AVMs: How to choose embolic agent and nidal approach according to the Yakes classification

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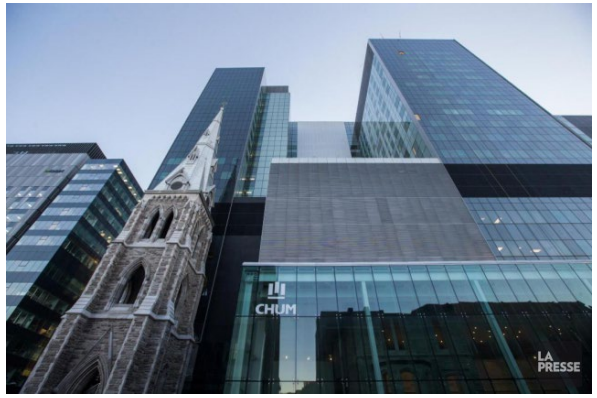
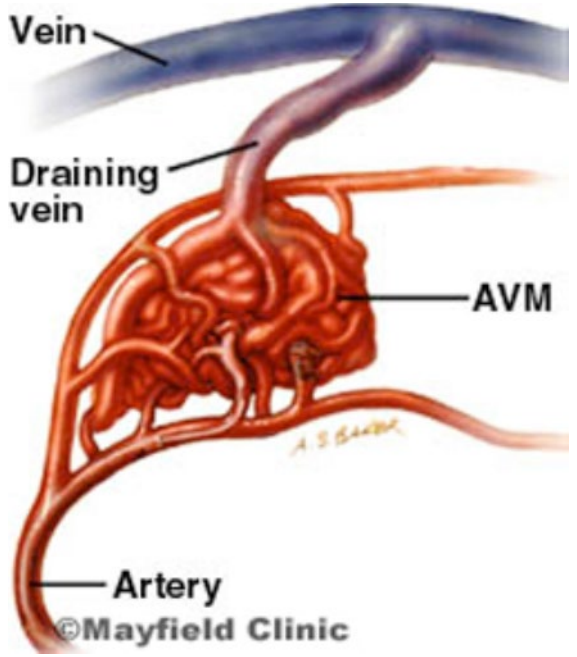


Disclosure

- Research grant
  - Canadian Institute of Health Research
  - Natural Sciences Engineering Research Council of Canada
  - Cook medical
  - Siemens Medical
  - Vitaa Medical
  - Starpax Medical
- Consultant
  - Vitaa
  - Cook Medical
  - Terumo Medical
- Patent licensed to Cook Medical
  - A sclerosing and embolizing gel

Overarching goal of AVM embolization long-term occlusion of the fistulas

- Fistulas occur in the nidus (if there is a nidus!)
  - Systematic targeting of fistulas
  - But different approaches are possible depending of
    - Angioarchitecture
    - Vascular territory: terminal vs non terminal vascularization
    - Imbalance between inflow and outflow
- Need to occlude the venous side of the fistula
- Ideal agent should combine flow occlusion and endothelial ablation in order to prevent endothelial recanalization



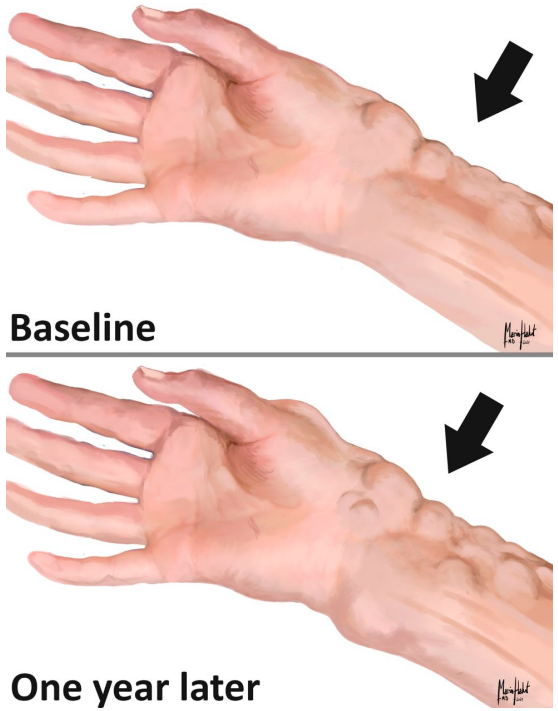
AVM decision taking

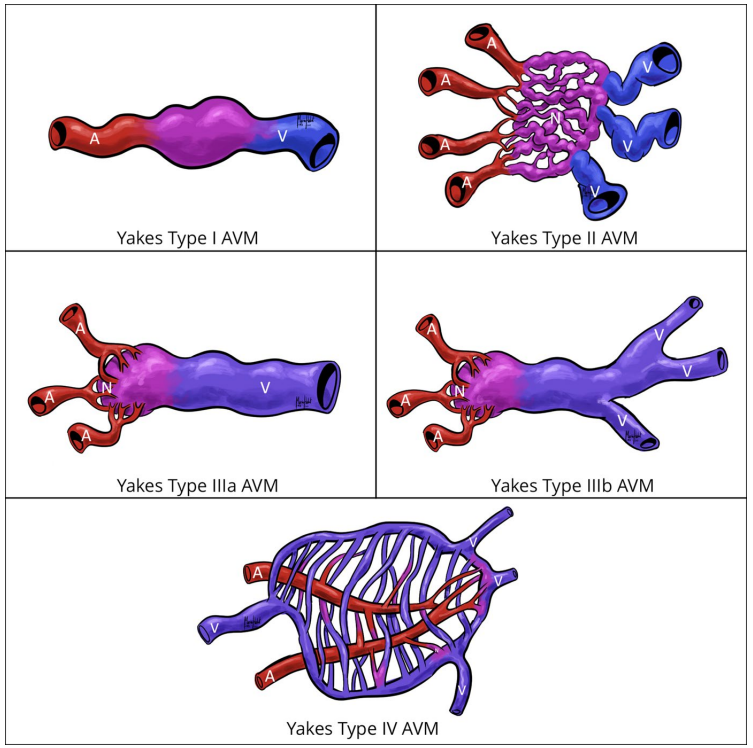
Patient symptoms
Anatomical location

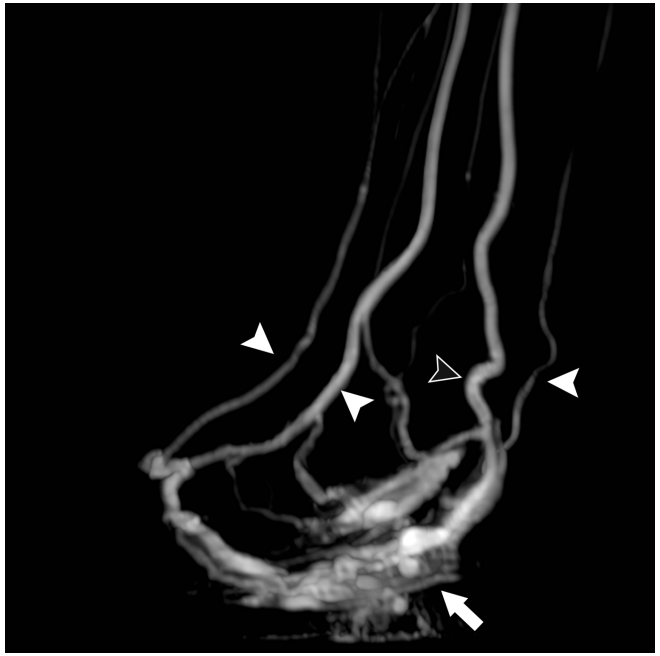
Angioarchitecture
Yakes classification

Flow dynamic
DUS
4D MRA

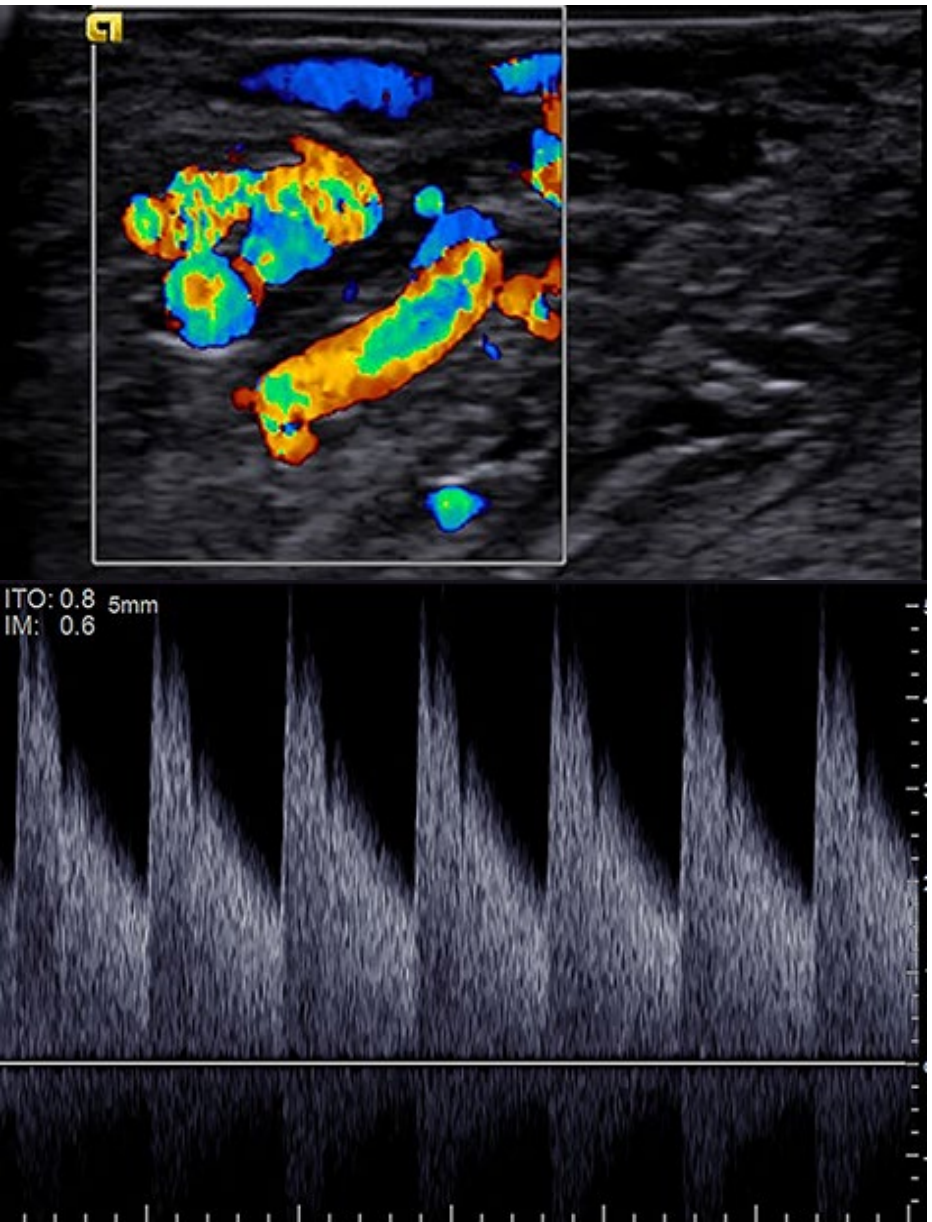
Nidus accessibility
Arterial
Direct
venous

