Clinical applications

Arterial approach

The following are the clinical applications of the Glubran®2-Ethiodized Oil mixture [4] (Fig.20):

- Arteriovenous malformations (AVM)
- Acute arterial & venous bleeding
- Hypervascular tumors (primitive/metastasis)
- Portal vein embolization
- Endoleaks
- Varicocele / pelvic congestion syndrome
- Hypersplenism
- Prostatic artery embolization (PAE)
- Non-vascular purpose:
  - Needle track embolization
  - Enterocutaneous leaks
  - Biliary tract

Buttock AVM

In this first example we have a painful buttock AVM. The MR image shows it is very superficial (Fig.20AF). We first attempted an arterial approach and soon realized it was impossible to reach the nidus that way. We proceeded then by puncturing the nidus by the means of a 21 G Chiba needle and injected a 1:4 mixture of Glubran®2 and Ethiodized Oil. In a case such as this, extra caution is required to avoid venous drainage, however, when you first inject contrast to assess the flow, remember this liquid is rather less viscous than a 1:4 mixture of glue, and that makes it more likely to reach collaterals. Inject the glue slowly but do not worry about reaching as far as the contrast.

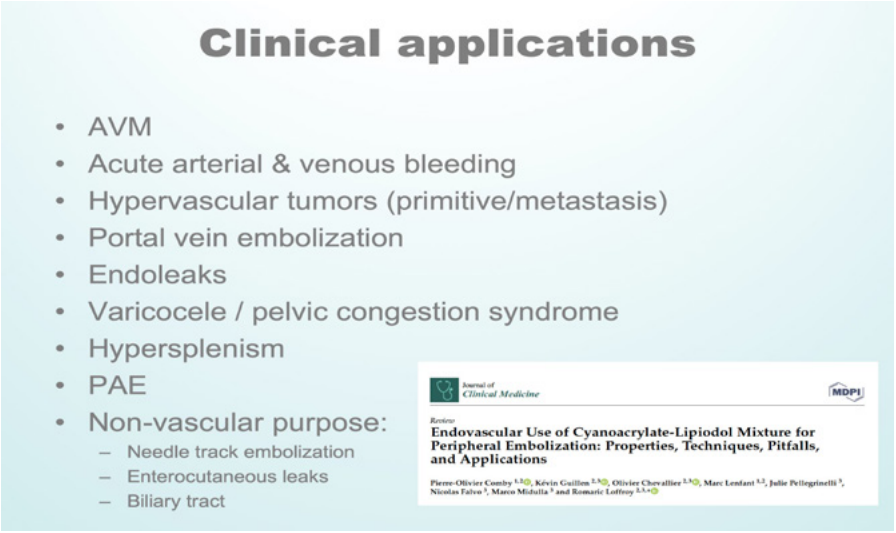


Figure 20

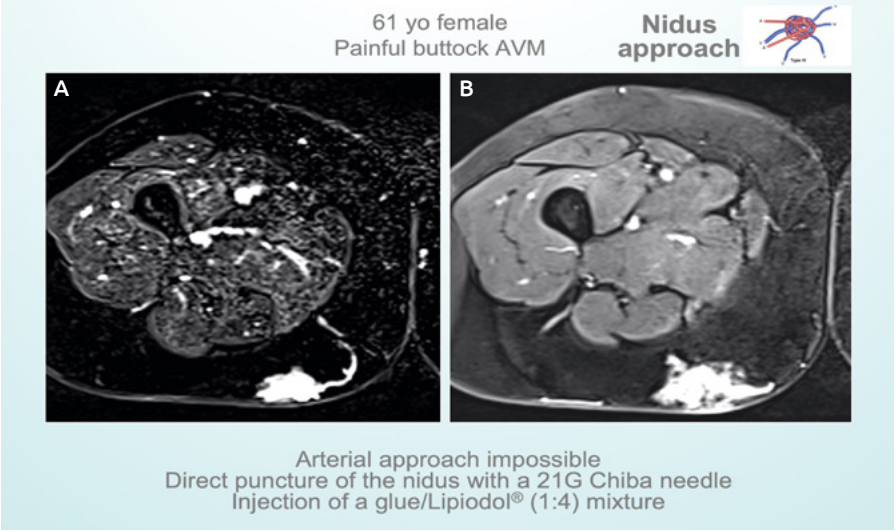


Figure 21 AB - 61 yo female - Painful buttock AVM - Nidus approach

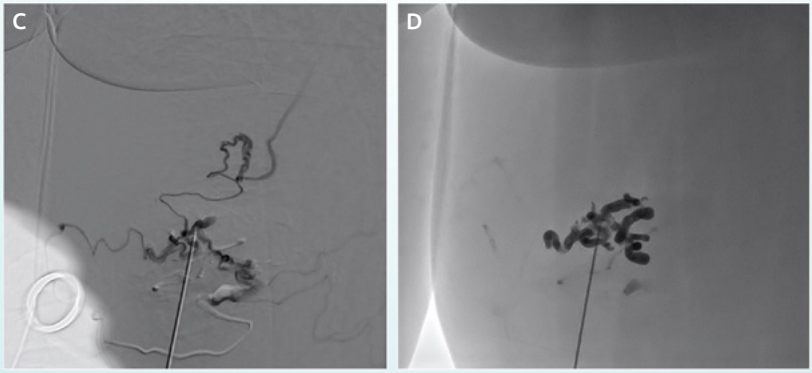


