



Chapter 2

The bleeding patient and your tool kit What and how to use?

Practical tips and tricks

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You just had a call from emergency services. Motor vehicle accident, patient seems in deep shock and is on his way in. Estimated time of arrival is 10 minutes. It is late in the evening, weekend.

How to prepare even in the Emergency Room?

Ok, the first thing is to take a deep breath. Evaluate the situation and consider who you need. If your institute has clear routines, activate them. If not, which resources are available, who is in the team, and who will be the team leader. Act upon that.

Arterial access

As we have mentioned earlier, the first active step in EVT_M is to insert a common femoral arterial sheath. You might have already used a small diameter (4 or 5Fr) CFA sheath in the ER. You have more catheter choices via a larger sheath of 5-7Fr, and therefore recommend a **5Fr short sheath** and a J-tip guide wire as the start kit. There are many types of wires, but try to get something you can work with, not too stiff and not too soft. Standard (e.g., Cook Medical), Schneider wire or Bentson wire might do. Check with your colleagues in radiology or vascular surgery, they can guide you. You will need



Figure 1.1



Figure 1.2

Figure 1 1-2: Introducer kit, Puncture needle (by Cook Medical and Cordis, with permission). There are many products on the market and these photos illustrate how a kit might look like.

to set up a kit for access and a kit for REBOA (as we mentioned before). Some of the sheath kits include a short wire and this can be also used for access. The most common sheaths are short (7-11cm), which might affect usage of REBOA later on, but, for vascular access, they are great and will minimize the risk of iliac dissection. You can choose to have bilateral accesses and place a second sheath on the contralateral side, for angiography while the REBOA is in the ipsilateral sheath. Also, bilateral pelvic embolization can be performed with a shorter procedure time.

So, a short 5Fr sheath is your first access tool after a successful puncture. However, with growing experience, we recommend starting with a larger 7Fr sheath when REBOA is considered a must. Some of us use a 7Fr sheath on any patient showing a hemodynamic instability or a major trauma mechanism. Remember, it is an early move so it is **safer to deploy a small sheath** (4Fr/5Fr) if you do not know if it will be used or not. Some of us use a 4Fr sheath that is used only for blood pressure measurements when not upgraded (arterial line). Femoral access **before a circulatory collapse** gives you a safe entry for REBOA. The majority of us though would start with 5-7Fr, as mentioned above. This is because you can use more tools (as embolization catheters) with 5Fr, and the potential risk of the size difference is minimal. Note though, that the authors here are experienced in endo/REBOA methods.

**Tips:**

- » Get a kit with all you might need, mark it and have it available.
- » Get to know what you have and how to use it.
- » Staff working with you should also know its content, where it is stored and how to use it.
- » Maybe you should do some team training in the ER...

Oops, you punctured the vein? Slow dark blood flow without pulsation? Use the puncture as a venous access. Do not remove it; get a 5-7Fr sheath in instead. Just use it for fluids (blood) as you may use the internal jugular or subclavian (axillary) veins for access. Your 5-7Fr access is a massive transfusion tool, and you can always upgrade it to > 9Fr, getting an even higher caliber massive transfusion tool. Just get the sheath in and go on to the artery (you don't want to stand with hand compression on the vein now when you are needed for other things). We should mention again that during CPR (or when there is no flow in the CFA), there will be no pulsatile flow, and the color of the blood can be darker, which may be misleading. Anyway, if you have it in, keep it in, and decide what to do with it later on.

Tips:

- » Don't remove your sheath until the panic is over. Do it in a "safe" place (ICU/OR).
- » In the femoral vein, use a bigger sheath. The risk of bleeding after removal is relatively low and it is a massive transfusion access.
- » Reconsider if there is a potential ipsilateral iliac vein injury before using vascular access on the injured side

General on upgrading to a REBOA sheath

If your calculated risk decision is that it is time to use REBOA, you will need to prepare for it. It depends, of course on where you are (pre-hospital, ER, hybrid suite, surgical suite) and time is your limit. Upsizing from 5Fr to an appropriate (7-14Fr) sheath should be performed over a **stiffer guide wire**, as the larger sheath will be easier to insert and the REBOA balloon requires the stiffness to be located safely. So, either you do a puncture with a 5Fr sheath and upgrade to an appropriate sheath that depends on your REBOA, or if you have already a low profile REBOA (Rescue Balloon or ER-REBOA), you can puncture directly with a 7Fr and use it for REBOA.