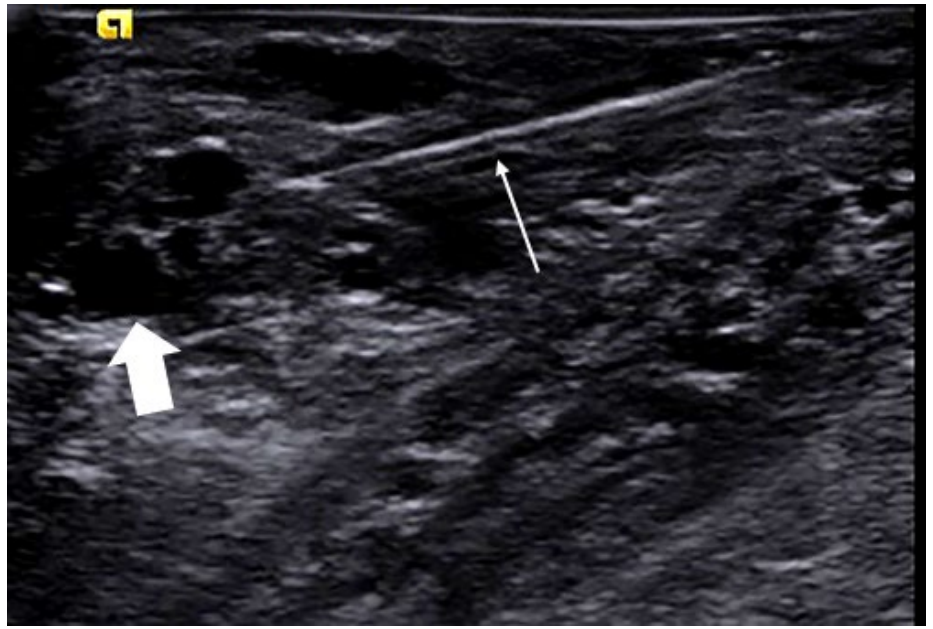


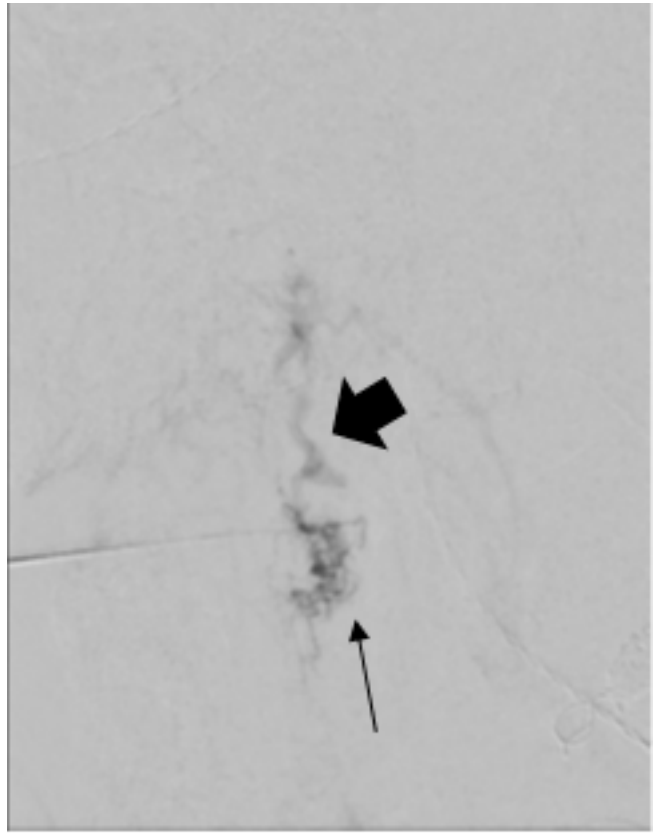


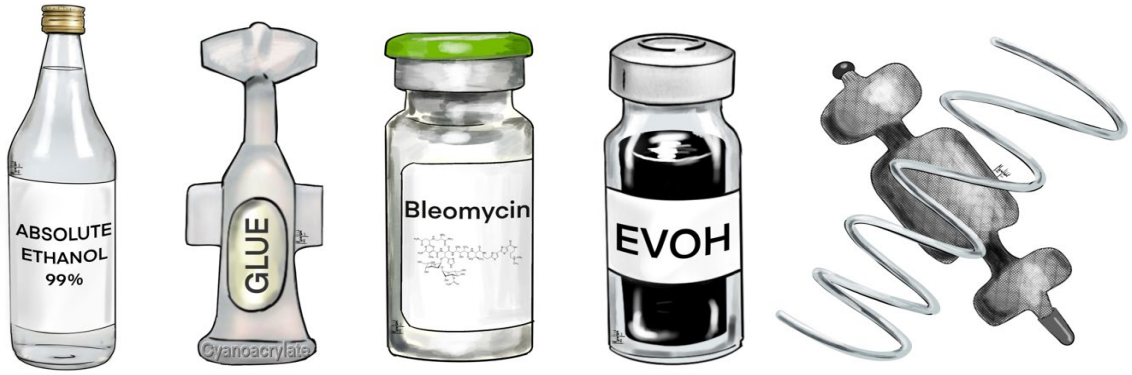


Direct puncture = Doppler ultrasound







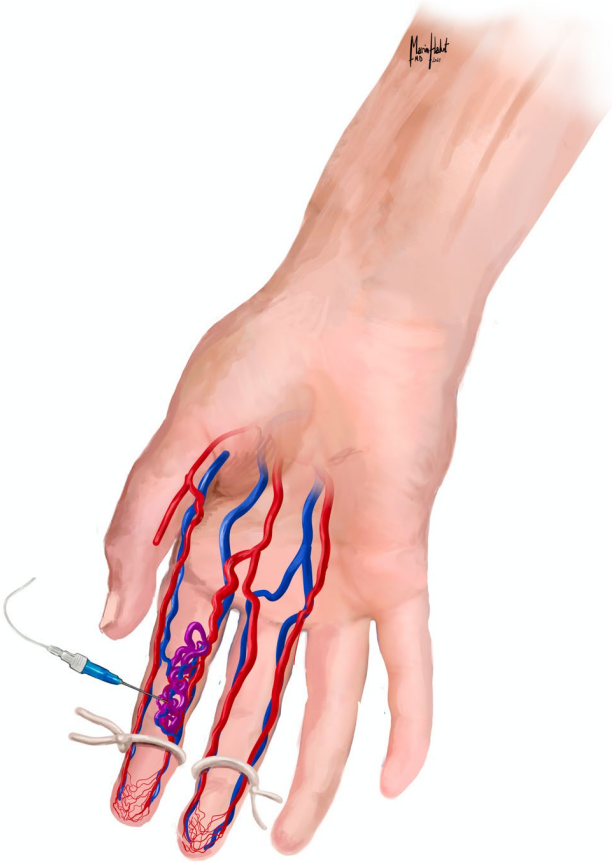


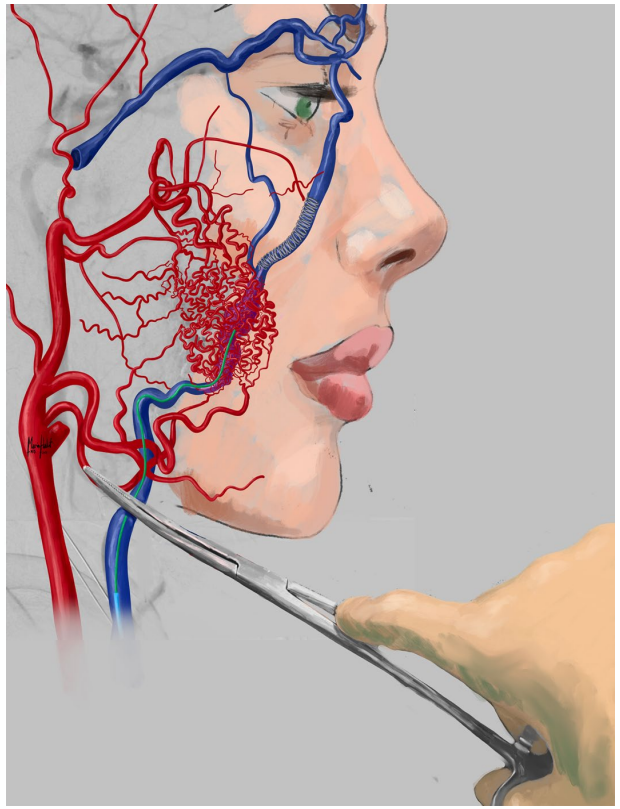
	Location	Yakes	Endo vascular	Direct Puncture	Venous	Endothelium ablation	Control
Ethanol	Not in GI,pancreas, bladder, vicinity of nerve	II, IIIa, IIIB, IV (50%)	yes	yes	With coils plugs	+++	+
Glue	Everywhere but the skin	II, IIIA, IIIB	yes	yes	With coils	+	+
Bleomycin	Everywhere	II, IIIa, IIIB, IV	no	Yes + interstitial	no	+++	+
EVOH	Everywhere but the skin	II, IIIA, IIIB, IV	yes	yes	yes	+	+++
Coils plug	Everywhere but the skin	I, IIIA, IIIB	no	no	yes	0	+++

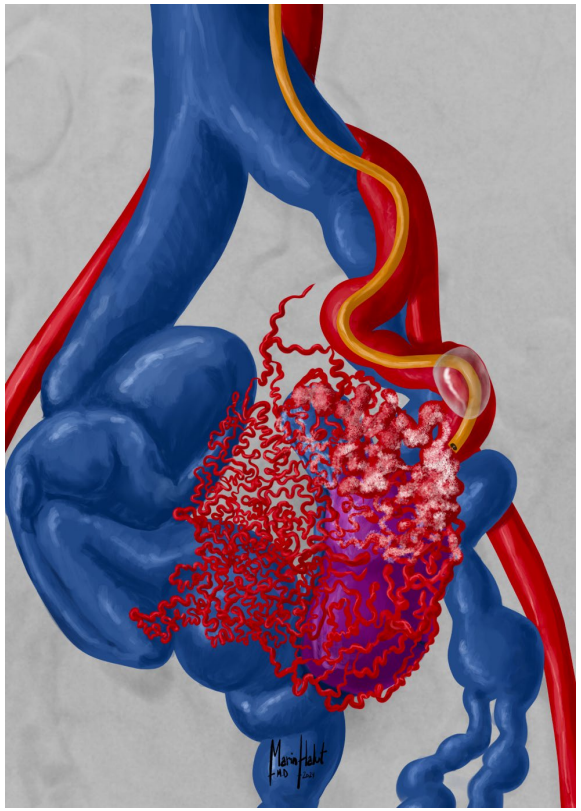
Ethanol how to use it ?