Figure 21 CD

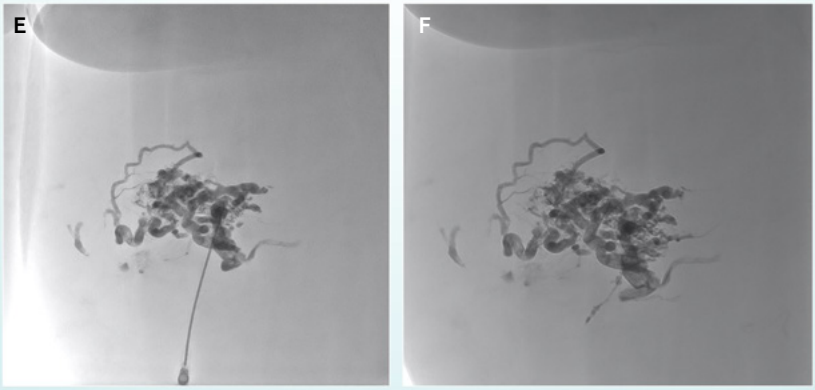


Figure 21 EF

In case of venous drainage in arms or legs, you can apply compression to stop the process. Keep injecting until you completely fill the nidus and reach your endpoint. Even though Onyx® might seem a good choice here, in case of very superficial AVMs it can be overly painful for the patient and sometimes leave marks on the skin. Glue is an easy and safe alternative.

Uterine AVM

A bleeding uterine AVM post-abortion with pseudoaneurysm and venous drainage (Fig.22AI). Using microparticles in this case would pose a serious risk of migration, whereas employing gel foam might result in an incomplete embolization. Notice how the microcatheter advances a long way, forming several loops. Nonetheless, the tip is quite far from the distal spot. Even in such a case, by using a 1:5 mixture we can achieve complete occlusion, as the glue travels distally enough to reach the spot. While copolymers are useful in many indications, they cause immediate reflux, which forces us to wait for

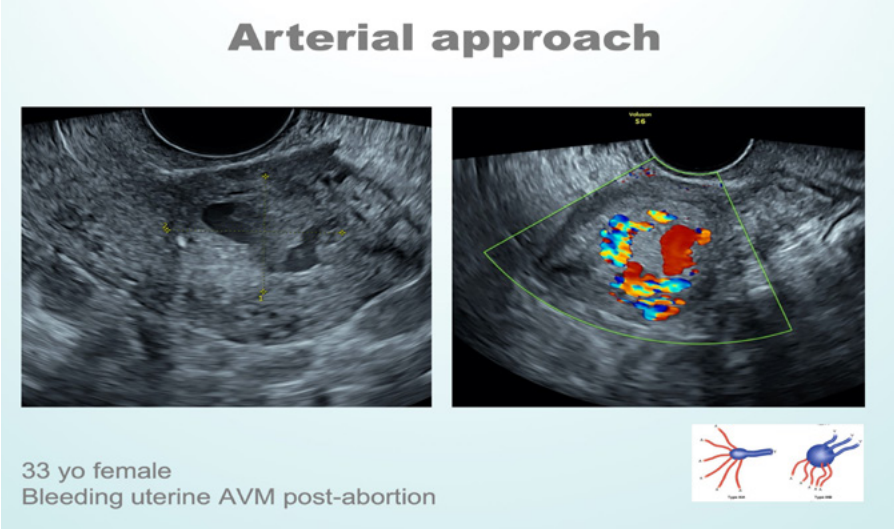


Figure 22 AB - 33 yo female - Bleeding uterine AVM post-abortion

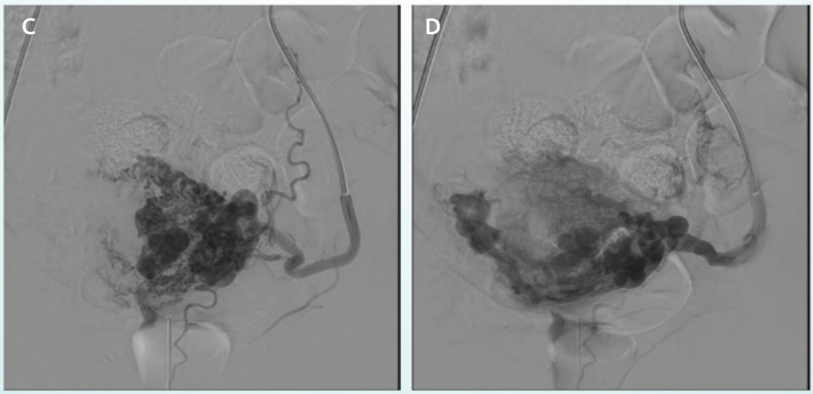


Figure 22 - C: initial angio arterial, D: initial angio venous

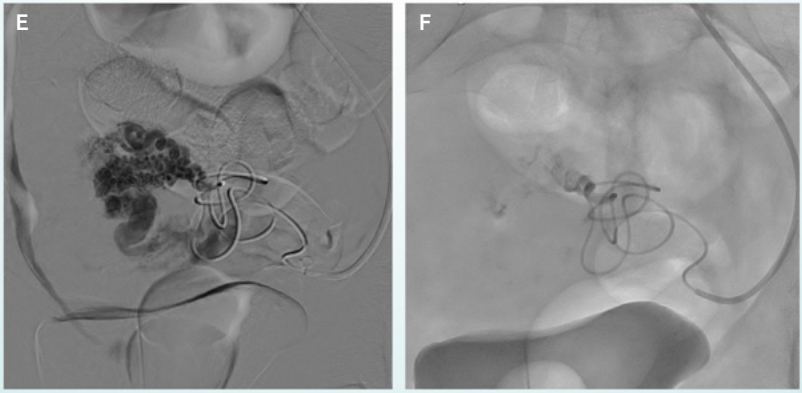


Figure 22 - E: first feeder before embolization, F: first feeder after embolization

