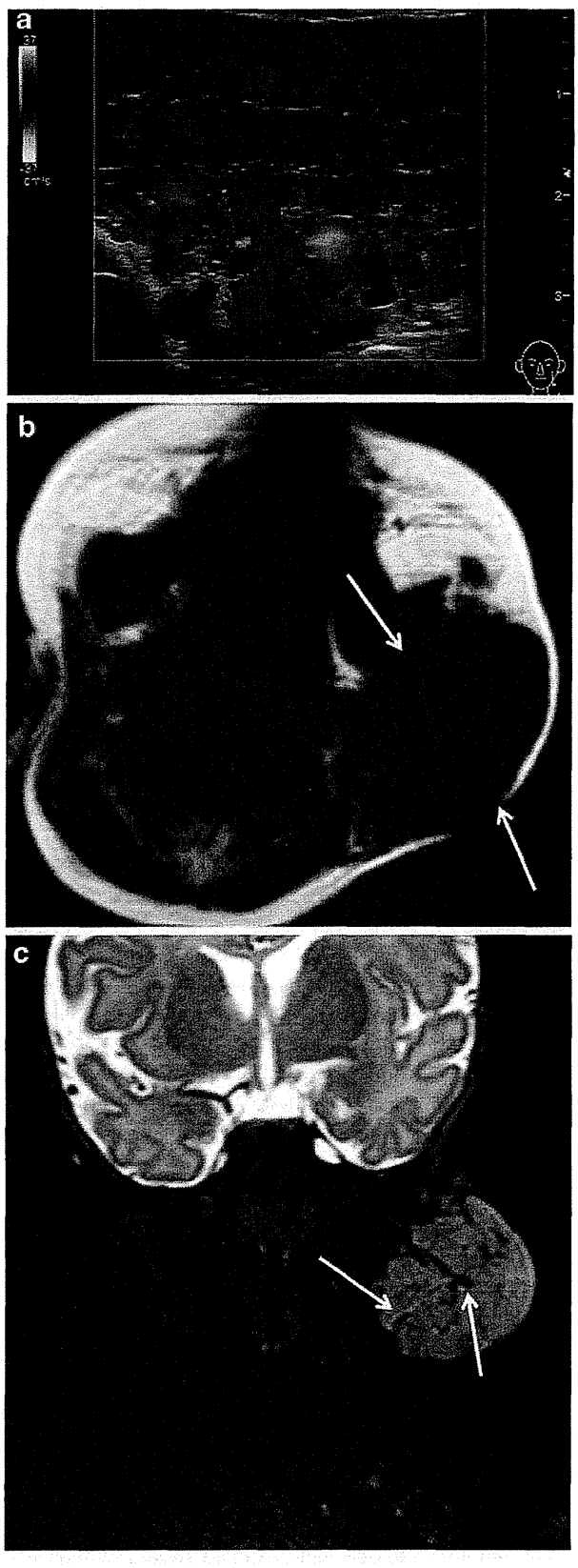
ISSVA classification	Classical classification (including WHO classification)
Vascular tumors	
Infantile hemangioma	Strawberry mark (Cherry hemangioma)
	Hemangioma of infancy
	Capillary hemangioma
Congenital hemangioma	Strawberry mark (Cherry hemangioma)
	Hemangioma of infancy
	Capillary hemangioma
Vascular malformation (High-flow)	
Arteriovenous malformation (AVM)	Arteriovenous hemangioma
Vascular malformation (Slow-flow)	
Venous malformation (VM)	Cavernous hemangioma
	Venous hemangioma
	Intramuscular hemangioma
Capillary malformation (CM)	Port-wine stain
	Hemangioma simplex
	Angiokeratoma
Lymphatic malformation (LM)	Lymphangioma, cystic hygroma, cavernous lymphangioma

approximately to "strawberry mark", "hemangioma of infancy" and "capillary hemangioma" in the WHO classification (Table 4).

Infantile hemangioma (IH)

Infantile hemangioma is the most common benign tumor in neonates and infants. It has a characteristic clinical course in which it rapidly grows after birth (several days to a few weeks after birth) until 12–18 months of age, and then slowly regresses over several years. The former is called "the proliferative phase" and the latter is called "the involuting phase." It is commonly known as a "strawberry mark," the term used in the WHO classification. Histopathologically, it is characterized by positive glucose transporter-1 (GLUT-1) staining. Although superficial lesions are diagnosed easily, diagnostic imaging is required for lesions in deep tissues and intractable alarming hemangioma involving the orbit or the respiratory tract. Interest in this disease has recently increased because it has been reported that beta blockers are highly effective against IH [3].