- Monitoring of arterial pressure if more than 20 ml
- Not exceed 0.5 ml/kg (pediatry) 1ml/kg (adult) total dose
- Not exceed 5 ml per bolus
- Be inside the nidus +++
- Negative roadmap technique to evaluate the volume
- Wait 5 minutes between injection
- Repeat DSA after each injection to evaluate residual flow and apparition of normal branches
- Do not use in the vicinity of nerve, GI, bladder, pancreas

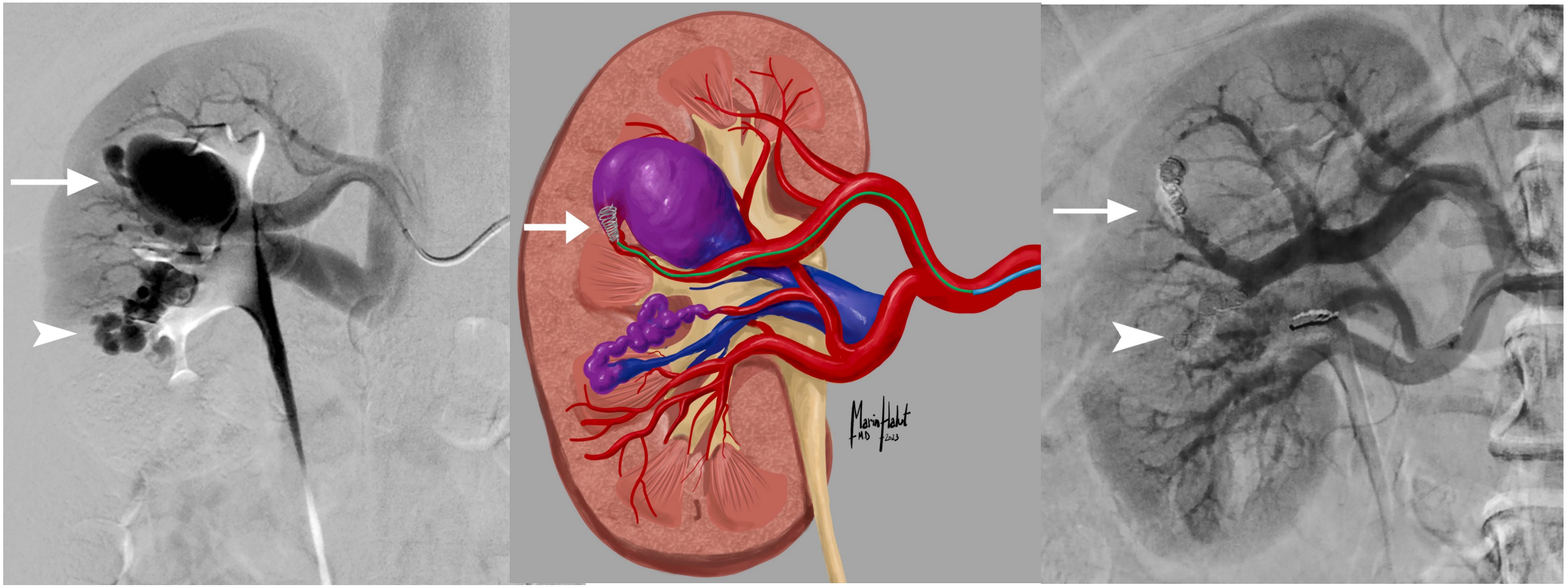
Control the flow



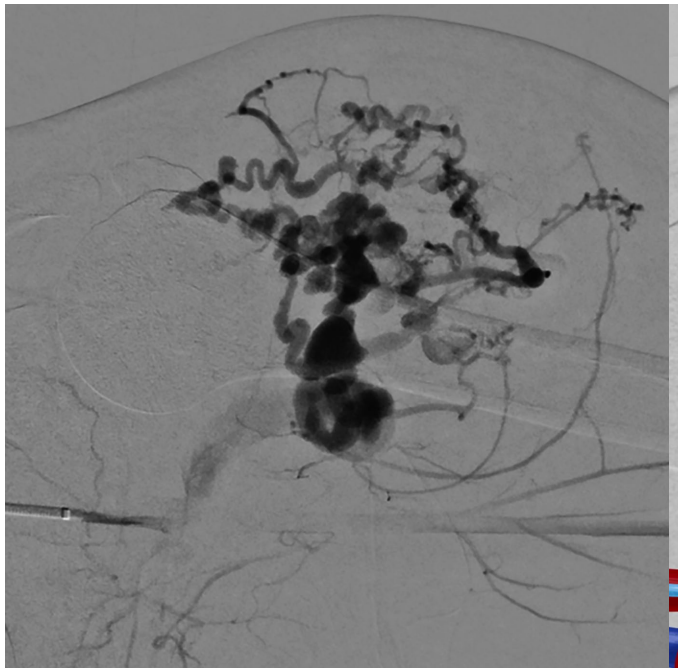
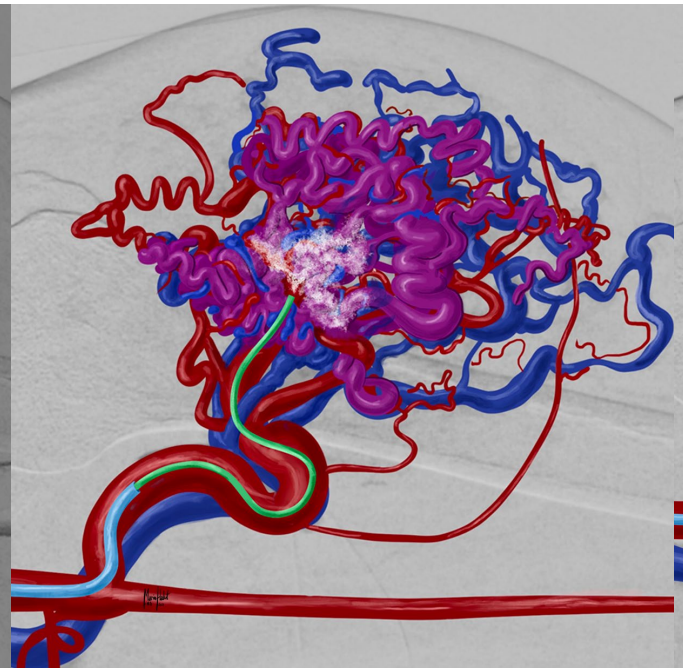
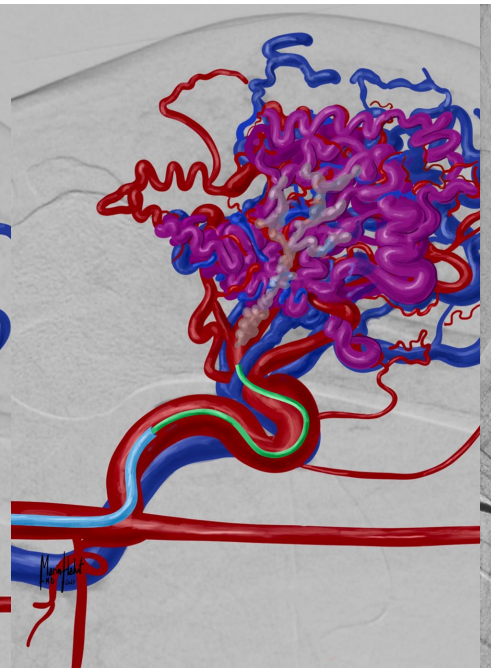
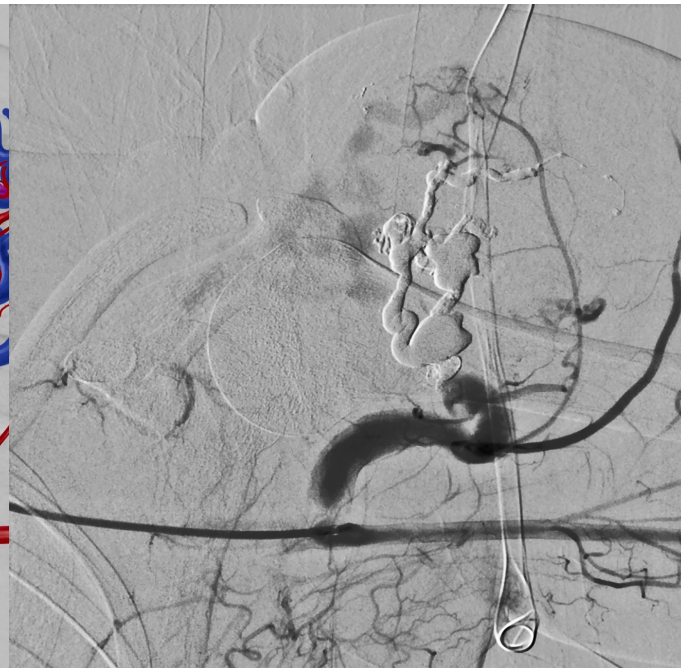




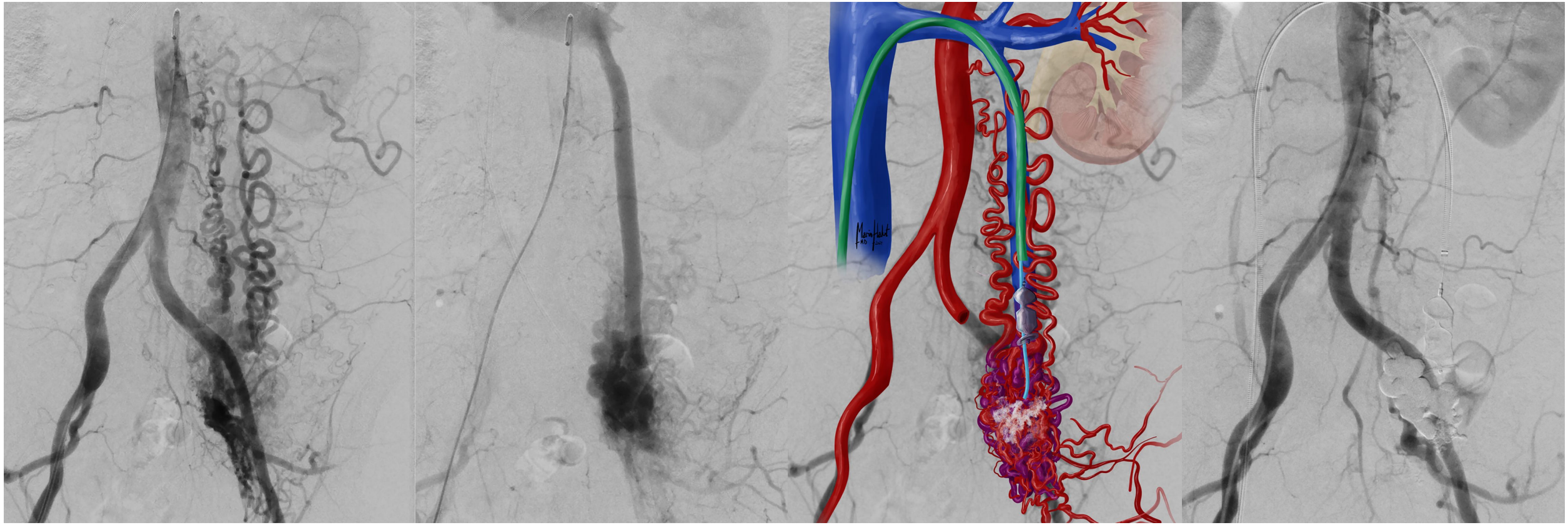
Yakes type I (endovasc, coils)