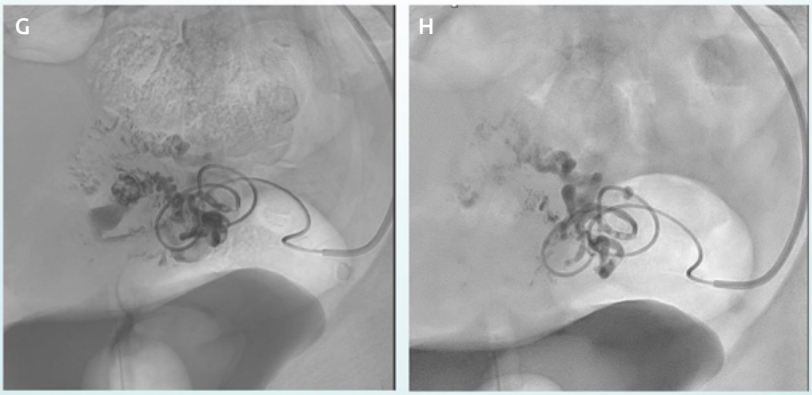


Figure 22 - G: second feeder before embolization, H: second feeder after embolization

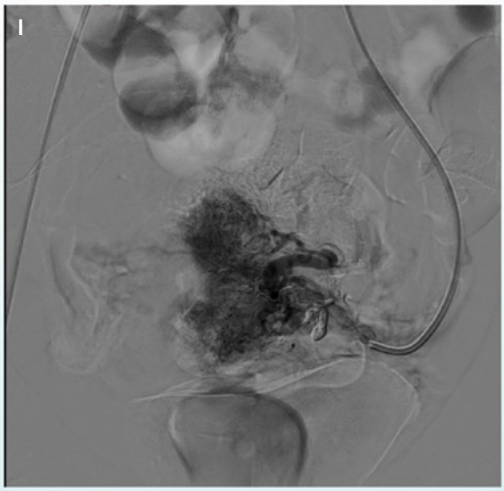


Figure 22 - I: final control

the cast along the microcatheter to harden, in order to be able to push again. Besides, when the tip is too far, Onyx® or Squid simply cannot be pushed distally enough. Glue here poses no risks. Reflux on the catheter is a non-issue, as it will not prevent safe removal. Migration to capillaries is not common in case of AVMs such as, for example, a renal tumor. The case would be different with direct connections, for example a fistula. However, should you feel doubtful, you have the possibility of doing a test with Ethiodized Oil alone first. The final result shows patency of the main uterine artery with both branches correctly embolized. Microcatheter withdrawal can be performed while injecting, however this is not compulsory. In case of big arteries, we can place the tip in the main artery and use a highly diluted mixture. In other cases, if we have reasons to be selective and maintain the rest of the tumor bed patent, we can place the tip at the furthest point and inject while retracting. These are just two different options. Here, the several loops the microcatheter forms tell us we are very distal, however, even in case of reflux along the microcatheter, removing it will not be a problem. If we feel we are at the endpoint and we need to leave the microcatheter in place for 30 seconds or so, there is no reason to worry, we can just proceed with the removal.

Cardiac hyperflow related dyspnea

Here is a case of cardiac hyperflow-related dyspnea (Figs.23-25) with a huge malformation in the inferior mesenteric artery. It is a typical AVM with a large dilation of the venous drainage. We started with a balloon-assisted embolization with Onyx® to slow down the flow, however, we soon realized the process was taking too long, and we agreed to use glue instead. This is due to the presence of many branches, which are easier and quicker to catheterize with glue. Thanks to the viscosity of the mixture, we have no passage to capillaries. The final result is rather good. The advantages to using glue in a case such as this are clearly visible. Employing mechanical agents is not an option here, as our goal is to reach the nidus. Big microparticles pose a high risk of recruitment of collaterals in such a long procedure. Glue, on the other

