

Chapter 9

Some more basic issues to consider about EVTm and embolization

Yosuke Matsumura, Junichi Matsumoto, Per Skoog, Lars Lönn and Tal Hörer

We wanted first to write about “What to do when you are inexperienced” or “What to do when back up has not yet arrived?”. We realized that in the bleeding patient, if you are not experienced, you will need back up even on patient arrival. Thus, the following text is built so you can make some choices and understand what can be done. You have a bleeder! You are not highly experienced! Call for backup and activate a multidisciplinary approach.

Endovascular techniques are being introduced in trauma surgery. The more tools you have, the more you can do! Is it so? Well, we know that at times you need just very basic tools, and the fact that you have many options might complicate the situation. The art of modern trauma and bleeding surgery is to know **when to use which tool and on what patient**. Your main problem is to **find the damn bleeding and stop it!** You stand there and know that the hypotensive patient is bleeding – but where? Some of us think that blunt trauma is more frightening than the knife in the belly that can “obviously” guide you to the bleeding source.

We will go through some basic methods and thoughts that might help you. Again, this is based on personal experience and opinion, so you choose what suits you. Do you suspect massive bleeding, and that the patient’s life will fly out of your hands? Take the patient to the safest place **where you can**



stop the bleeding. Don't go to the CT if you are inexperienced or not sure what to do. Unstable patients require very fast decision-making and skilled hands. You will not have these in the CT unless there is a clear plan and nearby surgical suite, and also VERY skilled people with you. CT (or CTA!) is a very powerful tool **but it does not stop the bleeding!** So, you need to do something, now! There are some tools that are bridges to surgery, and one of them is REBOA (as you saw in the other chapters). REBOA may help you **win some times until you get to a place where you can stop the bleeding.** In order to do a REBOA, you will need a **femoral arterial access**. Then, you must think whether REBOA is the correct tool for this patient. This is discussed in the other chapters.

Don't do "non-selective" angiography. You must know **where** to look for the bleeding focus.

IF the patient is stable, or if the abdomen is opened and already packed, and the pelvis is tightened, but the patient is still not stable, consider improved diagnostics and embolization. The alternative is if you had time for a **CTA on arrival**. You have identified a source of bleeding that is not easily accessible for open surgery, and the patient crashes. You might consider embolization, but remember that embolization takes some time. This time is highly dependent on where you are and, again, your skills. Internal iliac artery embolization can be done within 10 minutes by an experienced IR or endovascular surgeon but **transfer and preparation might take much longer**. Another option is to think hybrid (EVT), and work on packing the abdomen while embolization starts (get a vascular femoral access if that's not yet done), or a REBOA in place with pREBOA or iREBOA (see the relevant chapter). In other words, while performing laparotomy (if not done before), someone else can do the femoral access and insert the REBOA (if not done before). Remember also that we need teamwork here; someone has to take care of the REBOA while you look for the bleeder or pack. If you don't know exactly where the bleeding source is, your heroic embolization efforts will not turn out well. If you, on the other hand, have a good idea of where the bleeding is, and use the EVT set of mind as we described before, embolization might be a good solution. There are some scenarios where you can hold a patient at an acceptable systolic

blood pressure with pREBOA until help comes or your surgical suite is ready. Whatever you do, don't just leave a REBOA in place without planning the next step. Hold it, use pREBOA, and call for help!

To counter all this, we should mention that the majority of trauma patients are hemodynamically stable and you might consider embolization or stent-graft deployment. But you will need a CTA to localize the problem, except in the case of hemodynamically unstable isolated pelvic injury. CTA will show you the extravasation location, will give you the “map” on how to get there, and, of course, will show associated injuries. A minor bleeding in the pelvis with an intracranial hematoma might make you change your priority, i.e., of what to do first.

What do you need if you want to embolize and have never been there before? Well, **you need someone with experience beside you!** But, anyway, some tips on what is commonly used for embolization:

Macro catheter	5Fr or more (more options than 4Fr)
Micro catheter	Smaller catheters (often carry a 0.018 inch wire)
Selective catheter	A catheter with some kind of bend or hook
Hydrophilic catheter	Helps you get through angulations and change wires
Coils	Small metal spiral forms
Vascular plugs	Forms for bigger vessels
Liquid agents	Effective but tricky to manage, instant hemostasis if deposited in the right place and not dependent on coagulation status
Gelatin sponge	Water insoluble gelatin, good for in peripheral diffuse bleedings

Let us assume that you have basic endo-training and focus here on some basic embolization skills.

Access is always the first priority for EVT

(see also the chapter “It’s all about the access”)

If you want to do REBOA, arterial balloon occlusion, or embolization, or deploy a stent graft, you need a functional vascular access. We mentioned before that it should be already considered during the primary survey (AAB-CDE), but this is not yet anchored in any guidelines. Establishing a vascular access in an unstable patient is not easy, and if your patient is stable, consider



doing it **now**. This will help you in ten minutes when the SBP is 60mmHg. Use a small sheath (5Fr), and you will probably not cause damage if you do it correctly. We are assuming and encouraging you to get some training on this before doing it the first time. Don't go around and do things you are not trained in!