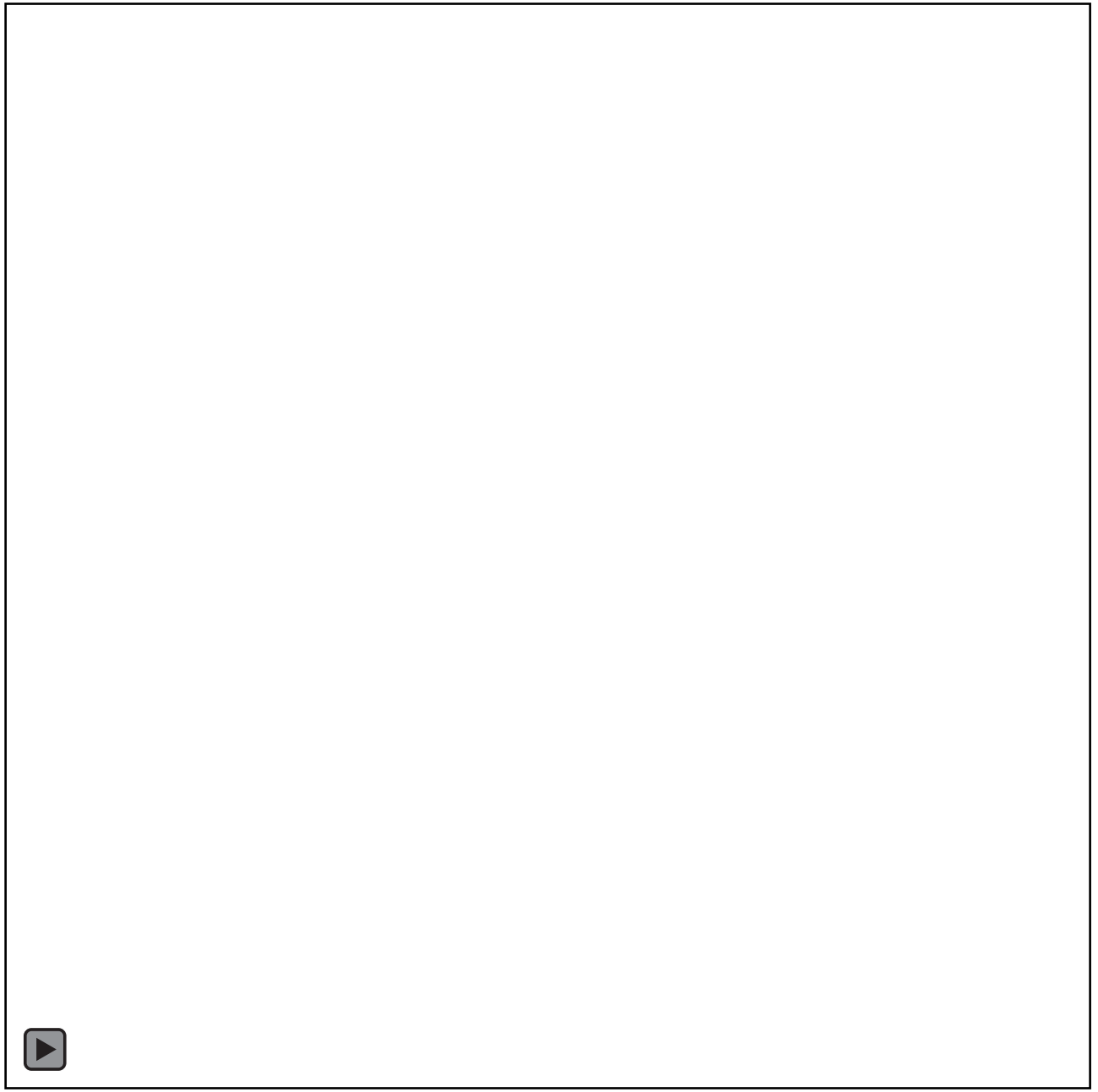
Yakes type II (endovasc, ethanol, glue)

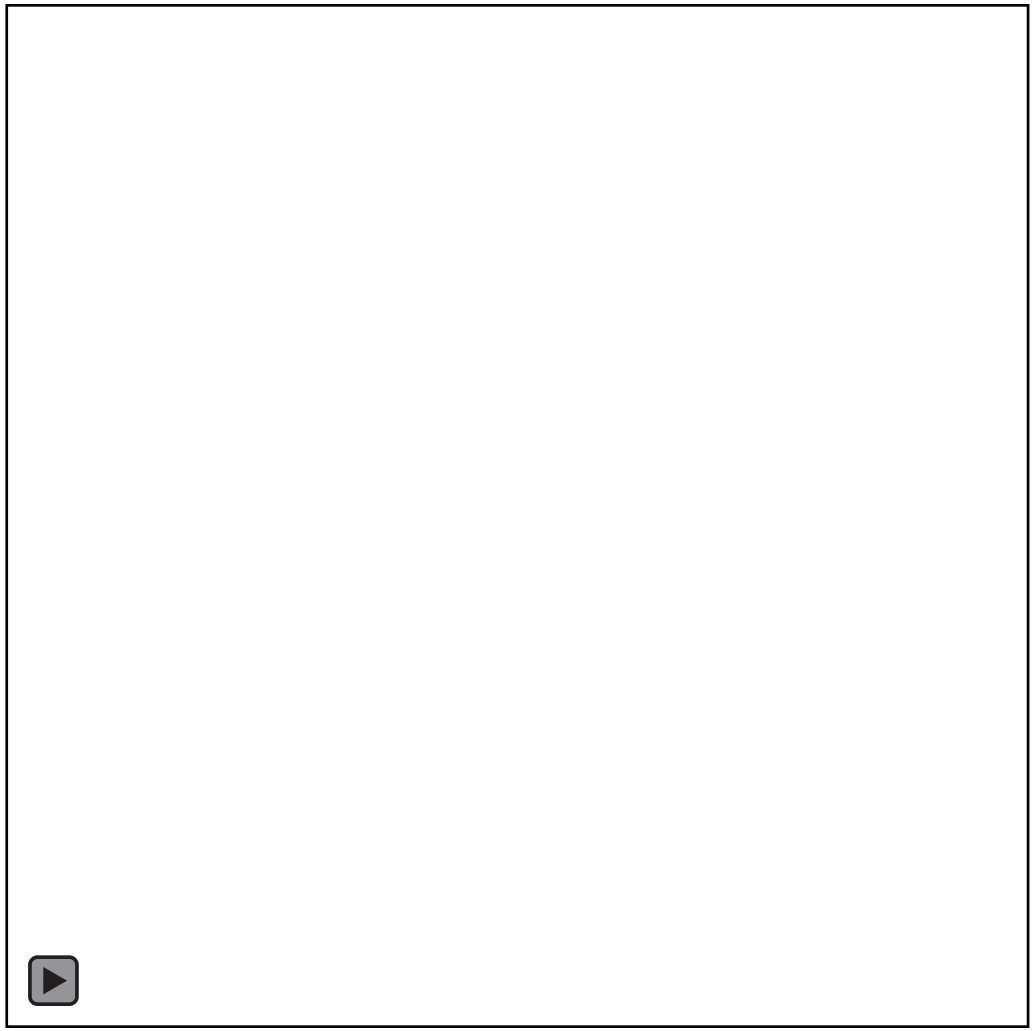
Yakes type IIIA (venous plug-ethanol-glue)