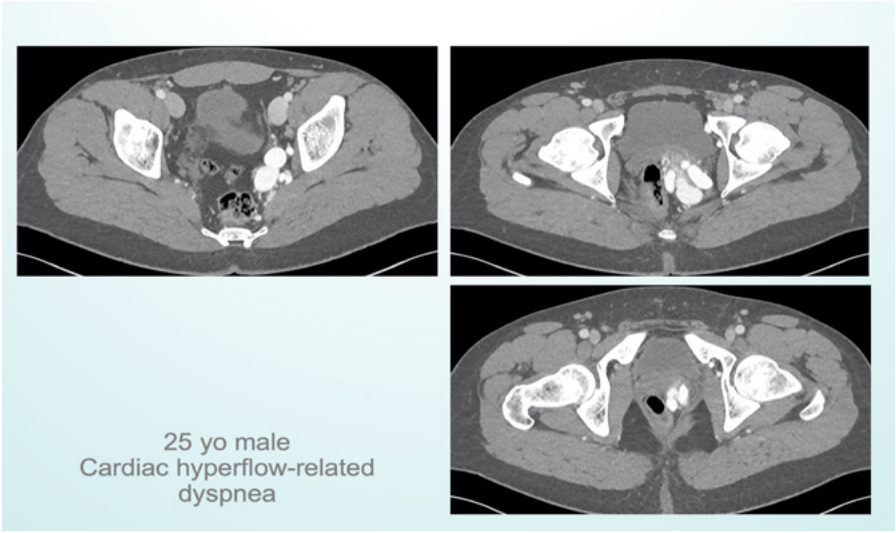


Figure 23 - 25 yo male - Cardiac hyperflow-related dyspnea

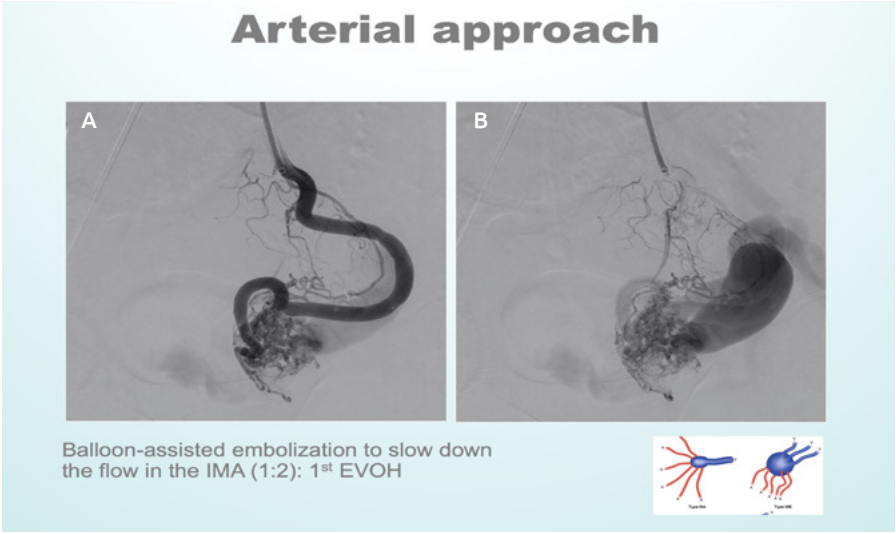


Figure 24 AB

Figure 24 CD

Figure 24 EF

Figure 25 AB

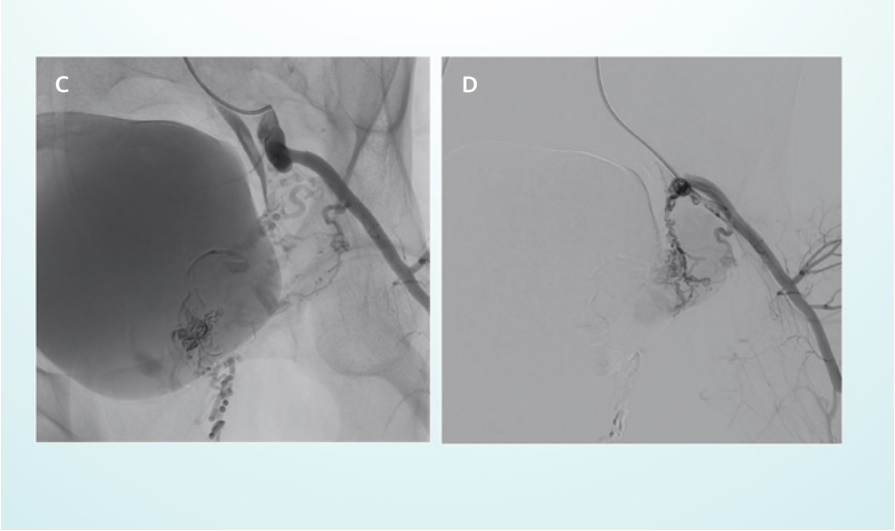


Figure 25 CD

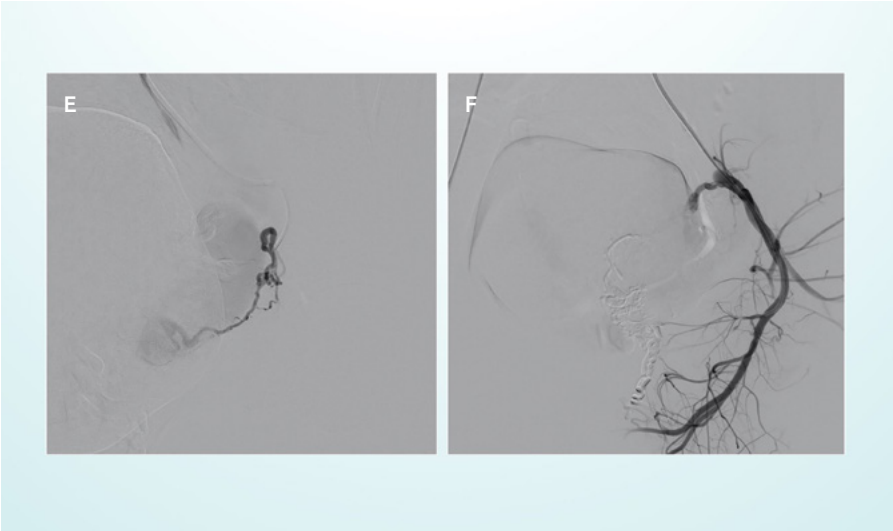


Figure 25 EF

hand, is fast and risk-free. At CT scan we can observe thrombosis of the venous dilation and the distribution of the glue with no passage.

Endoleak type II

Here is a type 2 endoleak where arterial approach (Fig.26), though preferable in my opinion, proved impossible. In order to perform a percutaneous approach, we first insert a metal needle in which we place the microcatheter, to prevent high pressure reflux from pushing it out. We use an ordinary kit for biopsy or nephrectomy and insert a 17 G needle under fluoroscopic guidance at CT scan. We then place a valve at the proximal port of the needle to lock the 2.4 F microcatheter in place. This method will reduce the pressure of the reflux and leave us enough time to inject a 1:4 mixture with no risk of occluding the dead space and trigger early polymerization. While Onyx® might appear as a good indication in this case, we need to take into account the large number of artifacts, even though the amount of tantalum has been