Imaging findings are different between the proliferative phase and the involuting phase [4]. In the proliferative phase, the pathological findings are the proliferation of vascular endothelial cells and the lobulated mass of tissues, which results in a sharply marginated hypervascular mass radiographically. Low to high echogenicity are observed on ultrasound images and arterial blood flow is seen on color Doppler images (Fig. 1a). On MRI, IHs are well-circumscribed, lobulated masses with isointensity or low intensity on T1-weighted images (Fig. 1b) and relatively uniform



◀ **Fig. 1** Infantile hemangioma in the proliferative phase on the cheek of a 13-month-old boy. **b** Axial T1-weighted MR image shows a well-defined mass, isointense to muscle (*arrows*). **c** Coronal fat-saturated T2-weighted MR image of the neck shows high intensity to muscle with flow voids (*arrows*). **a** Color Doppler US demonstrates arterial flow within a mass

high intensity, with flow voids reflecting arterial blood flow on T2-weighted images and fat suppressed (FS) T2-weighted images (Fig. 1c). On contrast-enhanced MRI, there is vivid staining in the early phase and the staining is maintained until the delayed phase. In the involuting phase, vascular endothelial cells pathologically decrease through apoptosis and are then replaced by fibro-fatty tissues. Reflecting this, decreased arterial blood flow and fat displacement are observed on images (Fig. 2).

Congenital hemangioma (CH)

Congenital hemangioma was first reported by Boon et al. [5] in 1996 as IH-like lesions that presented the peak proliferation or were regressing at birth. It is classified into two types: rapidly involuting CH (RICH), which achieves a complete regression by approximately 12–14 months after birth, and non-involuting CH (NICH), which may partially

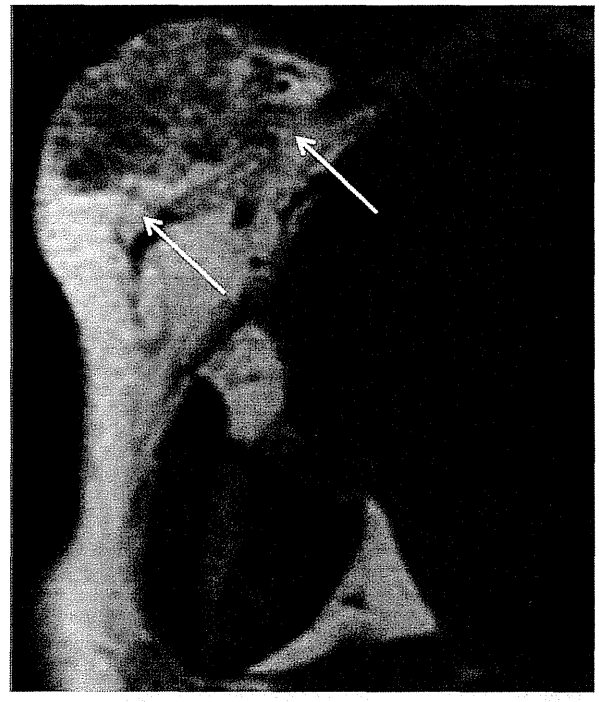


Fig. 2 Infantile hemangioma in the involuting phase on the right mandible of a 2-year-old boy who received laser treatment. Axial T1-weighted MR image shows a mass including loose fibrofatty tissue (*arrows*)

grow but does not regress. Unlike IH, immunostaining with GLUT-1 is negative in vascular endothelial cells. The incidence of CH is unknown but is believed to be low, and the incidence of NICH is believed to be lower than that of RICH. It is difficult to clinically distinguish between RICH and NICH at a given time point, and it is important to monitor the clinical course.

There have been few reports on imaging findings [6, 7]. Imaging findings on CH are basically similar to those on IH, and arterial blood flow is also seen in the mass (Fig. 3a–c). Unlike IH, CH tends to show inhomogeneous parenchyma in the mass with poor margins on ultrasound and MR images and it sometimes shows calcification (Fig. 4a–g). In angiography, aneurysm formation with AV shunt and venous dilatation tend to be obvious.

Kaposiform hemangioendothelioma (KHE)/tufted angioma (TA)

Kaposiform hemangioendothelioma was first reported by Zukerberg et al. [8] in 1993 as a Kaposi's sarcoma-like tumor that occurred in infants. KHE has been reported to occur in infants at birth and aged 10 years and younger in many cases, and reports on adult cases have been increasing recently. It is a locally invasive tumor showing progressive proliferation of vascular endothelial cells with poor margins. It sometimes invades the muscle and bone [9].

