Hemangiomas and Vascular Malformations: Classification, Imaging Diagnosis, & Management with Selected Cases

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Confusing terminology!

- Legacy of confusing nomenclature and non-standard descriptive terminology

- Examples: angioma, nevus angiectoides, varice aneurysm, cirsoid aneurysm, hemangioma cavernosum, arteriovenous angioma, red angioma telangiectaticum, blue rubber bleb nevus syndrome...

- Standardized descriptors and classification facilitate appropriate diagnosis and management
Classification Schemes: Progressing Toward Clarity

- **Mulliken and Glowacki (1982):** distinguished between vascular neoplasms and vascular malformations, with VMs classified based on vessel type and flow velocity.

- Adopted and modified by **International Society for the Study of Vascular Anomalies (ISSVA) (1996).**

- **Hamburg (1993):** classification based on embryologic development (extratruncular or truncular).
Hemangiomas and Vascular Malformations in Infants and Children: A Classification Based on Endothelial Characteristics

John B. Mulliken, M.D., and Julie Glowacki, Ph.D.

Boston, Mass.

Those difficulties which have hitherto amused philosophers, and blocked up the way to knowledge, are entirely owing to ourselves. That we have first raised a dust and then complain we cannot see.

George Berkeley (1685–1753)

The management of cutaneous vascular lesions is hampered by a bewildering nomenclature that has evolved from ignorance of pathophysiology. Textbook classifications offer an array of admixed histologic and descriptive terms. Hemangioma has been used as a generic word to describe a variety of vascular lesions with different etiologies and natural histories. The most common tumor of a proliferation of cells normally present in a tissue. Contemporary terminology of vascular lesions is enough to befuddle pathologist and clinician alike.

Historical Perspective

It has been argued whether vascular lesions are developmental malformations or types of neoplas-
Binary system

Vasoproliferative neoplasms show increased endothelial cell turnover. Mitoses seen on histopathology.

Vascular malformations are structural abnormalities without increased endothelial cell turnover. Grow in proportion to child.

Single vessel and combined types
<table>
<thead>
<tr>
<th>Vasoproliferative Neoplasms (endothelial cell turnover)</th>
<th>Vascular Malformations (structural abnormalities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infantile hemangioma</td>
<td>Slow flow (capillary, venous, lymphatic)</td>
</tr>
<tr>
<td>Congenital hemangioma (RICH and NICH)</td>
<td>Fast flow (AVMs, AVFs, arterial malformations)</td>
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<tr>
<td>Hemangioendotheliomas (of different varieties)</td>
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<td>Angiosarcoma</td>
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</table>
Mulliken & Glowacki/ISSVA

- Slow flow
  - Capillary
  - Venous
  - Lymphatic

- High flow
  - Arterial (aneurysm, ectasia, coarct)
  - Arteriovenous fistula
  - Arteriovenous malformation

- Complex combined
  - Regional syndromes (e.g. Sturge-Weber, Klippel-Trenaunay)
  - Diffuse syndromes (e.g. Maffucci, Proteus)
Regional vascular syndromes

- Sturge-Weber: facial CM, intracranial CM, VM and AVM
- Klippel-Trenaunay syndrome: limb/trunk capillary (port wine), venous, and lymphatic (accounting for limb hypertrophy) malformation (CVLM) with overgrowth.
- Parkes-Weber syndrome: CM, AVFs, overgrowth; lymphatic malformation may also occur.
- PHACE syndrome: neurocutaneous syndrome w/ CM in CN 5 distribution
- LUMBAR/PELVIS syndrome: syndrome w/ hemangiomas & pelvic anomalies
Diffuse syndromes - vascular anomalies with syndromic associations

- Maffucci syndrome: soft tissue venous malformation-like lesions associated with multiple enchondromas
- Proteus syndrome: sporadic, congenital progressive, hamartomatous syndrome with overgrowth and vascular anomalies
- Blue rubber bleb nevus (rare, familial): multiple cutaneous, musculoskeletal, and gastrointestinal tract venous malformations
- Solomon: capillary or venous malformations, intracranial arteriovenous malformations, epidermal nevi
- Bannayan-Riley-Ruvalcaba syndrome: PTEN suppressor gene mutation, vascular malformations, and early malignancies
Extratruncular forms of CVMs arise early in embryonic life, while vascular system is still in the reticular stage. Mesodermal tissue remnants retain potential to grow and proliferate when stimulated, may continue to grow after interventions.