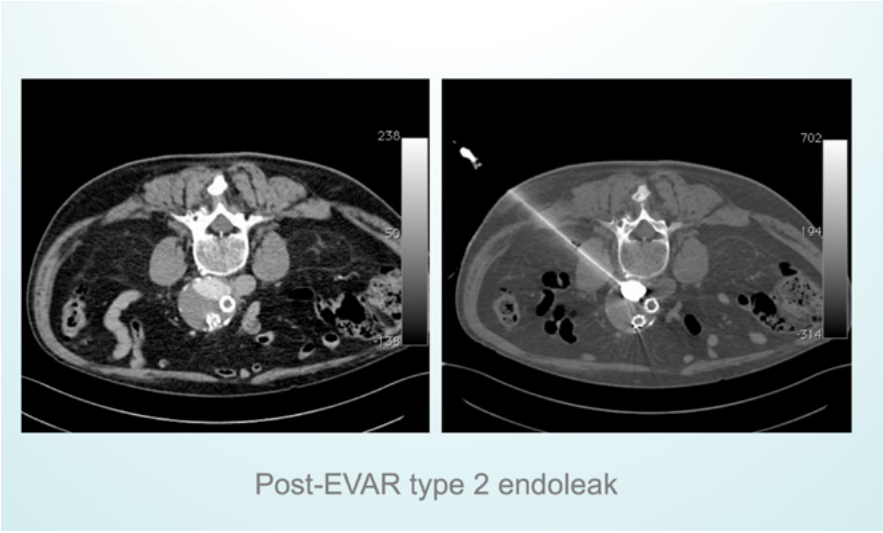


Figure 26 - Post-EVAR type 2 endoleak

recently reduced in both Squid and Onyx®. At CT scan, we can observe a low quantity of artifacts after the procedure with Glubran®2 / Ethiodized Oil.
Figure 27 shows an example of a type 2 endoleak A and B involving the inferior mesenteric artery, which is patent. In such cases, we usually start by accessing Riolan's arcade and then close the artery with coils, as the reflux would make deploying liquids challenging, if not impossible. As we can observe, the catheterism through the iliolumbar artery is quite complicated and we have extravasation, which does not allow to place the tip too distally. Nonetheless, this is not an issue. Just keep checking for dangerous collaterals and start injecting a 1:5/1:6 ratio mixture to reach the other side through reflux. Ensure both lumbar arteries are blocked, as well as the main nidus. Injection by direct puncture of the sack under CT guidance is not advisable, in our opinion, as triggering reflux in the lumbar arteries is not always an attainable goal and this may result in an incomplete embolization. We had a case in which we tried a transabdominal approach and injected the mixture

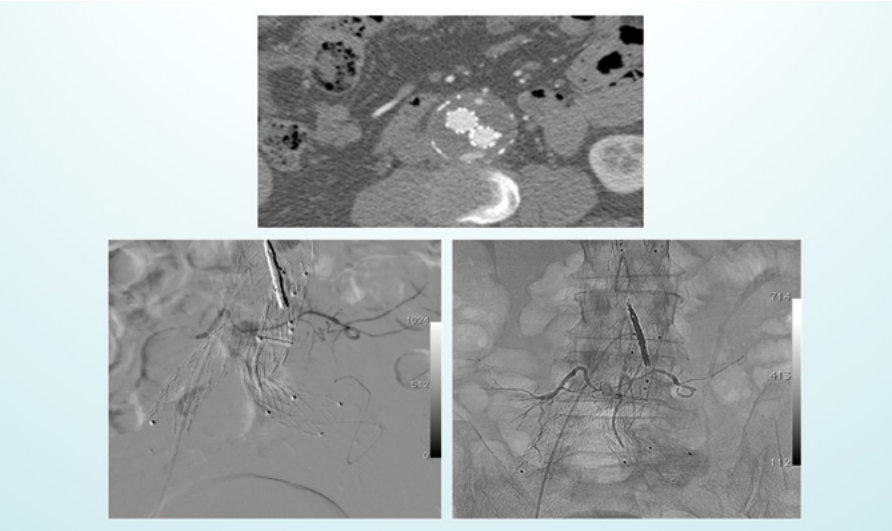


Figure 27 - Type 2 endoleak A and B

by direct puncture of the sack. We got reflux from a patent inferior mesenteric artery, which made us believe it was thrombosed but in fact it was not. Some glue migrated into the sigmoid branches. Fortunately, this brought no consequences for the patient, who was asymptomatic, however, the complications deriving by a cast of glue blocking the main trunk of the mesenteric artery can be disastrous. This is why it is crucial to check that the inferior mesenteric artery is occluded before injecting the mixture in the sack.
In a percutaneous approach, the dilution depends on the size of the artery. If it is big, choose a 1:4/1:5 ratio with a 3 ml syringe and a 2.4 F catheter. There is no need to keep injecting while retracting the catheter. You might need to prepare multiple syringes filled with mixture to ensure you have enough liquid to complete it. A fluoroscopy prior to the procedure may help to assess the outcome in advance. As previously mentioned, reflux in the main lumbar artery is not always attainable, so ensure the injection is performed very slowly in order to be able to correctly detect the endpoint.

The problem with injecting in the sack is that the liquid we are injecting causes engrossment and that is why it is difficult to understand when the endpoint has been reached. The same will happen with copolymers. We usually inject 5 or 6 ml of Onyx® or Glubran®2, however, at times this quantity will not be enough.

False aneurysm

This is a false aneurysm of the hepatic artery (Fig.28) that we attempted to treat with a covered stent that was not well deployed. We found it impossible to retrieve the stent and still detect patency, which led us to successfully attempt a percutaneous approach with direct injection of glue in the pseudoaneurysm.