Today, tufted angioma is believed to be a subtype of KHE, and is a tumor showing intradermal proliferation of vascular endothelial cells in clusters called "cannon balls." It often develops on the skin and rarely requires diagnostic

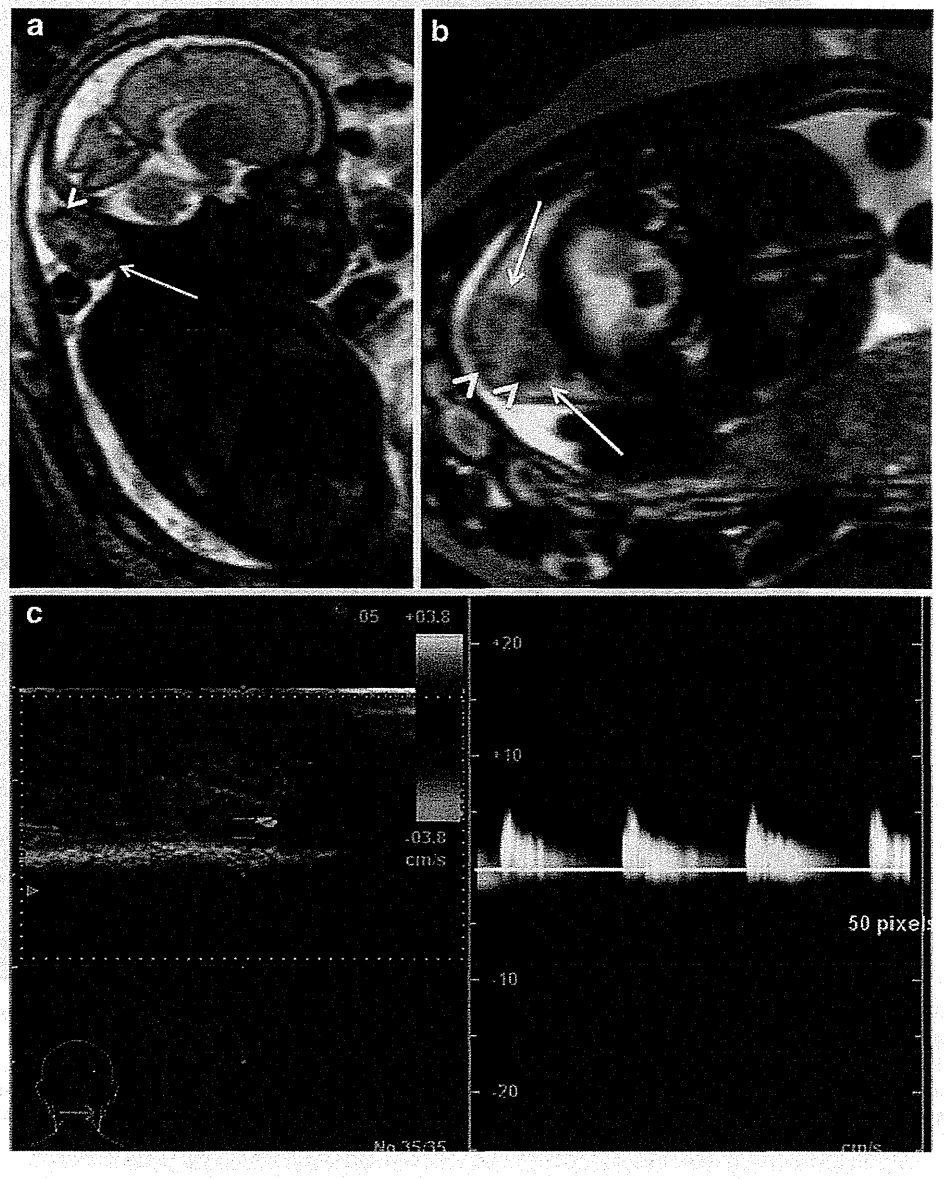


Fig. 3 Rapidly involuting congenital hemangioma (RICH) involving the posterior cervical region. **a**, **b** Sagittal and axial fetal MR images on single-shot FSE sequence show well-defined subcutaneous mass (*arrows*) with flow voids (*arrowheads*) at 29 weeks gestation. **c** Color Doppler US shows arterial flow in the mass. The lesion demonstrated significant involution in 6 months