Yakes type IIIA

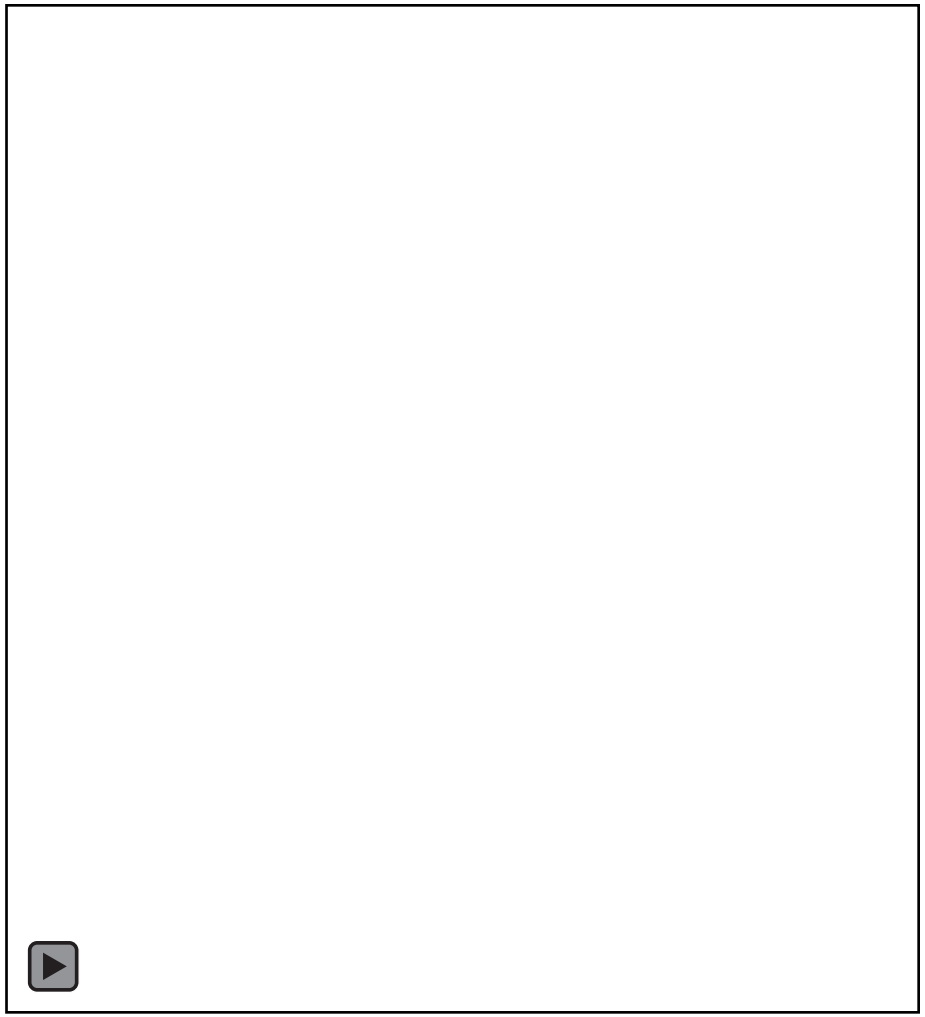


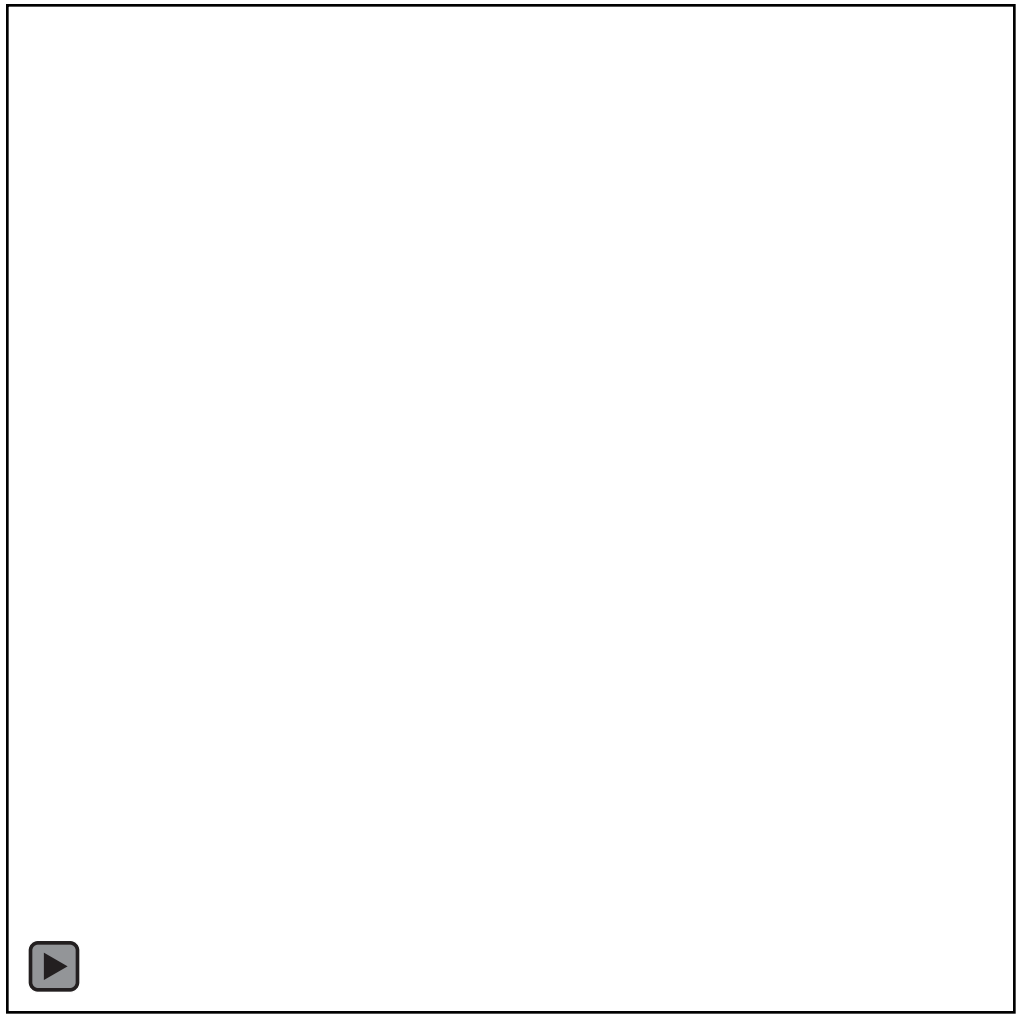
Yakes type IIIB (ethanol, direct puncture, venous retrograde)



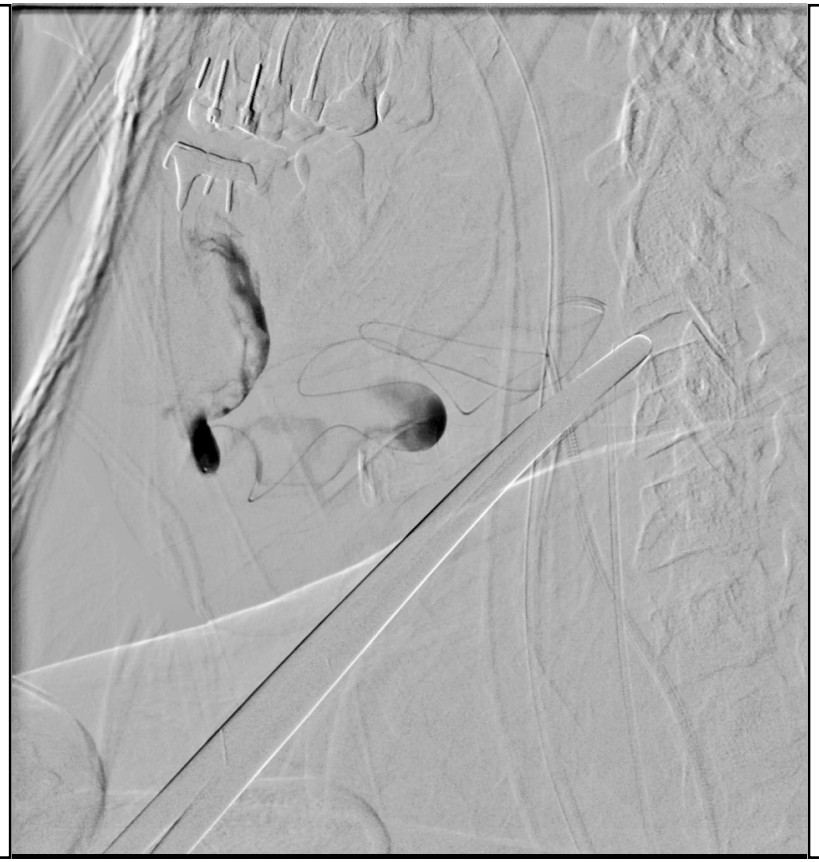
Patient with AVM of the mandibula & floor of the mouth. Previous surgical ligation in Russia…..

DSA +direct puncture

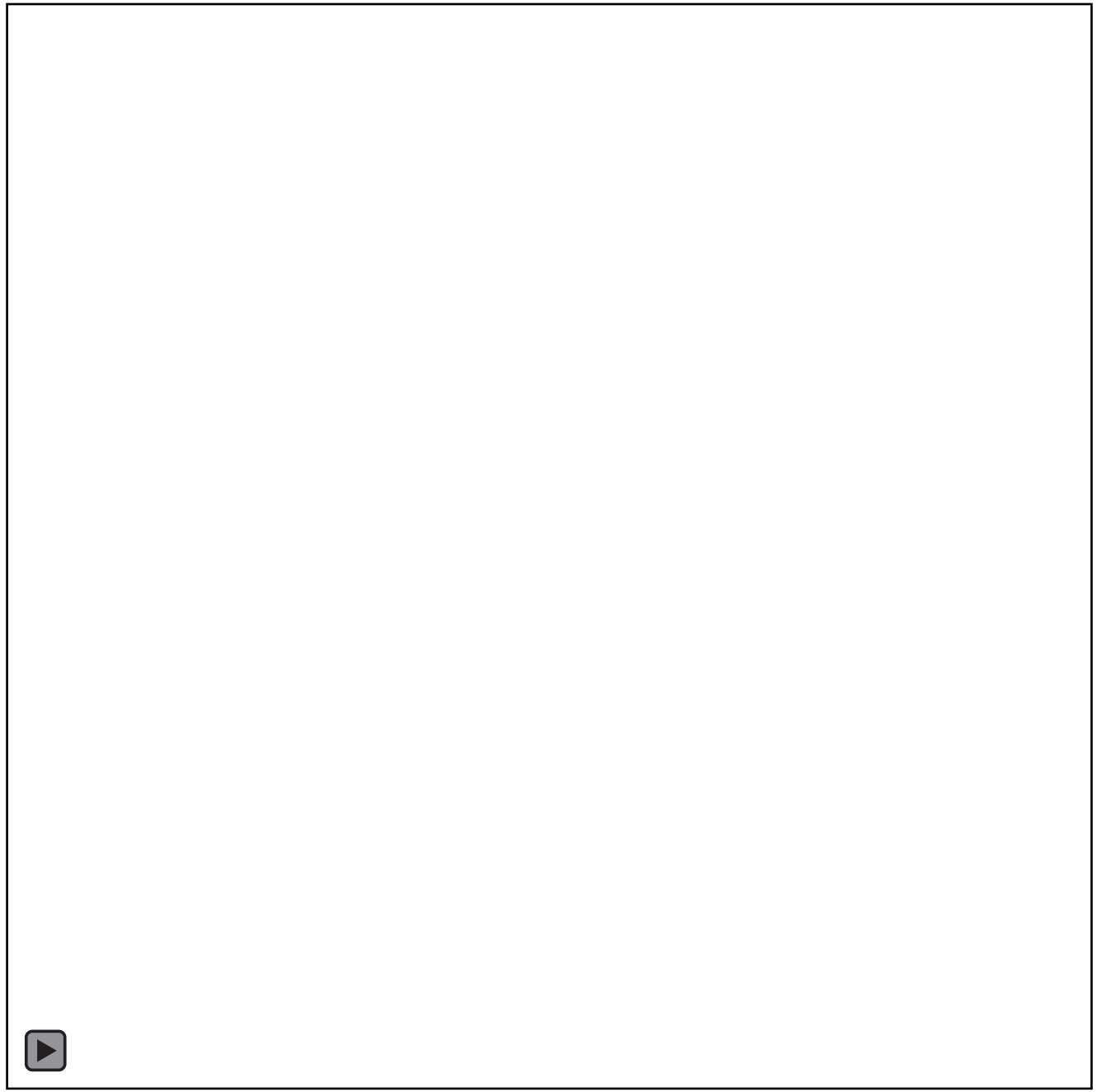




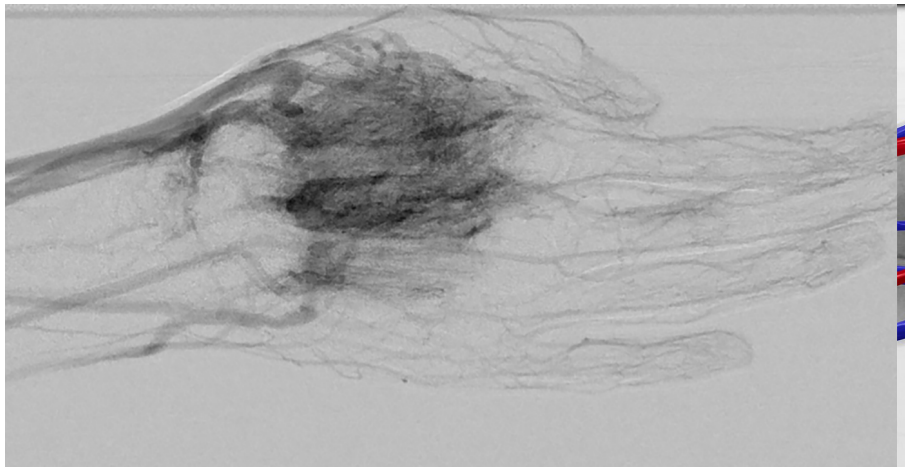
Combined with retrograde venous approach