Figure 2



Figure 3.1



Figure 3.2



Figure 4

Figure 2: Mobile vascular access/REBOA trolley in the surgical department, Örebro, Sweden. Used in any iatrogenic or gynecological bleeding in the OR, or in rAAA for vascular access and aortic balloon. Should include all basic tools for percutaneous and open surgical cut-down vascular access.

Figure 3 1-2: The entrance to the surgical suites in Örebro, Sweden. Note the three angiography tables ready for use. Surgical suite with hybrid capabilities (right). You can build a very simple hybrid room with just a few “accessories”. We call it “Semi-hybrid suite”.

Tips:

- » Get early femoral arterial access with a 5Fr sheath and upgrade **if** needed.
- » Remember, REBOA is **just a bridging tool** and will not replace definitive treatment! Don't delay the treatment if you cannot get access; change strategy and move on.

So, it depends on where you are and this affects the choice of the “tools” for access and REBOA. In the ER you have to build this kit while in the hybrid suite it is there (among other products, so you need to be able to find it fast!). You might want to fix a mobile trolley in the hybrid suite, so you can take it to other places if needed (i.e., iatrogenic injury in the orthopedic surgical suit or post-partum bleeding). The different REBOA products are discussed elsewhere.

Tips:

- » Decide if you want one REBOA kit with everything and then build one. Some of us have two kits: one for vascular access, and one for REBOA.

Figure 4: Trauma patient (penetrating abdominal injury) in the surgical suite. The C-arm ready to use **if** needed. The patient is placed (always) on a sliding or angiography table. The C-arm, when not in use, is “on” and stays at the side with its monitors, ready-to-use.



Ultrasound and/or CT

Are you familiar with ultrasound? You will use ultrasound (US) in the FAST exam, of course. If you prefer to access the CFA by an US-guided puncture, the vascular probe (linear) gives you a clear image. The US or FAST machine should be “on” and the linear probe available. We will discuss the US puncture in other sections, but it can be used for vascular access, REBOA or wire arterial lumen confirmation and much more.

Experiencing difficulty in getting your access? This is rarely a problem in experienced US guided hands, but if it happens, do not hesitate to do a cut-down. Remember to have your equipment ready. An open vascular access kit with surgical knife, scissors, retractor and pincett should be at hand. All this basic stuff should be in your “Access Kit” and you should know how to use it!

You have to consider whether to do a CT and how fast you need it. It would be wise to inform the CT staff that you need them (depends on your institute). Some of us inform them about every major trauma and get a CT scan available directly, but in other places it can take some time. Today, with modern imaging, scan time itself is short (up to one minute for a whole-body scan). The time-consuming matter is the transfer of the patient to and from the CT. These patients require many tubes, monitoring lines and people around them. Before and after scanning, how long does it take to fix and move these lines? Make sure that you know what to do with all the lines and monitors, and use a transfer bed, if possible with place for the equipment. Some of us will not use FAST but can get a very fast CTA (even in the emergency department, door-to-door), where you can get much more information on the patient’s status and exclude, for example, cerebral bleedings. We cannot reach a consensus here. Practice what you think and what your institute allows.

Remark:

- » Remember that **time is running**, and you don’t want to be in the CT scanner when things happen, unless you have a hybrid suite in your trauma bay (a CT-on-rail hybrid solution). Remember: CT does not stop bleedings...
- » Even in the CT scanner, plan your moves, where to go, who you need, etc. Always have a Plan B.

Training of transfers can be advocated as this might reduce errors and time of transfer. The CT protocol itself should be a fast one. You can use different



Figure 5.1



Figure 5.2



Figure 5.3



Figure 5.4

protocols but you need both an arterial and a venous phase (with a 60 seconds' delay between the phases). Some of us use a "trauma CT protocol" or "massive bleeding protocol", with a head-to-knees one scan with contrast, and then, 60 seconds later, a new scan. A majority use highly concentrated contrast media with high volume (e.g., 370mg/ml Visipaque, 100–150ml total volume). Talk to the CT staff. They can adjust the protocol. The CT time today, with both phases, will be less than three minutes! But, you need to prepare the patient and transfer to the CT.

Tips:

- » **For fast CTA you need fast, safe transfer;** train on it and get all the things on the patient's bed that you can move quickly. Take good care of the catheters and tubes!
- » Get a good trauma CTA protocol (trauma CTA) and cooperate with the CTA staff. In major trauma, do not use an elective CTA protocol.
- » **Monitor your patient at ALL times during the transfer and procedure.**

And a word of caution:

- » You don't feel the patient should go through the CT, too unstable? Take him to the place you feel is best in your hospital and solve the problem! CT should be done only if you know what you are doing, on the proper patient and with a proper protocol!
- » What's the plan? where should we be after the CTA? prepare the next step now!