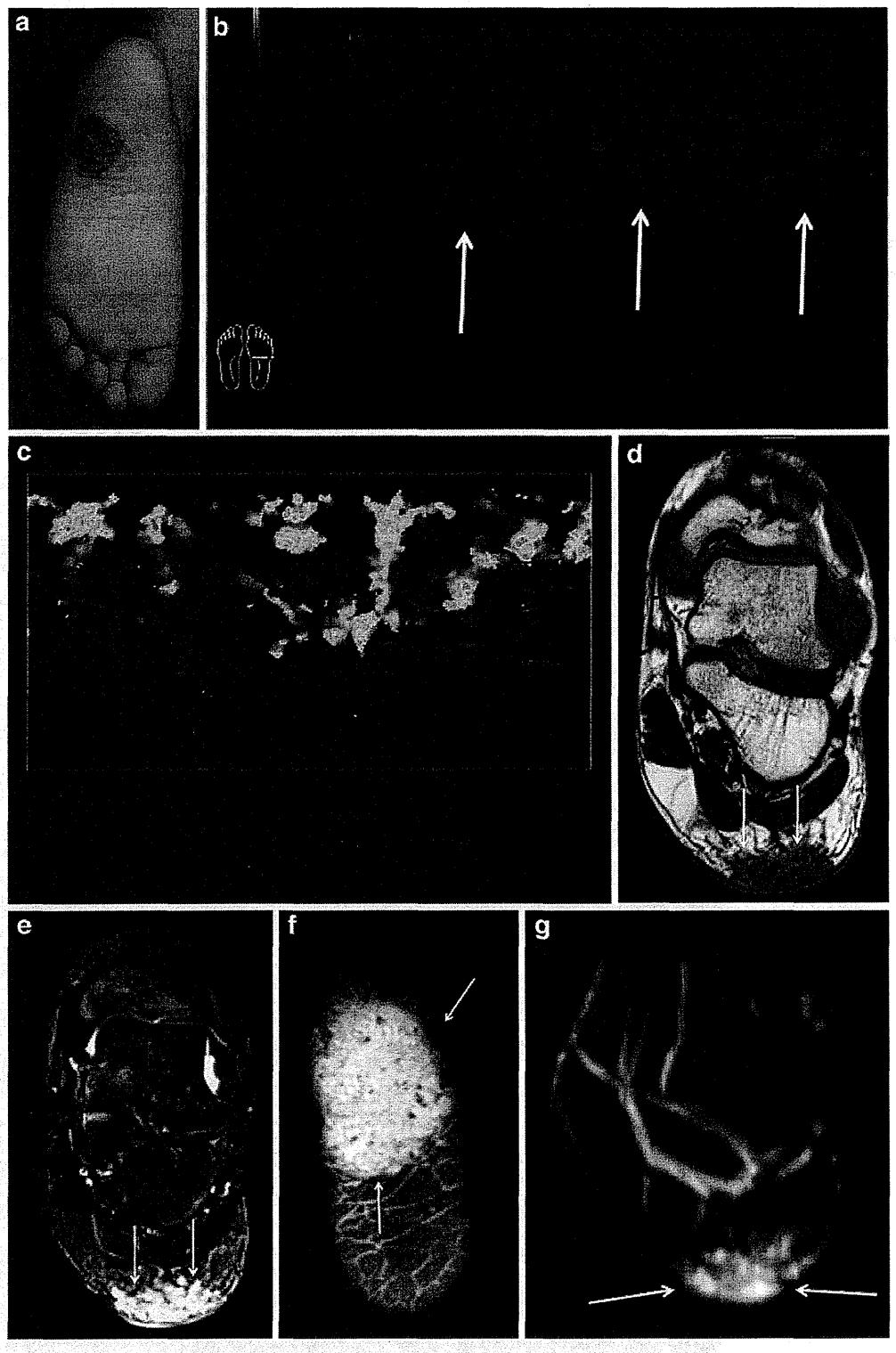


Fig. 4 Non-involuting congenital hemangioma (NICH) in the left sole. **a** A soft-tissue mass with reddish discoloration present since birth in a 12-year-old boy. **b** US shows ill-defined heterogeneous plantar solid mass (*arrows*). **c** Color Doppler US shows hypervascular mass with arterial flow. **d** Coronal T1-weighted MR image shows an ill-defined mass isointense to muscle (*arrows*). **e** Coronal fat-saturated T2-weighted MR image shows high intensity to muscle (*arrows*). **f** Axial fat-saturated contrast-enhanced T1-weighted MR image shows vivid enhancement of the lesion (*arrows*). **g** Time-resolved MR angiogram shows prominent enhancement in the arterial phase (*arrows*)