Truncular forms of CVMs arise at a later stage, when developmental arrest occurs during the vascular trunk formation. Affects main vessels. Lost the potential to grow and proliferate. Minimal risk of recurrence.
<table>
<thead>
<tr>
<th>Types</th>
<th>Truncular</th>
<th>Extratruncular</th>
</tr>
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<tbody>
<tr>
<td>Predominantly arterial defects</td>
<td>Aplasia or obstruction</td>
<td>Infiltrating</td>
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<td></td>
<td>Dilatation</td>
<td>Limited</td>
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<tr>
<td></td>
<td>Dilatation</td>
<td>Limited</td>
</tr>
<tr>
<td>Predominantly lymphatic defects</td>
<td>Aplasia or obstruction,</td>
<td>Infiltrating</td>
</tr>
<tr>
<td></td>
<td>Dilatation</td>
<td>Limited</td>
</tr>
<tr>
<td>Predominantly AV shunting defects</td>
<td>Deep</td>
<td>Infiltrating</td>
</tr>
<tr>
<td></td>
<td>Superficial</td>
<td>Limited</td>
</tr>
<tr>
<td>Combined/mixed defects</td>
<td>Arterial and venous</td>
<td>Infiltrating hemolymphatic</td>
</tr>
<tr>
<td></td>
<td>without shunt</td>
<td>Limited hemolymphatic</td>
</tr>
<tr>
<td></td>
<td>Hemolymphatic with</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or without shunt</td>
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</table>
Bad Terminology

- Use of suffix -oma has been problematic because it has been used to describe non-neoplastic entities.
- For example, “lymphangioma” is not a vasoproliferative lesion, it is a lymphatic malformation.
- Adult hepatic, vertebral body, orbital, and cavernous “hemangiomas” are venous malformations; lack GLUT1.
- Why is this important? Misdiagnosis leads to wrong treatment.
Imaging Diagnosis

- US is first-line test and can be definitive; also required for planning percutaneous treatment; deep venous system can be evaluated for latency
- MRI is reserved for “problem solving”
  - lesion type
  - extent of disease, involvement of neuromuscular or other vital structures
  - angioarchitecture for high-flow lesions
- CT generally not used except for delineating angioarchitecture of complex lesions (especially in pelvis) or evaluating bone involvement
- Radiography can show phleboliths in venous malformations but otherwise not used
Imaging Workflow

- Patient undergoes clinical evaluation
- If hemangioma, imaging often not required
- If vascular malformation, US obtained first
- MRI with contrast next if more characterization required; MR angiography useful for evaluating angioarchitecture of AVMs or to show patency of deep venous system
Hemangiomas

- Proliferative lesions occurring in children, infantile and congenital
- Placental origin stem cells
- GLUT1 expression (glucose transporter) is the molecular signature (of infantile hemangiomas)
Infantile Hemangioma

- Infantile hemangioma is most common tumor of infancy (4-10% of infants)
- GLUT 1 +
- Proliferate over first year, then gradually involute with regression by 8 years
- Can be multiple, with syndromic associations
- Laser therapy, propranolol, steroids

Lowe et al (2012) SROE
Congenital hemangiomas (RICH & NICH)

- Fully formed at birth, GLUT1 -
- NICH: grow with child
- RICH: regress within two years
- Occur periarticular
- Imaging features overlap
- Tx for NICH = surgery

chw.org
9-day-old male with left posterior thigh lesion
9-day-old male with left posterior thigh mass: hemangioma
4-month-old female with chest lesion
4-month-old female with chest lesion: hemangioma
US Imaging: Basic Approach

Vascular mass?
HEMANGIOMA

Vascular lesion but not a mass?
VASCULAR MALFORMATION
Hemangioma Reporting Template

- Circumscribed mass
- Dimensions
- Tissue compartment (i.e. skin, subcutaneous, intramuscular)
- Vessel density (important for assessing response to Rx)
- Feeding artery?
- Extent fully evaluated?
Hemangioma Pitfalls

- Be wary of presenting age when making diagnosis of hemangioma
- Other vascular tumors should be considered in differential
- Hemangiomas can undergo fibrofatty involution over time, which could be confusing if prior imaging is not available
Vascular Malformations

- Morphogenic abnormality of various vessels, not proliferative
- Subdivided into
  - Low flow: capillary, venous, lymphatic
  - Fast/high flow: arterial with or without additional components
    - Pure arterial (e.g. coarctation, aneurysm)
    - Arteriovenous fistula
    - AVMs
Low Flow: Capillary

Superficial lesions
Common examples: Angel’s kiss, stork bite, port wine stain
Treatment: conservative, laser
Low Flow: Lymphatic

- Dilated lymphatic channels filled with proteinaceous fluid without connections to the normal lymphatic system
- Lesions can be macrocystic (>2 cm, cystic on US), microcystic (solid on US) or mixed
- Soft nonpulsatile masses commonly in head/neck, trunk, extremities
- MRI: multicystic masses insinuating between tissue planes
- Treatment: percutaneous sclerotherapy or surgical excision
- Sclerotherapy: doxycycline, STS, bleomycin
- Macrocystic lesions may require catheter drainage
Successfully treated w doxycycline sclero
3-year-old female with left sided swelling
3-year-old female with left sided swelling: lymphatic malformation
3-year-old female with left sided swelling: sclerotherapy
US Imaging Low Flow Lesions: My Approach

Venous Malformation

Lymphatic Malformation

Gray Scale

Doppler
MRI Imaging Low Flow Lesions: My Approach

Venous Malformation

T2

Post contrast

Lymphatic Malformation
7-year-old female with left thigh swelling
7-year-old with left thigh swelling: lymphatic malformation
21-year-old male with right thigh swelling and leakage of fluid
21-year-old male with right thigh swelling and leakage of fluid
21-year-old male with right thigh swelling and leakage
21-year-old male right thigh lymphatic malformation sclerotherapy
12-year-old male with painful left flank lump
12-year-old male with painful left flank lump: lymphatic malformation
Low Flow: Venous