Over-the-wire technique, tips and tricks

To avoid iatrogenic vascular injury, you should advance your catheters using the “over the wire” technique. The catheter tip might be stiff enough to injure the vessel wall if you push it without a wire, so never use just a catheter without a wire. Grab the catheter end in your left hand and the guidewire tip is in your right hand, and insert it into the catheter.

Probably you are using your favorite catheter (or the one your boss has decided is your favorite catheter). Advance the wire with a constant stroke length and count the strokes. You will, with experience, get to know when to stop the wire just before the tip arrives at the catheter tip. The moment the guidewire tip enters the vessel lumen is crucial, especially if the vessel contains a plaque. The wire might penetrate the vessel intima, causing a dissection. You should stop the wire completely, take a deep breath, and then advance the wire slowly with maximum care under fluoroscopy vision. Once the wire tip is inside the true lumen, you will feel almost no resistance to advancing. After placing the wire in the target position, you should hold the guide wire end in your right hand and move the catheter further with your left hand (the catheter will follow the wire). If you don't grab the wire end, it might migrate upwards. An important basic tip is that you need to use at least twice the length of guidewire for the catheter when you exchange the catheter using the guidewire. If you use an 80cm catheter, guide wire length should be 180cm (not 150cm). Exchanging the catheter in the aorta is less stressful than in a selected artery, but the basic procedure is the same.

After embolization (discussed separately) in pelvic fracture patients, you will confirm remaining bleeding (such as from the lumbar artery, branch of external iliac artery) by pelvic angiography. You will need a pig-tail (angiography catheter).

Angiography – contrast injection issues

After cannulating the target artery, the first thing you should do is to confirm backflow of blood. Inject some milliliters of sterile water. Contrast media injection testing should be done softly. Stop injection if you feel extraordinary resistance or see any vessel flow, since you might be in a dissection. A power injector can make beautiful images through mechanical constantly powerful injection. However, it takes some minutes to connect and is not always available. Most of us believe that manual injection through a macro catheter can achieve good quality images. You can easily inject 8–10mL/1–2sec manually. Most micro catheters can only allow 1.5 to 2.5mL/sec due to their pressure limit. Think about the diameter of the catheter when injecting.

Pelvic fracture related embolization tips

A pelvic fracture is a good example since the procedure might be straight-forward. Remember that a significant number of pelvic injuries give venous bleeding and are more challenging to embolize if needed.

Tighten first the pelvis binder and reevaluate hemostasis. Venous bleeding is best treated with external pelvic banding, primarily, external fixation, or extra-peritoneal packing. Arterial embolization will contribute to reducing inflow into the pelvic region, and might reduce venous bleeding. **Before starting angiography, decide which vessel you are treating!** Most IR people will choose the contralateral side for femoral access. So, if it is bleeding on the left side, puncture the right CFA and get in with a 5Fr sheath. If you have a REBOA on that side, you can do a parallel puncture or use the ipsilateral side. In young people with a sharply angled aortic bifurcation, some of us would advocate ipsilateral access if possible. In some patients, you will need to do bilateral embolization. This depends on your local routines.

What catheter to use? Find a favorite one that you can work with. Cobra, Shepherd, there are plenty. Do a pelvic angiography to map the aortic bifurcation! Inject 10mL contrast using RAO 20–40 degrees just to identify the Internal Iliac Artery (IIA) and its branches (the C arm angulated to the patient's right side). The oblique view will show the bifurcation. Thus, this is both a diagnostic angiography and a mapping of the iliac bifurcation. Then, you direct the guidewire into the IIA. Embolization can start there or more selectively. This is starting to be a part of a more advanced methodology, and we will not go into detail here.



Some more words on embolization agents in the pelvis

The choice of embolization material is determined by the injury pattern and your own experience. In a proximal major vessel injury like in the IIA main branches, stent-graft deployment isn't an option, but a vascular plug in combination with coils might be helpful. Plug embolization gives rapid bleeding control but also has some risk of distal ischemia for the plug. If it is 1st or 2nd branches to the IIA that are injured, both coils and bigger gelfoam particles can be used as well as liquid polymer agents. Gelfoam particles (2–4mm) are easy to prepare quickly and have a temporary embolic effect. Inject the gelatin sponge slowly and non-selectively (from your catheter in the proximal IIA). In hemodynamically unstable pelvic-fracture patients we advise that you do not try to do super-selective embolization! The large gelatin sponge won't go distal and migrate the fastest way, downstream. Gelatin sponge and contrast saline can be injected alternately. Embolize until the gelatin sponge fills up to the catheter. Then pull back the catheter to CIA, aspirate if needed and inject contrast as post-embolization study. If you cannot aspirate the gelatin sponge out of catheter lumen after embolization, you may remove the catheter and flush it outside the body. But remember that you might need to get back there and continue, and re-entering the same place takes time! Coils require intense packing to have an instant effect and are easier to identify while you are performing the embolization (you can see them on the x-ray). However, they might not work as well due to coagulopathy. In peripheral and diffuse bleedings, a gelfoam-saline-contrast mixture (see recipe below) can be injected non-selectively. A non-reversible alternative is a liquid polymer embolization agent like Onyx or NBCA that works regardless of coagulation status. Onyx might be very useful as it will go downstream and block the “back door” of the bleeding from feeding arteries.