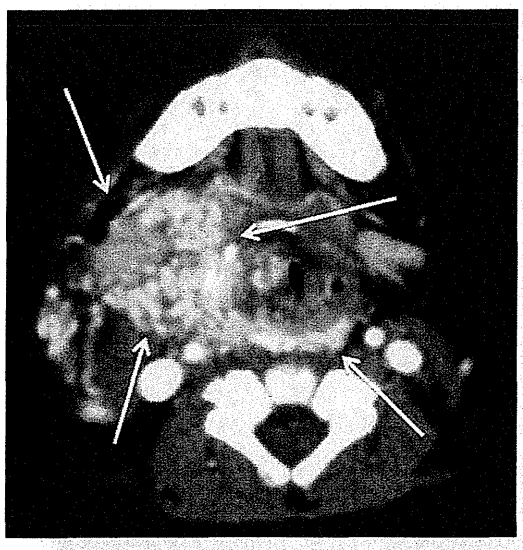


Fig. 5 Kaposiform hemangioendothelioma in a 2-month-old boy with Kasabach–Meritt syndrome. Axial contrast-enhanced CT image shows an ill-defined mass with prominent enhancement in the arterial phase (*arrows*)

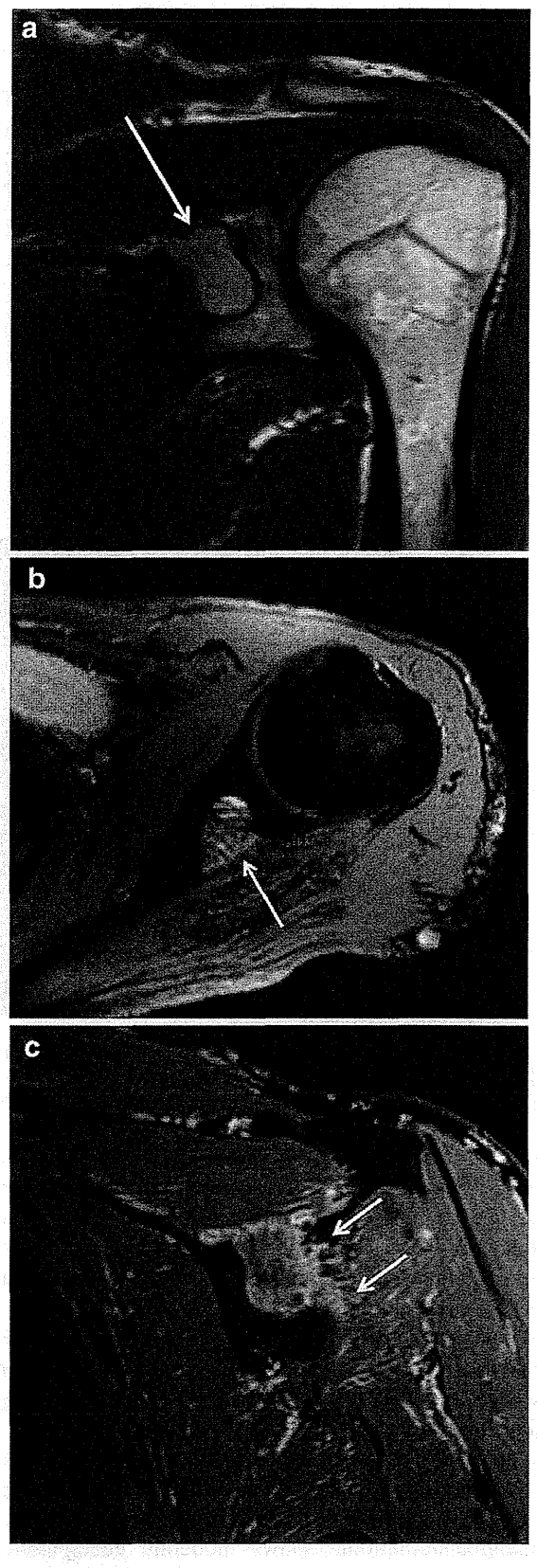


Fig. 6 Retiform hemangioendothelioma in a 42-year-old woman who presented with left shoulder pain. She had undergone several surgical operations for local recurrence from childhood. **a** Coronal T1-weighted MR image shows a slight, ill-defined mass near the suprascapular notch, hyperintense to muscle (*arrow*). **b** Axial fat-saturated T2-weighted MR image shows intermediate intensity to muscle (*arrow*). **c** Coronal contrast-enhanced T1-weighted MR image shows a heterogeneous, ill-defined mass with proliferation of vascular channels of peripheral area (*arrows*)

imaging, and is considered to be the same lesion as angioblastoma (Nakagawa) [10] in Japan. It is now believed that KHE and TA cause Kasabach–Merritt syndrome [11].