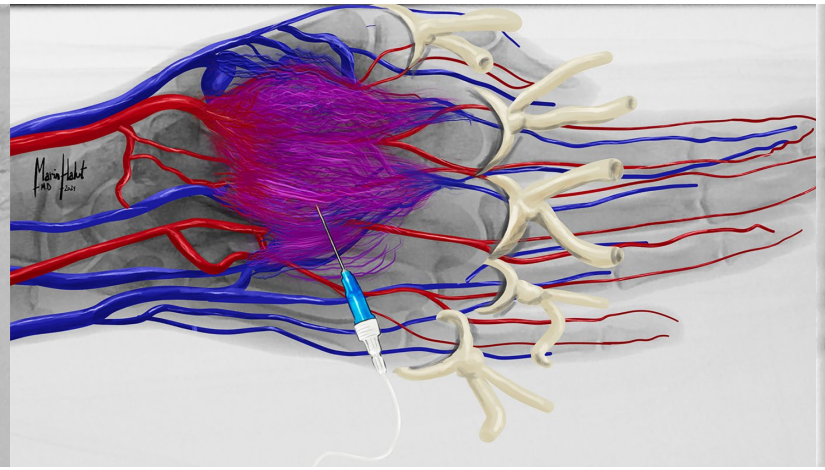


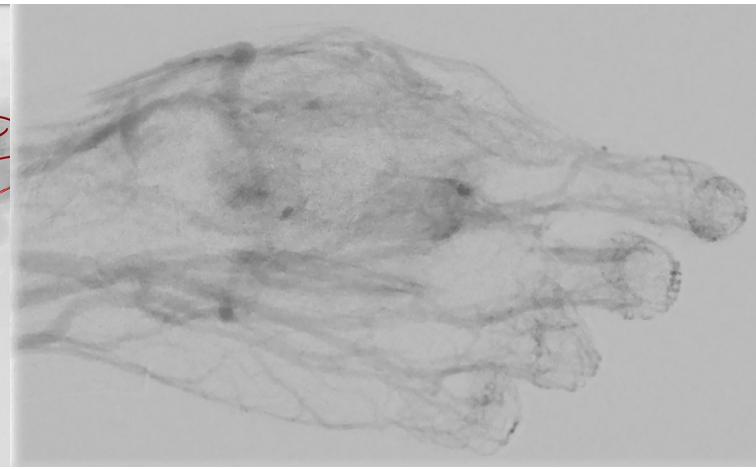
CTA



Yakes type IV (bleomycin)







Outcome

- Ethanol (alone or in association)
  - Success rate
    - 68-100%
  - Recurrence
    - 2.9% and 11.1%
  - Complications 7.5-45%
    - Major 0-19%
- *Bouwman FC et al. J Vasc Interv Radiol 2020;31(11):1801-1809*
- *Li XY et al. Cardiovasc Intervent Radiol 2022;45(4): 476-485*
- *Kim Re t al. J Vasc Surg2021;73(6):2090-2097*
- *Ko SE et al. J Vasc Interv Radiol 2019;30(9):1443-1451*
- *Do YS et al. J Vasc Interv Radiol 2010;21(6):807-16*
- *Do YS et al. Radiology 2005;235(2):674-82*

- Bleomycin interstitial
  - Success rate 84%
  - Complication
    - Skin hyperpigmentation 31%
    - Anaphylactic shock 3%
- *Jin Y et al. et al.Radiology 2018;287 (1):194-204*

- Onyx
  - Success rate 73-90%
  - Recurrence ?
    - Better symptom improvement if surgery
  - Complication 10-31%
    - 5- 18% major
- *Schmidt-VF et al. Cardiovasc Intervent Radiol 2022;45 (7):992-1000*
- *R. M. Brill et al. J Vasc Interv Radiol 2021;32(12):1644-1653*

- Glue
  - Devascularization>75% = 56%
  - 72% clinical improvement
  - Pre-embolization wiht glue help resection surgery
- *E. Le Fourn et al. Eur J Dermatol 2015;25(1):52-6*
- *Goldenberg-DC et al. Plast Reconstr Surg 2015;135(2):543-552.*

Cardiovasc Intervent Radiol (2022) 45:992–1000
https://doi.org/10.1007/s00270-022-03169-0

Schmitt VF et al. CVIR 2022

Image-Guided Embolotherapy of Arteriovenous Malformations of the Face

- 28 patients 50 embolization procedures EVOH
- 12 months mean FU
- 58% complete devascularization
- 24 % complications
  - 18% major (necrosis, nerve injury, infection)

Table 3 Clinical outcome at final follow-up (n = 24) depending on the treatment concept

Characteristic	Embolotherapy only (n = 12)	Embolotherapy + subsequent surgery (n = 12)
Symptom-free	2 (16.7%)	10 (83.3%)
Partial relief of symptoms	7 (58.3%)	2 (16.7%)
No improvement of symptoms	3 (25.0%)	0 (0.0%)
Progression despite embolization	0 (0.0%)	0 (0.0%)

SD standard deviation

Treatment Outcomes of Embolization for Peripheral Arteriovenous Malformations

Frédérique C.M. Bouwman, MD, Sanne M.B.I. Botden, MD, PhD, Bas H. Verhoeven, MD, PhD, Leo J. Schultze Kool, MD, PhD, Carine J.M. van der Vleuten, MD, PhD, Ivo de Blaauw, MD, PhD, and Willemijn M. Klein, MD, PhD

J Vasc Interv Radiol 2020; 31:1801–1809

Table 5. Angiographic Outcomes Specified for the Different Angioarchitecture Types

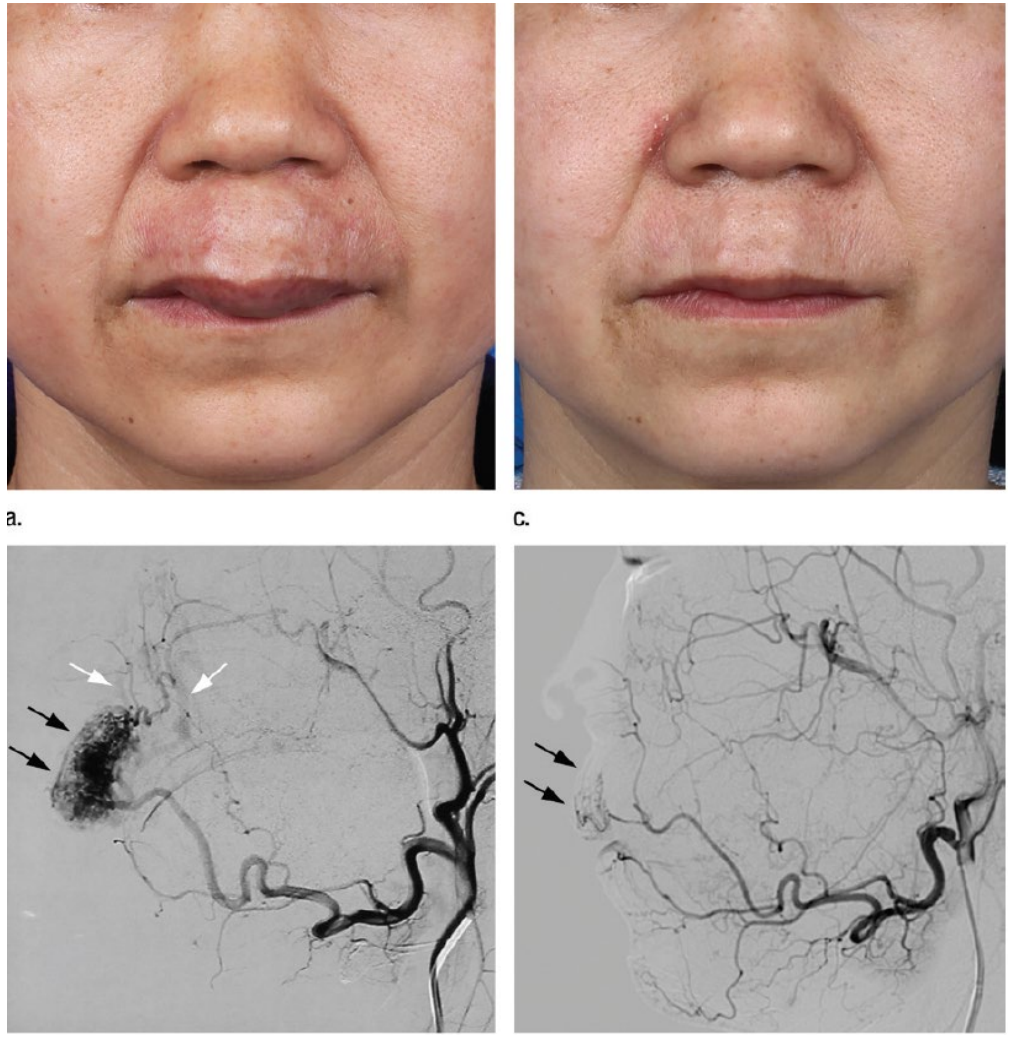
Angiographic Outcomes	Total (n = 93)	Type I (n = 3)	Type II (n = 57)	Type IIIa (n = 5)	Type IIIb (n = 15)	Type IV (n = 13)
Total group (n = 93)						
Total (100%)	35	3	20	5	5	2
Near-total (90%–99%)	20	-	12	-	5	3
Substantial (70%–90%)	9	-	4	-	1	4
Partial (30%–70%)	26	-	19	-	4	3
Failure (0%–30%)	3	-	2	-	-	1
Treatment finished (n = 57)						
Total (100%)	29	3	17	3	4	2
Near-total (90%–99%)	17	-	10	-	4	3
Substantial (70%–90%)	4	-	2	-	-	2
Partial (30%–70%)	6	-	5	-	-	1
Failure (0%–30%)	1	-	1	-	-	-
Treatment ongoing (n = 32)						
Total (100%)	6	-	3	2	1	-
Near-total (90%–99%)	3	-	2	-	1	-
Substantial (70%–90%)	4	-	1	-	1	2
Partial (30%–70%)	18	-	14	-	2	2
Failure (0%–30%)	1	-	1	-	-	-

Note–The group with the treatment status "other" was not included in this table.

