The Houdart CNS AVM Classification, The Do Peripheral AVM Classification, and the Yakes AVM Classification & its Therapeutic Implications

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Previous Classifications Of AVMs: The Houdart CNS Classification, The Do Peripheral Classification

Disclosure

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Interventional Neuroradiology

A proposed angiographic classification of intracranial arteriovenous fistulae and malformations

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Abstract. We propose an angiographic classification of intracranial vascular lesions as arteriovenous, arteriovenous and arteriovenous fistulae. For each of these classifications, 99 intracranial arteriovenous lesions were reviewed in Rijswijk. Arteriovenous fistulae included 76 isolated brain arteriovenous malformations (AVMs) and 1 AVM associated with a giant arteriovenous fistula (AVF). Arteriovenous fistulae included 3 giant AVMs of the brain, 4 with a giant aneurysm and 13 direct intracranial arteriovenous fistulae. Arteriovenous fistulae were classified into one of three types: (1) AVM with a single feeding artery; (2) AVM with multiple feeding arteries; (3) AVM with a single feeding artery and a single draining vein. The types of fistulae were then classified into five groups, depending on the location and size of the fistulae. The classification is based on the clinical presentation of the lesion and the severity of the disease. The classification is useful for the identification of the most common lesions and for the selection of the most appropriate treatment. The classification is also useful for the evaluation of the results of different treatments. The classification is easy to use and can be applied to all types of arteriovenous lesions. The classification is also useful for the evaluation of the results of different treatments. The classification is easy to use and can be applied to all types of arteriovenous lesions.
The Yakes AVM Classification System and its Therapeutic Implications

Type I: A direct artery to vein fistula connection.

Type IIa: Multiple arteries/arterioles connecting to a typical "nidus" interconnecting vascular tubular structures that then drain into out-flow veins.

Type IIb: Same as Type IIa except the "nidus" drains into an aneurysmal vein single out-flow vein.

Type IIIa: Multiple in-flow arterioles shunting into an aneurysmal vein that has a single vein out-flow. Fistulae are in the vein wall.

Type IIIb: Multiple in-flow arterioles shunting into an aneurysmal vein with multiple out-flow veins. The fistulae (nidus) are in the vein wall.

Type IV: Multiple arteries/arterioles that branch in "en passage" fashion to form innumerable micro-fistulae that diffusely infiltrate the affected tissue. Because the tissue is viable and not devitalized, capillary beds must also be present admixed among the innumerable AVFs. The innumerable micro-AVF drain into multiple veins. The tissue's normal post-capillary venous drainage then competes with the arterialized vein out-flow for drainage causing venous HTN in the tissue.

Treatment of Complex AVMs

- Determination of AVM angioarchitecture is critical for endovascular decision making which in turn determines success or failure.
- Ethanol and fibered coils as embolic agents.
- Retrograde vein, transcatheter, and direct puncture approaches are used to deliver embolic agents.

Yakes Type I AVM

Direct AV connection that can be treated at times with ETOH, but always with fibered coils, Amplatzer plugs, and the like. Mechanical device occlusion can be curative.
Yakes Type I AVM

- 54 year old female
- Two sons with HHT
- Father, grandmother and aunt with HHT
- Extensive telangectasia in lips, tongue, fingers, GI tract
- Occasional bleeding
- Shortness of breath with exercise
- CT thorax – multiple 1.5-2cm PAVM

Yakes Type I AVM

41 year old female with an AVM of the Rt. Kidney. Endovascular mechanical occlusion with coils from the arterial side and retrograde vein side proved curative.
Yakes Type I AVM

Type I

Type I

Yakes Type IIa AVM

27 yo male with Lt Axillary AVM with weakness and ischemia in Lt forearm and Lt hand.

Patient previously extensive surgery with Gortex Graft bypass from the Lt Common Carotid Artery to the Lt Radial Artery.
Direct Puncture Technique:

- 21 or 23 gauge butterflies
- Success in accessing malformation depends on recognition of location of nidus
- Ethanol injected at rate to match flow and avoid reflux
- Occasionally manual compression and other techniques were used to achieve flow arrest to augment thrombosis of treated compartments
Yakes Type IIb AVM

In this AVM subtype a “nidus” is still present, however, instead of multiple outflow veins draining from the nidus, there is a single aneurysmal out-flow vein.

Two endovascular approaches are curative for this Type IIb AVM. As in Type IIa AVMs, transarterial and nidal direct puncture ethanol embolizations are curative.

Yakes Type IIb AVM

42 yo male
Severe Lt pelvic pain
Type I:
A direct artery to vein fistula connection.

Type IIa:
Multiple arteries/arterioles connecting to a typical "nidus" interconnecting vascular tubular structures that then drain into out-flow veins.