On diagnostic imaging, it is characteristically seen as hypervascular invasive tumors with poor margins [12] (Fig. 5). On MRI, KHE/TA typically appears as ill-circumscribed masses with low or isointensity areas on T1-weighted images and high intensity on T2-weighted images. On contrast-enhanced MRI, it often shows inhomogeneous staining. Similar tendencies are observed on ultrasound images, which show poorly-marginated hypervascular lesions with low to high echogenicity.

Other, rare hemangioendotheliomas

Hemangioendothelioma is a vascular tumor of borderline malignancy that develops from vascular endothelial cells, and is positioned between hemangioma (benign) and angiosarcoma (malignant). The subtypes include epithelioid, retiform, composite, pseudomyogenic and papillary intralymphatic angioendothelioma. The assignment of the

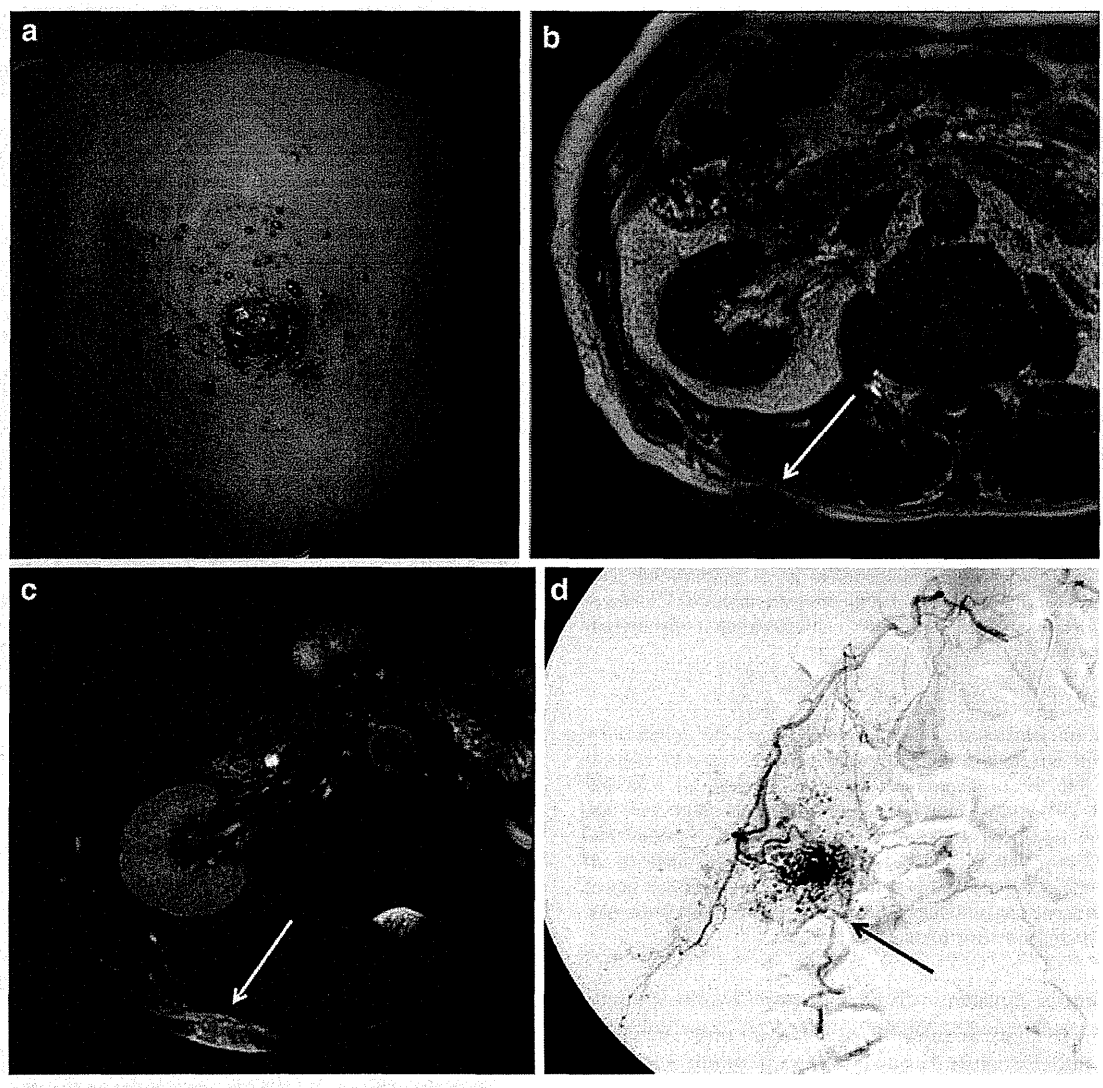


Fig. 7 Pyogenic granuloma of the back in a 66-year-old man. **a** Clinical image shows multiple reddish papules. **b** Axial T1-weighted MR image shows a homogeneous mass isointense to muscle (*arrow*). **c** Axial fat-saturated T2-weighted MR image shows high intensity to muscle (*arrow*). **d** Angiography shows ill-defined prominent enhancement area (*arrow*)