Jin Y et al. et al.Radiology 2018;287 (1):194-204

Treatment of Early-stage Extracranial Arteriovenous Malformations with Intralesional Interstitial Bleomycin Injection: A Pilot Study[1]

- 34 patients with early-stage AVM,
- 27 (84.4%) response rate
  - 9 (28.1%) with a complete response
- Stable outcome in 96.9% during FU (mean 20.7 months)
- Four (12.5%) patients showed no response
- 1 major complication, anaphylactic shock
- 10 skin hyperpigmentation (31.2%)
- 1 flagellate erythema (3.1%)



Contents lists available at ScienceDirect

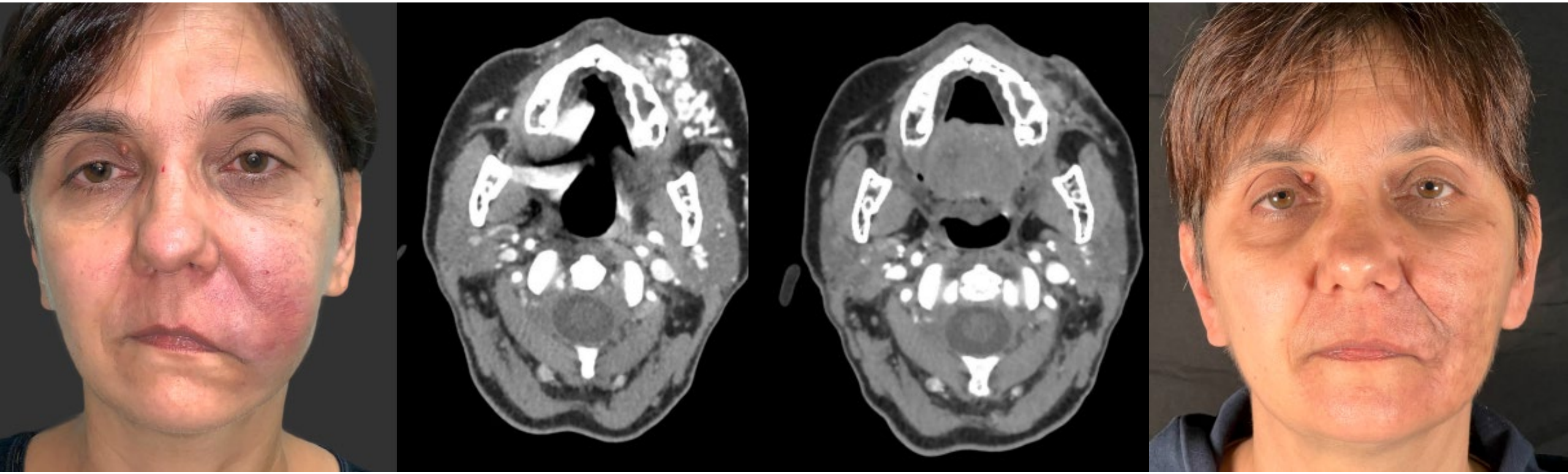
Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

MEST: Modified electrosclerotherapy to treat AVM (Extracranial Arterio-venous malformations). Better than BEST☆,☆☆

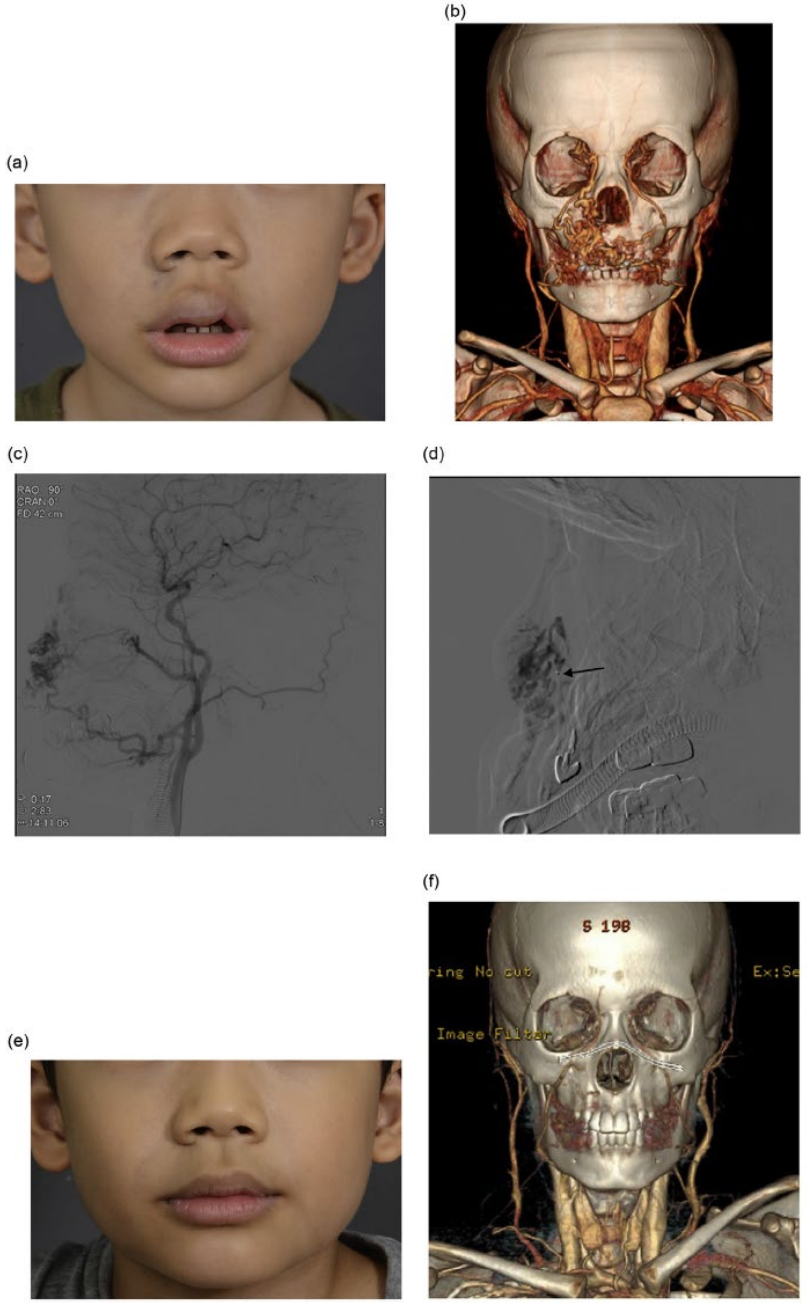
- Echo guided interstitial injection of bleomycin around the nidus
- 8 minutes wait
- Electrosclerotherapy
- 10 patients
- Mean 2 sessions
- 100% response...

MEST



Transarterial Bleomycin BEST

- Slow intra-arterial bleomycin infusion
- Flow control
- Electrosclerotherapy
- 19 patients
  - Early stage AVM (Schobinger I and II)
  - 1.6 session
  - 74% improvement
  - 26% slight recurrence during FU (mean32.6M)
- 2 minor complications
  - Hyperpigmentation
  - Cellulitis