- Present at birth, natural history: slow steady enlargement
- Head and neck, extremities, trunk; usually solitary lesions
- Superficial lesions soft/compressible; no bruit; often blue or purple in color, absence of warmth
- Present with swelling/pain, secondary to thrombosis in part of lesion (from slow flow)
- D-dimer elevation specific to VMs (opposed to LMs or AVMs); histology: thin walled venous channels (no smooth muscle)
- Ultrasound: monophasic flow on Doppler, sometimes not detectable
- CT: phleboliths, dystrophic calcifications, peripheral enhancement
- MR: T2 bright
Low Flow: Venous

Treatment

- Contrast venography: lesion size, draining veins, assess deep veins, sclerosant volume
- Sclerosants: ethanol, sodium tetradecyl sulphate foam, Ethibloc, polidocanol and more recently bleomycin
- Tourniquet, BP cuff, or manual compression to reduce outflow
- Coils or glue can be used in cases of “rapid outflow”; coils also for protection of non-target veins
- Complications: systemic toxicity of sclerosant, nontarget embolization, skin necrosis
33M pain left palm

Ethanolamine oleate sclero

Hyodoh et al 2005 Radiographics
4-year-old female with left calf pain & discoloration
Possibilities?
Next step?
4-year-old girl with left calf pain: venous malformation
US Imaging Low Flow Lesions: My Approach

Venous Malformation

Lymphatic Malformation

Gray Scale

Doppler
MRI Imaging Low Flow Lesions: My Approach

Venous Malformation

Lymphatic Malformation

T2

Post contrast
6-year-old female with painful plantar foot lesion
6-year-old female with painful plantar foot lesion
6-year-old female with painful plantar foot lesion: venous malformation
6-year-old female with painful plantar foot lesion: sclerotherapy
18-year-old male with right knee swelling and pain
18-year-old male with right knee swelling and pain
18-year-old male with right knee swelling and pain
18-year-old knee venous malformation sclerotherapy
Low Flow Vascular Malf Reporting Template

- Ill-defined lesion with tubular anechoic spaces
- Size? Extent?
- Tissue compartment?
- Flow? Compressible?
- Phleboliths?
- Micro- or macrocystic if lymphatic malformation?
High flow: AVFs, AVMs

- Pure arterial malformation: coarct, ectasia, aneurysm
- Arteriovenous malformations (no capillary bed intervening between AV connection)
  - Most commonly occur intracranial, extremities, trunk
  - Aggressive clinical course, including growing mass, pain, ulceration, ischemia, bleeding, heart failure; warm pulsatile lesions
  - Ultrasound imaging: Doppler shows low resistance pattern in feeding arteries and arterial waveforms in draining veins; aliasing seen in nidus
  - MRI: multiple hypertrophied arteries and dilated veins associated with the lesion; flow voids; lack of identifiable soft tissue mass (if there is, consider malignant neoplasm e.g. sarcoma)
AVMs: Cho Classification

I Arteriovenous (3 or fewer feeding art)

II Arteriolovenous (multiple feeding art)

IIIa Arteriolovenular (nondilated)

IIIb Arteriolovenular (dilated)
High Flow: Treatment

- Goal: eliminate nidus
- Type I AVMs: transarterial, transvenous, or direct puncture approaches
- Type II AVMs: transarterial, transvenous, or direct puncture approaches
  - Multiple tortuous feeding arterioles and a large dilated venous component --> venous outflow needs to be closed
- Type IIIa AVMs: transarterial approach (too fine to be punctured directly)
- Type IIIb AVMs: transarterial or direct puncture approaches
- Agents: glue, ethanol, Onyx, particles, coils
US Imaging of AVMs

- High flow component must be present! A few interstitial arteries do not count.
- Look for arterialized waveform in draining veins
- Look for low resistance waveform in conducting arteries which should have high resistance pattern
MRI Imaging of AVMs

- Angiographic images are key; look for early venous enhancement
- Delineation of number of feeding arteries and draining veins important
- Flow voids seen on T2 imaging
8-year-old female with pulsatile scalp lesion
8-year-old female with pulsatile scalp lesion
8-year-old female: scalp AVM
Case: Type II AVM (arteriovenous)

- 59F large right pelvic AVM with high cardiac output, exertional fatigue and dyspnea; progressive cardiac enlargement
- Local pelvic symptoms: pulsating sensation, sense of crowding, difficulty emptying bladder, sporadic episodes of bleeding from her external genitalia
- Prior interventions: ligation of her right internal iliac artery in 1981, transarterial coil embolization procedures (no transvenous embolization)
CTA findings

Complex arterial nidus emptying into single, enlarged low right internal pelvic vein, emptying into right EIV
Summary: Key Points

- Differentiate between vascular tumors and vascular malformations
- Hemangioma is most common vascular tumor in children
- Lymphatic and venous malformations are most common vascular malformations; AVMs are rare
- Use a systematic approach