term used for hemangioendothelioma was problematic because it was used for different types, including benign, borderline malignant and malignant tumors, resulting in confusion in the past. Now it is generally used to mean a tumor of borderline malignancy, except for epithelioid hemangioendothelioma.

Hemangioendothelioma includes superficial tumors that occur on or under the skin and tumors that occur in deep tissues such as muscles. Each type has different imaging findings in general [13].

Superficial lesions involve thickening of the skin and subcutaneous tissues, and often form localized masses. Characteristics in lesions are non-specific. Hemangioendothelioma shows moderate echogenicity on ultrasound images. On MRI, the mass shows isointensity on T1-weighted images and iso or high intensity on T2-weighted images. The proliferation and dilation of the vascular channels are not obvious in many cases.

In contrast, deep lesions show obvious proliferation of vascular components compared to other soft tissue masses, and AV shunts are identifiable. On ultrasound images, although the echogenicity of masses are various (low to high echogenicity), bleeding is seen as a cystic change and AV shunts are identified on color Doppler images. On MRI, although they show non-specific findings of isointensity areas on T1-weighted images and high intensity areas on T2-weighted images, an obvious enhancement is seen in the early phase on MRI with gadolinium (Gd), reflecting the proliferation of vascular channels (Fig. 6a–c).

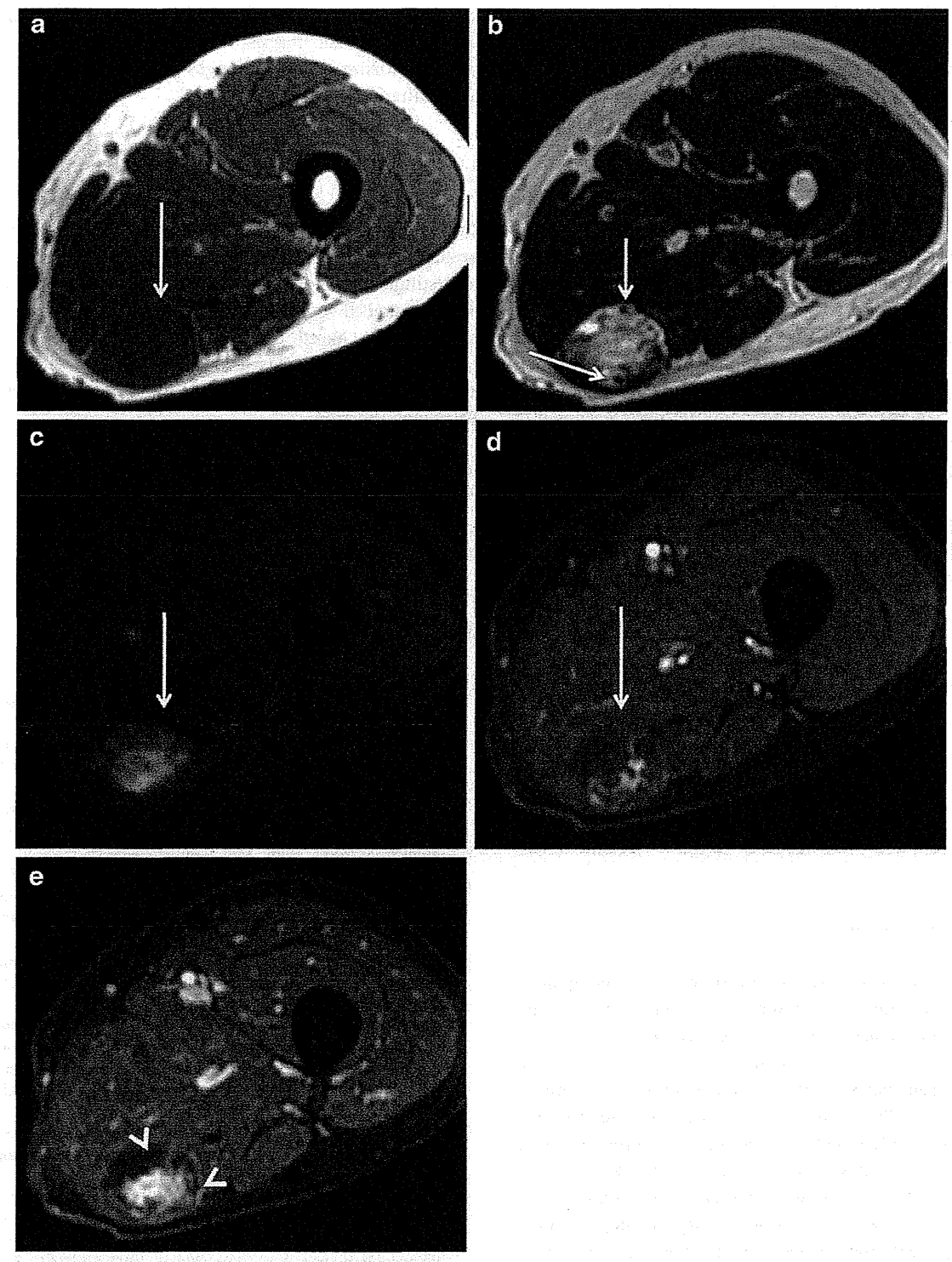


Fig. 8 Angiosarcoma of soft tissue in a 50-year-old female in the thigh. **a** Axial T1-weighted MR image shows a well-defined mass in the hamstring, isointense to muscle (*arrow*). **b** Axial T2-weighted MR image shows a heterogeneous signal with flow voids (*arrows*). **c** Diffusion-weighted MR image demonstrates diffusion restriction (*arrow*). **d**, **e** Axial contrast-enhanced T1-weighted MR image shows gradual enhancement from arterial phase (*arrow*) to venous phase (*arrowheads*)

Dermatologic acquired vascular tumors

These are vascular tumors that are skin lesions and are rarely examined through diagnostic imaging. In this paper, a description is provided only on pyogenic granuloma, which is sometimes found as a subcutaneous mass.

Pyogenic granuloma

Pyogenic granuloma was first reported by Poncet and Dor [14] in 1897. Despite its name, it is not a granuloma but a vascular tumor. It is a protruded lesion with hemorrhagic tendencies that occurs on the skin or mucosa. It often causes ulcers to have a granulation tissue-like appearance and it appears to be pyogenic because of secondary infections and exudative change; and for these reasons it is named "pyogenic granuloma" [15]. The etiology is not clear, and the involvement of local factors such as trauma, infection, and chronic stimulation is suspected. Favorite sites include the areas for cervicofacial and oral surgery and for dermatology, but it sometimes occurs in the gastrointestinal tract or other sites.