Angiomyolipoma

Benign tumors such as an angiomyolipoma are good example of glue embo-

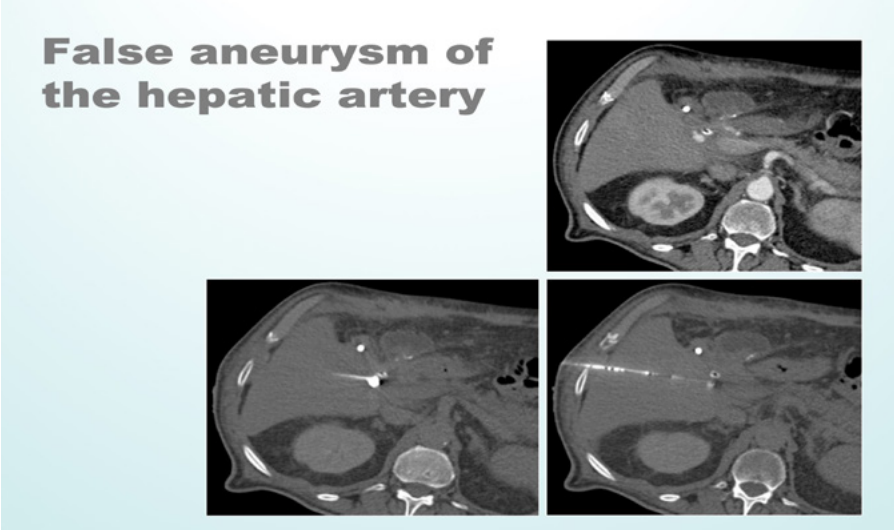


Figure 28 - False aneurysm of the hepatic artery

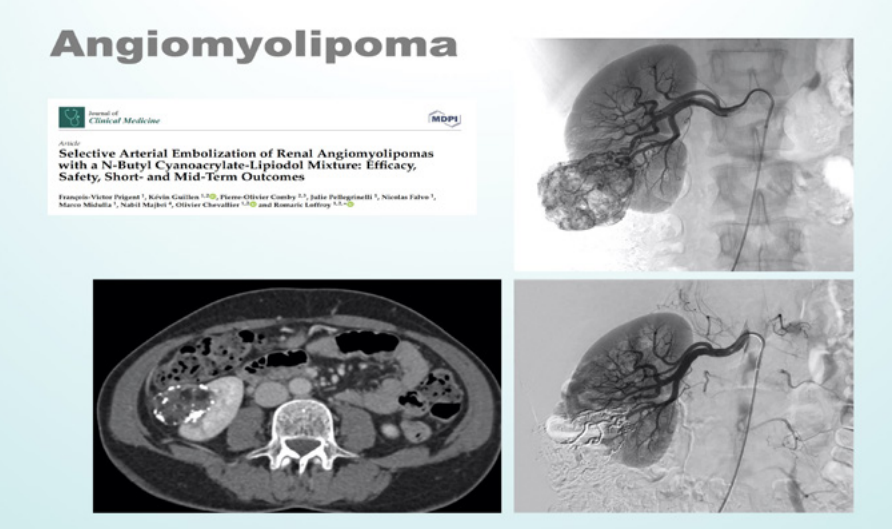


Figure 29 - Angiomyolipoma 1

lization (Fig.29). Here we have two main arteries for which we used a 1:5/1:6 ratio. We abundantly flushed using about 10 ml of dextrose solution and observed the drops of glue going distally until we got reflux. At that point, we stopped injecting and removed the microcatheter. In this kind of procedure, you have the possibility to check your progress step by step, which makes the procedure fast and neat, when compared to using microparticles. The same microcatheter may be reused after careful flushing with dextrose solution. Observe the even distribution of the agent. We recently published a paper on this procedure [5]. Figure 30 shows another example of a typical angiomyolipoma with a large hematoma and multiple aneurysms.
Having a single branch to intervene on makes this the perfect embolization. Use a 1:6 ratio and flush abundantly. Watch the glue go distally, wait for stasis and then for reflux. Stop injecting and retrieve the microcatheter. The whole process is very fast and simple when performed with glue. Microparticles are not a comparable alternative, as the same procedure would take

Figure 30 - Angiomyolipoma 2

about two hours to complete. Choosing the right size for the microparticles is a time-consuming decision as it is empirical and may need different tests. Besides, microparticles alone would not be enough to occlude the aneurysm, some other agent would have to be added at the proximal port or coils would have to be deployed after catheterizing each branch. Glue guarantees perfect results and can be used for both the distal and proximal embolization. Do not hesitate to flush abundantly using between 5 and 10 ml of dextrose solution.

Keep in mind that the highest the dilution, the biggest the quantity of mixture at our disposal.

When we employ a 1:1 ratio, the total amount of liquid amounts to 2 ml, which might not be enough for veins, PCS, or large varices in women. In those cases, remember to prepare in advance a few extra syringes already filled with mixture, as 2 ml would not be enough to completely occlude the pelvic reservoir and the main left ovarian vein.

Kidney pseudoaneurysm

Here we have a pseudoaneurysm in the kidney due to complications occurred after a partial nephrectomy (Fig.31). Placing the tip of the microcatheter at the bleeding site will allow to successfully conclude the procedure with as little as two drops of glue.
Choose a 1:3 dilution ratio, but keep in mind that these conditions allow for any ratio to work. Using coils might seem a safer choice here, however, the risk with coils is for the embolization to be more proximal than expected and to have to sacrifice a lot of collaterals to occlude the main branch. Glue represents a faster and safer choice, provided that we pay the proper attention.

Humeral bone metastasis

An example of a hypervascular humeral bone metastasis from kidney tumor (Fig.32). It is very similar to a high flow AVM and thus presents serious risk of venous passage, which discourages the use of microparticles.