The anterior pelvic portion has collateral flow from the contralateral side, so here injuries MIGHT require bilateral embolization. If you have bilateral access and prefer a contralateral approach, you can go to right IIA from left sheath and vice-versa, a so-called “symmetrical procedure”. If you have only one sheath, you will need to access ipsilateral IIA from your femoral access.

At the end of the procedure perform a distal aortogram. Your aim is to identify remaining extravasation. In unstable pelvic fracture patients, one might consider bilateral non-selective gelatin sponge embolization as a rescue procedure. Some centres are doing this routinely.

Your pitfalls in the pelvis:

- » You can't get a vascular access.
- » It takes time to cross over and get into the IIA.
- » An unstable catheter in place.
- » You cannot identify the bleeding focus.
- » Coiling does not stop the bleeding and time is running out.

Renal embolization issues

In most cases a femoral access is the easiest way, but you can take the brachial or axillary artery approach (It's trickier. You need experience here). Start the procedure by doing a high dose, high flow (15ml/s, 20-30ml) aortogram with angiography catheters in the Th12-L1 area. Here, you look for the main renal arteries. Catheterize the renal artery with a selective catheter (something with a hook or 90-degree angulation usually works). When you are inside, perform a hand-injected series and seek for extravasation. Placing a macro-catheter in the renal artery and use of coiling is the fastest way to stop the bleeding in, for example, transections of the main artery. Vascular plugging is an alternative. A better choice is a selective or super-selective branch embolization if possible. It might be wise to have a guiding sheath (6-7Fr) in the renal artery hilum and work with a macro catheter (4-5Fr) and micro-catheters in the branches. This will give you the opportunity to do contrast angiography control and be more selective with micro coils or embolization liquid. If you encounter renal vascular pedicle injury, renal artery stent can be an option. These methods are not a beginner's maneuvers!

Pitfalls:

- » You can't get access to the arteries, or have unstable catheters so you can't enter the arteries. Consider another approach/access.
- » Wire perforation of the kidney/vessels. Consider embolisation.
- » Unintentional complete embolization of a kidney, with its consequences. No easy solution.



Splenic embolization

With a selective catheter, you catheterize the coeliac trunk and often end up in the hepatic artery. Here, a stable catheter position might be a bit tricky to achieve. Consider using a guide catheter or sheath at the celiac artery (6-7Fr). Do an angiogram and continue to the splenic artery. You will need to change the C-arm position to see the celiac artery going anteriorly. Decide if the bleeding requires a proximal embolization (vascular plug or coils) or a peripheral selective embolization using a micro system. Even if you decide to put your devices proximally, the spleen will have collateral blood supply (from the proximal splenic artery, but beyond the dorsal pancreatic artery), but you will probably lower the perfusion pressure and make the patient stable. Liquid embolization agents might also be used here. Embolization here might take time. There are no magic tricks and you need experience (or a friendly experienced colleague to take over). Balloon occlusion of the splenic artery is another effective temporary solution for splenic injury.

Pitfalls:

- » Failure to enter the celiac artery and stay there. Consider another approach/access.
- » High flow in the artery with migration of the coils. Change coils. Another approach.
- » Re-bleeding due to collaterals or “back-door” bleeding. Change approach. Liquid embolisation?

Hepatic issues

Catheterize the celiac artery with a hooked catheter. Again, this position can be unstable so you might need a guide catheter sheath. Hand inject 10ml contrast and try to understand the anatomy and find the source of bleeding. Use multiple projections. Then, use a macro catheter and a hydrophilic 0.035 inch wire and advance as close as possible to the bleeding area (blush). Might be beneficial to use a micro catheter. In the liver, it is particularly important to close the back door of the bleeding. It depends on the situation, but it might be enough to decrease perfusion pressure by proximal bleeding vessel coils. Gelatin sponge can go into the systemic circulatory system through AV shunting, and may result in iatrogenic pulmonary embolism. **Embolize as selectively as possible!**



Figure 1.



Figure 2.

Figure 1-2: Arterial phase followed by venous (late) phase CTA. Note the extravasation. CTA at both the early and late phases can give lots of information.

Pitfalls might be:

- » An unstable catheter.
- » Wire perforation and more damage.
- » You can't find the bleeding vessel/area. Change approach.
- » Unintentional pulmonary migration of the embolic agent due to AV shunting. No easy solution.

Some take home messages:

- Get some training in basic techniques before you do any endo procedure.
- Get more training and help from your colleagues, and don't play around with unstable patients!
- Know the material and how to use it.
- Think before using it!

Good luck!