There are no detailed reports on imaging findings. Pyogenic granuloma is a sharply marginated mass with slightly high echogenicity on ultrasound images, and shows high flow on color Doppler images. On MRI, when compared to the muscle, the mass shows isointensity on T1-weighted images and high intensity on T2-weighted images and FS-T2-weighted images (Fig. 7a–d). Some case reports (including intravenous variants) state that many pyogenic granulomas are generally highly enhanced in contrast enhanced CT and MRI because they are vascular tumors [16, 17].

Angiosarcoma of soft tissue

Angiosarcoma is a vascular tumor of high malignancy involving vascular and lymphatic cellular elements and often occurs on and under the cervicofacial skin in the elderly [18]. Lesions in the skin account for 33 %, those in the soft tissues account for 23 %, and those in the bones account for 6 % of the total. Local recurrences and metastases are often observed and the most common site of metastasis is the lung. The well-known "Stewart–Treves syndrome" refers to an angiosarcoma, a rare complication that forms as a result of chronic, long-standing lymphedema in patients with breast cancer, who have had mastectomy and/or radiotherapy.

On MRI, it shows non-specific imaging findings of isointensity on T1-weighted images and high intensity on T2-weighted images and FS-T2-weighted images. The mass shows prominent enhancement with Gd, and is characterized by obvious vascular proliferation; in particular, vascular proliferation is often seen along the periphery of such masses. Because of high tumor cellularity, diffusion-weighted images generally show diffusion restriction [19] (Fig. 8a–e).

Conclusion

Although vascular tumors are generally handled as suggested by their traditional term, "hemangioma", it is useful to distinguish tumors requiring treatment from those that are expected to spontaneously regress and only have to be followed up, based on the ISSVA classification. It is essential for radiologists to become familiar with clinical and imaging findings on vascular tumors based on the ISSVA classification.

Acknowledgments The authors thank Jay Starkey, MD for valuable assistance in manuscript preparation.

Conflict of interest The authors declare that they have no conflict of interest.

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