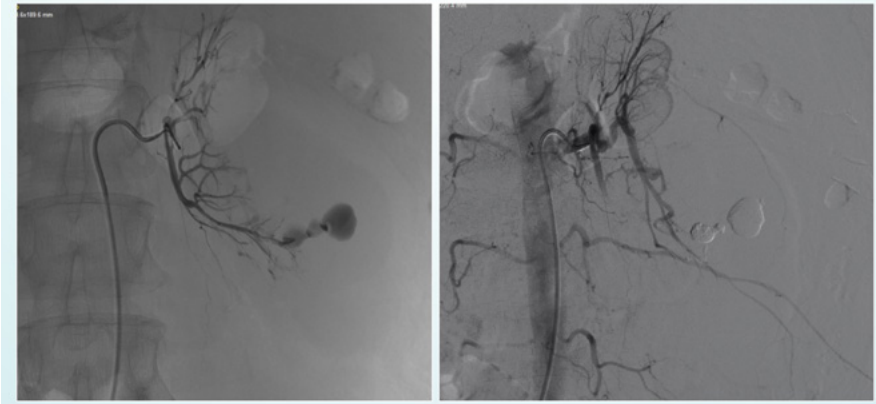


Figure 31 - Pseudoaneurism of the kidney

We catheterized three branches using a 1:1 dilution ratio. Performing a test using Ethiodized Oil alone is a safe way to assess transvenous passage before the actual procedure. The cast of Glubran®2 in the different branches is clearly visible and the final result is extremely good. Using big microparticles in such an indication may appear as a valid option, however, time always represent an important factor to take into consideration. The embolization will take longer to complete, and it will very likely lead to recruitment of collaterals. Glue, on the other hand, will allow you to promptly cut the flow.

Tibial bone metastasis

Another case of hypervascular metastasis from kidney tumor prior to surgery for which we used a 1:5 dilution ratio (Fig.33). We can see the cast of glue perfectly occluding the two main branches of the popliteal artery. Once again, the procedure was completed in a remarkably short time.
A randomized study from Portugal [6] has recently compared cyanoacrylates

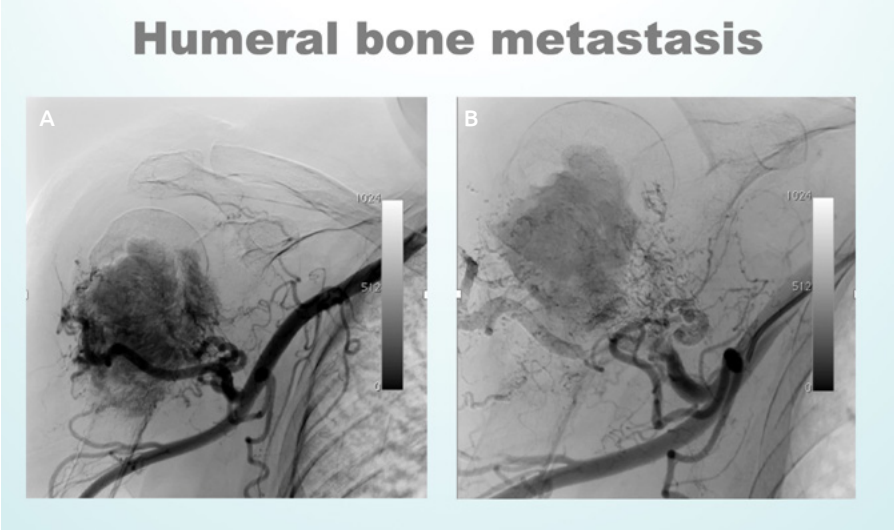


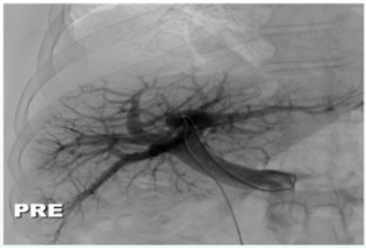
Figure 32 - Humeral bone metastasis: (A) before embolization; (B) after embolization.

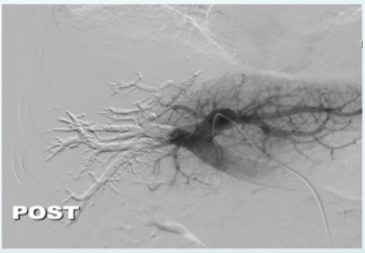
Figure 33 - Tibial bone metastasis: (A) before embolization; (B) after embolization.

with particles plus coils and concluded as follows: "*Portal vein embolization with N-butyl-cyanoacrylate plus iodized oil produced greater and faster liver growth as seen at CT in participants with liver cancer, compared with portal vein embolization with polyvinyl alcohol particles plus coils, allowing for earlier surgical intervention*" (Figs.34,35).

Previous studies also testified to the safety of using NBCA in portal vein embolization, as concluded by a 2018 systematic review and meta-analysis, which stated that: "***PVE utilizing NBCA*** *to induce hypertrophy of the FLR prior to contralateral lobe resection in the setting of hepatic malignancy* ***is safe and effective***" [7]. Although particles and coils are widely used in this kind of procedure, not only are they extremely time-consuming, but the results are hardly comparable.

We used a standard contralateral approach from the right side. We first inserted a sheath, then a 5 F catheter in the main branch, and finally a microcatheter, quite distally. Using a 1:8 dilution we started to inject the mixture





group (*P* = .27). Conclusion Portal vein embolization with *N*-butyl-cyanoacrylate plus iodized oil produced greater and faster liver growth as seen at CT in participants with liver cancer, compared with portal vein embolization with polyvinyl alcohol particles plus coils, allowing for earlier surgical intervention. © RSNA, 2021 *Online supplemental material is available for this article.* See also the

Randomized Controlled Trial > Radiology. 2021 Jun;299(3):715-724.
doi: 10.1148/radiol.2021204055. Epub 2021 Apr 6.