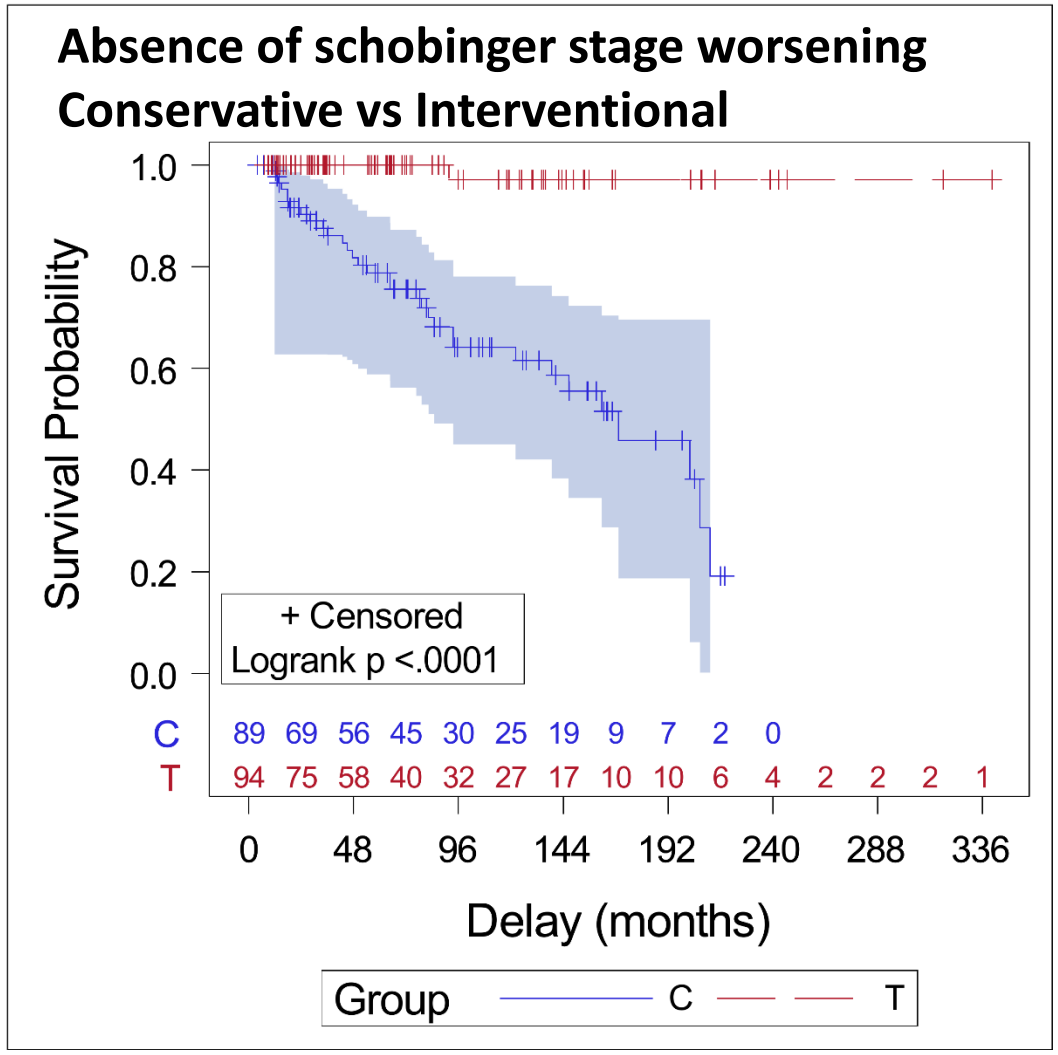


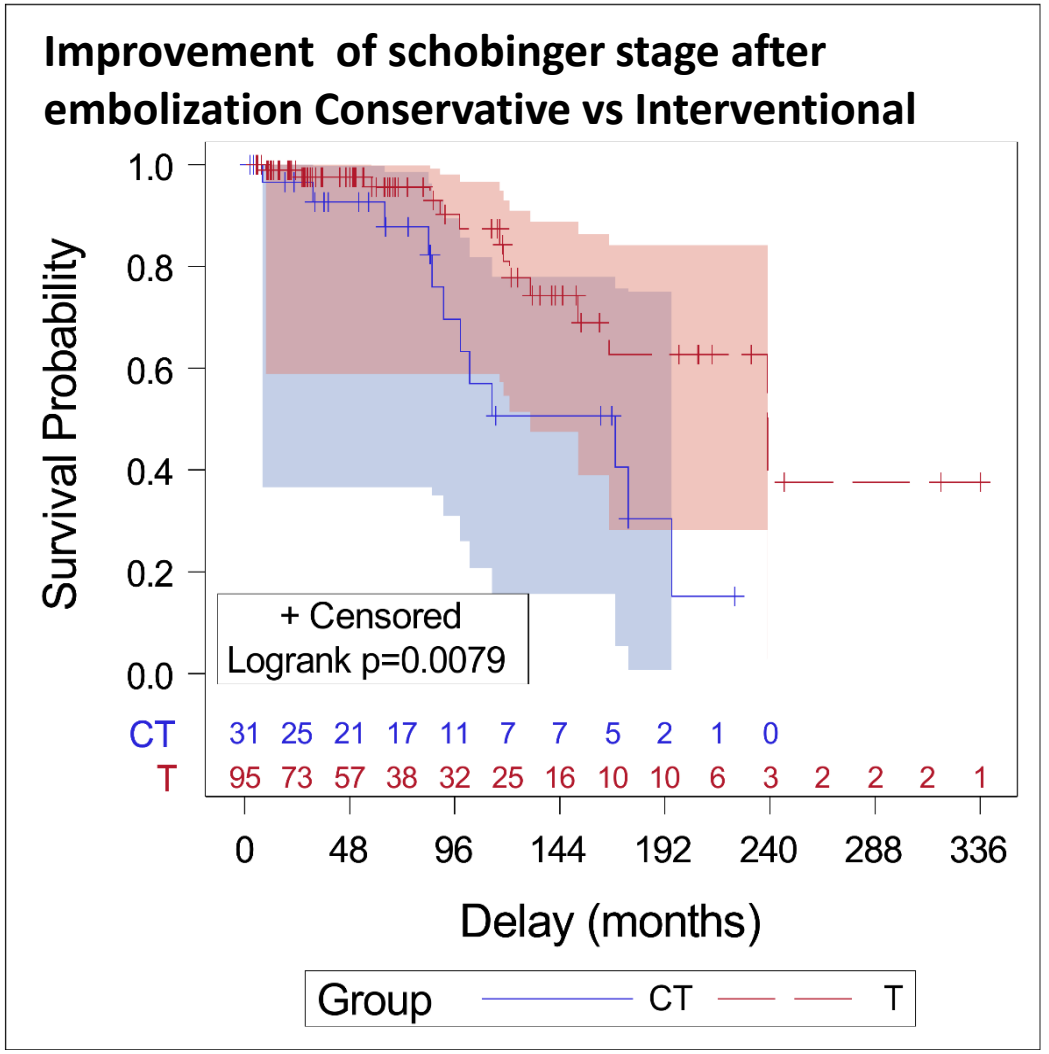
Lee SY et al. J Plast Reconstr Aesthet Surg. 2023 Feb;77:379-387

CHUM series

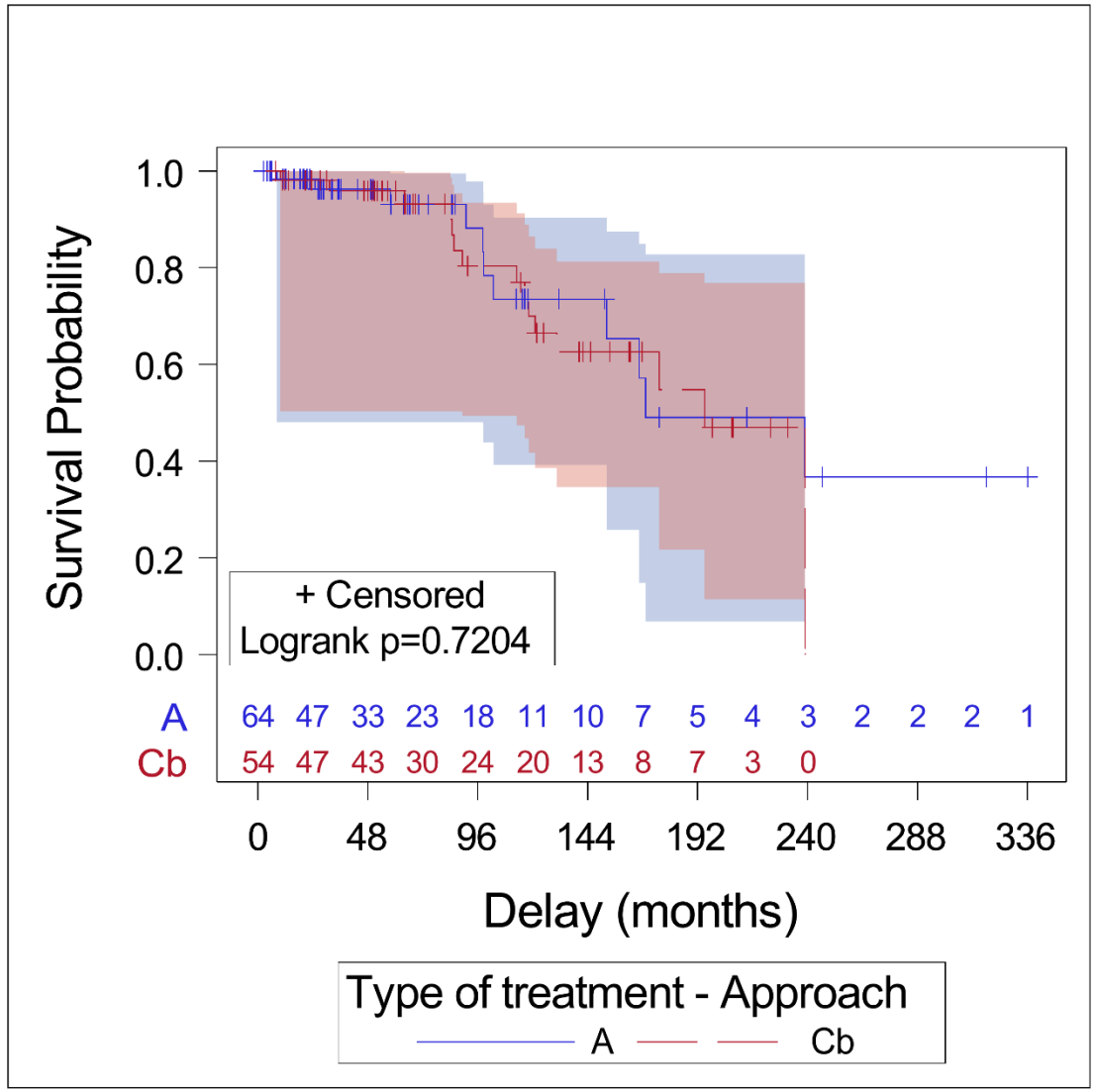
- 188 patients
- 129 received endovascular with or without surgical treatment
    - 55 Ethanol alone
    - 55 Ethanol combined with liquids and mechanical
    - 19 no ethanol
- 59 were managed conservatively.
- Ten-year survival without worsening of clinical stage
    - 97.1% for the treatment group
    - 64.1% for the conservative group ($p<0.0001$)
- Among treated patients
    - 5-year improvement of clinical stage = 92.7% and 95.6%
    - 10-year improvement of clinical stage = 50.7% and 81.0%.
- Complications occurred in 7.7% of procedures, with 1.4% classified as major.

Conservative vs Interventional Management

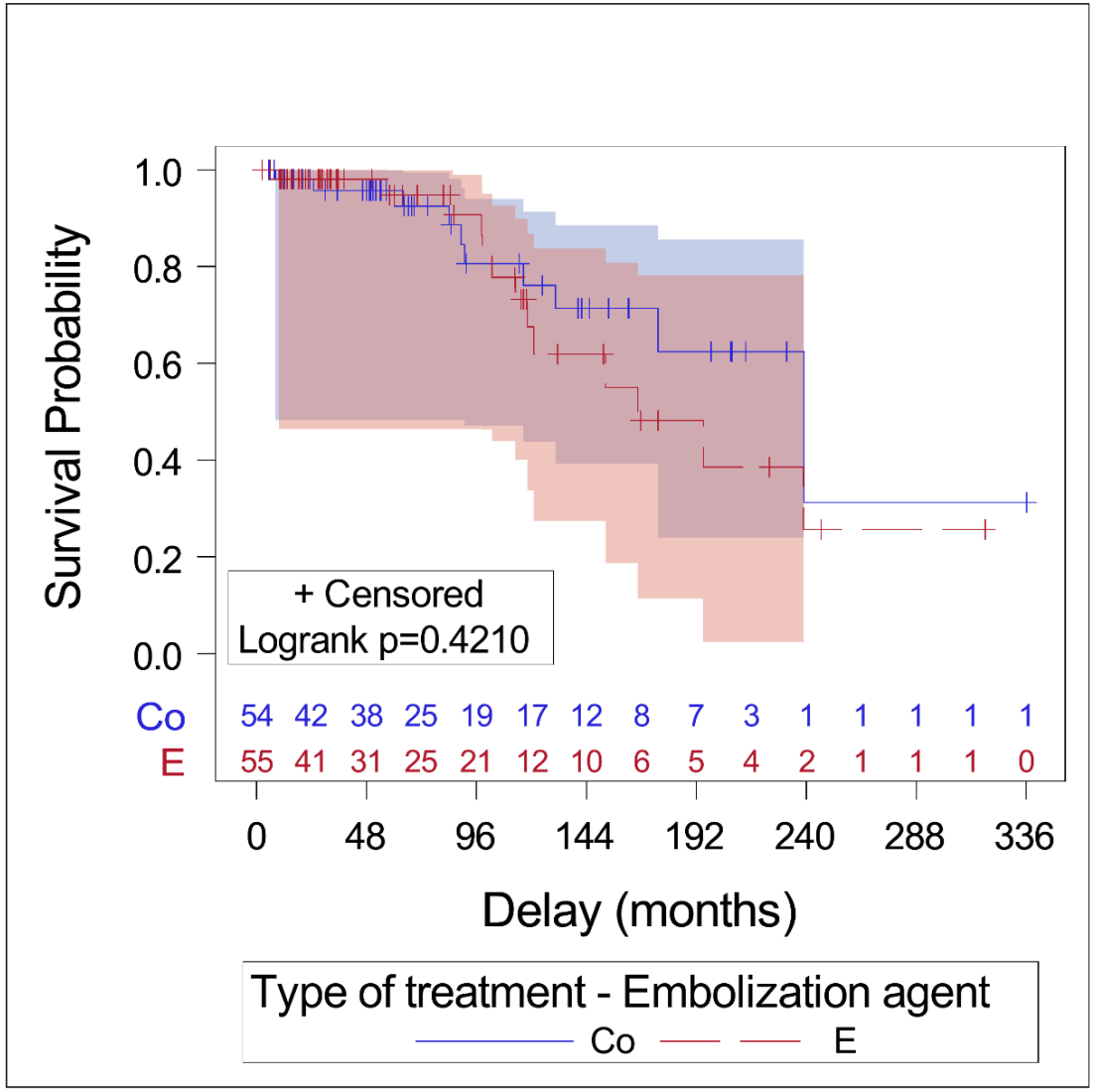




Ten-year survival (Schobinger improvement)
Trans-arterial approach (A group) vs. combined approach (Cb group)



Ten-year survival (Schobinger improvement)
Ethanol alone (E group)
Ethanol combined with other agents (Co group)



Conclusion

- Careful evaluation on 4D MRA, DUS and DSA
- Need to adapt your strategy to patient symptoms, angioarchitecture and nidus accessibility
- Need to be inside the nidus and be sure your embolization reach the venous side of the fistula to close it
- DUS is of paramount importance to target the nidus or fistula areas
- Use ethanol endovascular only if you are in the nidus (no evidence of normal branch)
- Good to decrease the inflow with a first endovascular approach before doing direct puncture or venous retrograde approaches.