Type IIb:
Same as Type IIa except the "nidus" drains into an aneurysmal vein single out-flow vein.

Type IIIa:
Multiple in-flow arterioles shunting into an aneurysmal vein that has a single vein out-flow. Fistulae are in the vein wall.

Type IIIb:
Multiple in-flow arterioles shunting into an aneurysmal vein with multiple out-flow veins. The fistulae (nidus) are in the vein wall.

Type IV:
Multiple arteries/arterioles that branch in "en passage" fashion to form innumerable micro-fistulae that diffusely infiltrate the affected tissue. Because the tissue is viable and not devitalized, capillary beds must also be present admixed among the innumerable AVFs. The innumerable micro-AVF drain into multiple veins. The tissues normal post-capillary venous drainage then competes with the arterialized vein out-flow for drainage causing venous HTN.

Multiple in-flow arteries into an aneurysmal single out-flow vein.
Ethanol and/or coils can be curative.

Type IIIa AVM

Multiple in-flow arteries into an aneurysmal single out-flow vein. Ethanol and/or coils can be curative.

Yakes Type IIIa AVM

32 year old female with a pelvic AVM.

Prior embo and total occlusion of all lumbar arteries and both internal iliac arteries with glue and coils.

Now presents with non-healing sacral skin ulcer, cellulitis, and pelvic pain.
Type I:
A direct artery to vein fistula connection.

Type IIa:
Multiple arteries/arterioles connecting to a typical "nidus" interconnecting vascular tubular structures that then drain into out-flow veins.

Type IIb:
Same as Type IIa except the "nidus" drains into an aneurysmal vein single out-flow vein.

Type IIIa:
Multiple in-flow arterioles shunting into an aneurysmal vein that has a single vein out-flow. Fistulae are in the vein wall.

Type IIIb:
Multiple in-flow arterioles shunting into an aneurysmal vein with multiple out-flow veins. The fistulae (nidus) are in the vein wall.

Type IV:
Multiple arteries/arterioles that branch in "en passage" fashion to form innumerable micro-fistulae that diffusely infiltrate the affected tissue. Because the tissue is viable and not devitalized, capillary beds must also be present admixed among the innumerable AVFs. The innumerable micro-AVF drain into multiple veins. The tissues normal post-capillary venous drainage then competes with the arterialized vein out-flow for drainage causing venous HTN in tissue.

Type IIIb AVM

Multiple in-flow arteries/arterioles shunting into an aneurysmal multiple out-flow veins. More challenging to treat as the multiple veins must be occluded.
Type I: A direct artery to vein fistula connection.

Type IIa: Multiple arteries/arterioles connecting to a typical “nidus” interconnecting vascular tubular structures that then drain into out-flow veins.

Type IIb: Same as Type IIa except the “nidus” drains into an aneurysmal vein single out-flow vein.

Type IIIa: Multiple in-flow arterioles shunting into an aneurysmal vein that has a single vein out-flow. Fistulae are in the vein wall.

Type IIIb: Multiple in-flow arterioles shunting into an aneurysmal vein with multiple out-flow veins. The fistulae (nidus) are in the vein wall.

Type IV: Multiple arteries/arterioles that branch in “en passage” fashion to form innumerable micro-fistulae that diffusely infiltrate the affected tissue. Because the tissue is viable and not devitalized, capillary beds must also be present and mixed among the innumerable AVFs.

The innumerable micro-AVF drain into multiple veins. The tissues normal post-capillary venous drainage then competes with the arterialized out-flow to drainage causing venous HTN in tissue.

Type IV AVM

Multiple in-flow arteries with innumerable fistulae throughout a tissue admixed with capillary beds. Multiple out-flow arterialized veins force the tissue veins to compete for out-flow and cause venous HTN. A 50-50% mixture of ethanol and non-ionic contrast can be curative in this lesion type.

Yakes Type IV AVM

5 yo female with “Infiltrative” form of AVM involving the entire Rt ear and growing toward the adjacent scalp.

Example of innumerable microfistulous AVMs admixed with capillary beds or the tissue would not be viable.
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- 36 female
- Previous failed treatment
  - Surgical excision
  - Embolisation & covered stent
  - Radiotherapy
  - Hyperbaric oxygen
  - Thalidomide
- Continued growth

Yakes Type IV AVM

1999 2003
From 2008 to 2014 patient has undergone serial ethanol embolotherapy by direct puncture to circumvent catheterization obstacles due to the previous procedures (coils, ligations, covered stents).
Conclusion

- The Yakes classification is an useful guide for treatment options
- Angioarchitecture defines the approach and the means for treatment
- Hemodynamics plays an essential role in maximizing the treatment outcome