BestFLR Trial: Liver Regeneration at CT before Major Hepatectomies for Liver Cancer–A Randomized Controlled Trial Comparing Portal Vein Embolization with *N*-Butyl-Cyanoacrylate Plus Iodized Oil versus Polyvinyl Alcohol Particles Plus Coils

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CVIR CRSE CrossMark

REVIEW

Portal Vein Embolization Utilizing *N*-Butyl Cyanoacrylate for Contralateral Lobe Hypertrophy Prior to Liver Resection: A Systematic Review and Meta-Analysis

Ethan Wajswol[1] · Tarek Jazmati[2] · Sohail Contractor[2] · Abhishek Kumar[2]

Figure 34 - Portal vein embolization

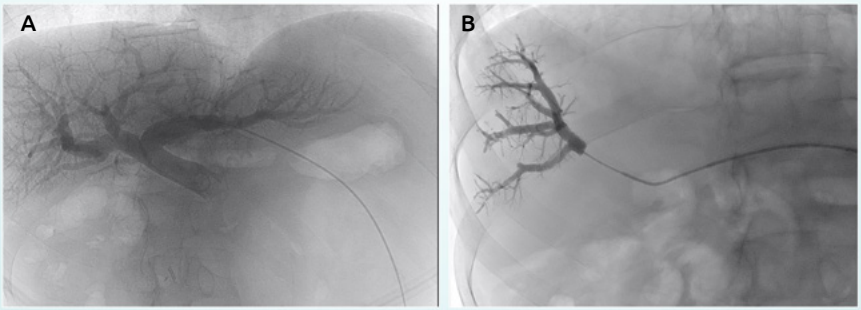

Figure 35 AB - Portal vein embolization.

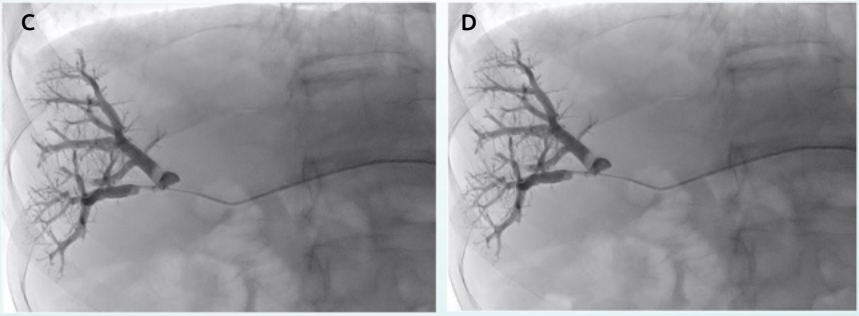

Figure 35 CD

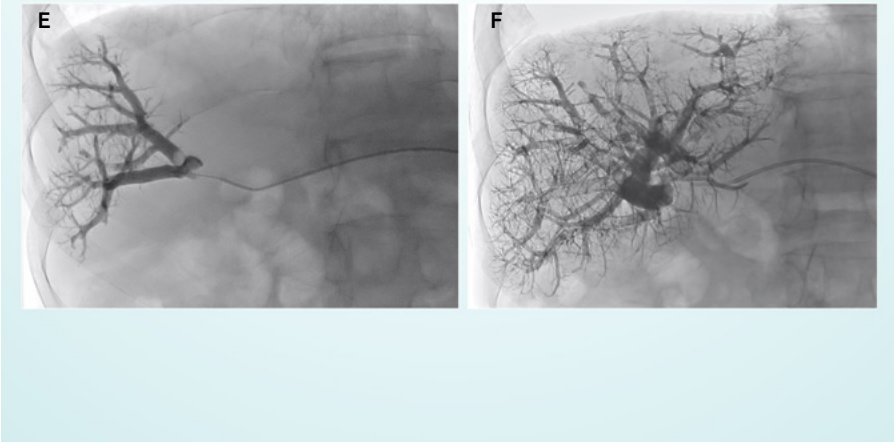

Figure 35 EF

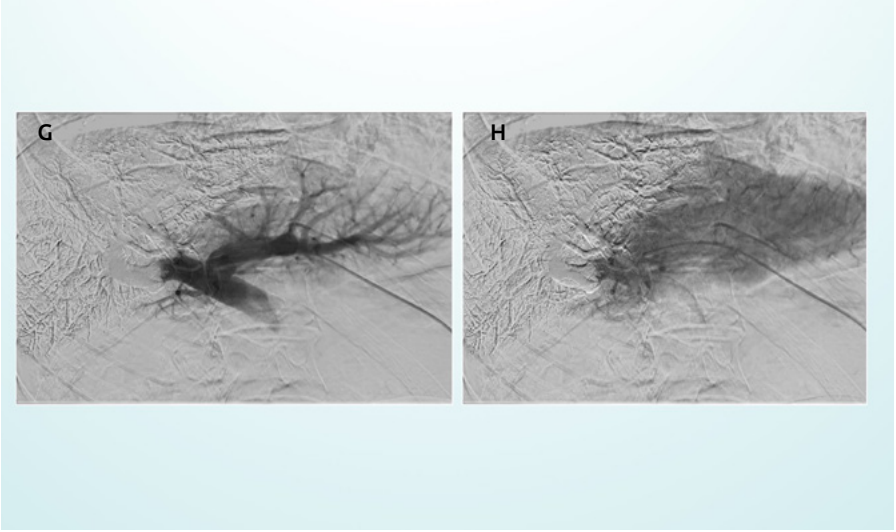

Figure 35 GH

while removing the microcatheter at the same time in order to generate reflux. As you may have noticed, this is a different technique that relies on reflux to reach the other branches and complete the embolization. If needed, you can flush the catheter on the table and go back to embolize a different branch. The kind of embolization you will achieve using this method is very distal. Pay attention to the proximal port, especially when using a 1:8 ratio. An alternative is to prepare two different dilution rates, 1:8 for the distal port and 1:1 for the proximal port, although it is not necessary to embolize the proximal port. Concerning quantity, 9 ml is most likely enough in this case. The procedure is fast and easy and the result completely satisfactory. Flushing directly in the 5 F catheter is a possibility, provided that we make sure there is no glue on the tip lest we run the risk of leaving glue in the left port in the process of removing the catheter. A coaxial technique is always safer to manage.

The evidence from the randomized study has now proved that glue is the best embolic agent for portal vein embolization.