Figure 5 1-4: Transfer to CT. The logistics may be complicated. Good transfer kit/bed and training as well as good communication might solve many problems. The patient must be monitored during transfer and examination, which is challenging.



In the Angiography Suite/Hybrid OR

Guidewires, catheters and sheaths: As we mentioned above, a femoral sheath might be placed in the ER, but again, it depends on where you work and your settings! When you place the sheath in the angiography suite, you can see your wire using fluoroscopy. You might decide to use a long sheath in the angiography suite (>11 cm). A long sheath will make your catheter operation smoother, particularly in atherosclerotic and tortuous arteries/older patients. Your advance with longer sheaths in the vessels might save time in the long run due to fewer obstacles when exchanging wires and catheters. Some of us use a 7Fr sheath and then upgrade to longer and larger sheaths, depending on the situation. You should know that in young patients in hemodynamic shock, even small sheaths will block the flow (occupy the whole vessel lumen), and with longer sheaths it is the entire femoral and iliac length. Something to think about and bear in mind when you are there and when you want to take them out!

The choice of type of sheath is up to you: what do you have, what are your hospital routines, and what do you feel comfortable with?

Guidewires: Guide wires are fundamental tools in endovascular procedures. You should know that there are different lengths of wires. They are used to change the systems you are working with and to guide you to the target. For example, in REBOA, short wires are enough (about 150cm) but longer wires are necessary for exchange when working in the thorax region. Especially in tortuous and dilated aortas, a 45-60cm sheath (12-14Fr) in combination with a stiff guidewire (Lunderquist, Back-up Meier or Amplatzer, around 260-300cm) gives the necessary support for the occlusion balloon in REBOA. Tortuosity is less of a problem in young patients but is a major issue in older ones.

When using fluoroscopy to place the catheter in the target artery, angled nitinol hydrophilic guide wires (0.035inch) may be the standard for most people. When you want to navigate to a visceral organ, 150cm is long enough. If you expect to exchange the catheter over the wire, you need at least 180cm (depending on what you have and are going to use). However, longer guide wires, 260cm or longer, are inconvenient to handle. Some of us would recommend long wires at the start to prevent problems. Don't expect any clear consensus here. These things will come with experience!



Figure 6.1

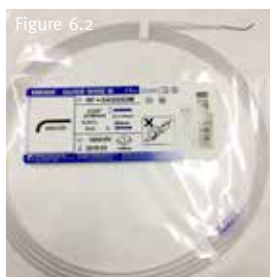


Figure 6.2



Figure 6.3

Figure 6 1-3: Example of some 0.035inch guidewires. There are many products with different characteristics and prices. Try to minimize the volume of products and work with instruments you know or have practiced with.

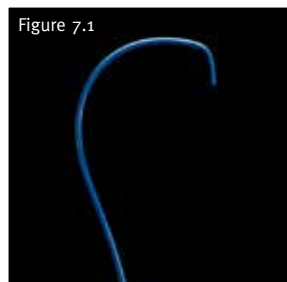


Figure 7.1

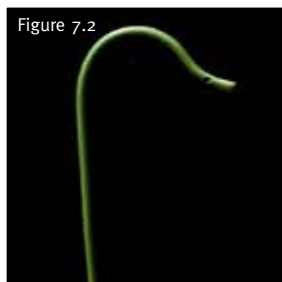


Figure 7.2



Figure 7.3

Figure 7 1-3: Cobra and Shepherd Hook catheter. You will find many products in the catalogues of different companies. These are just examples. Ask around for advice and do your selection. You can see here how they are exposed on shelves for easy selection.

Catheters

» Next, you have to decide on which angiographic catheter to use. There are many kinds. Expert opinions may be inconsistent about the best or preferred catheter. However, you should be familiar with three types (only a suggestion, there are many types!): Berenstein, Cobra, and a catheter with a reversed tip like Shepherd's Hook. Using one of these three types, you can exchange and cannulate most branches below the aortic arch. The important thing is that you need support from the opposite aortic wall when navigating into branches; thus, in elderly patients with larger aortas you need wider loops of the catheters.

In principle, the Cobra is useful for branches going upwards, cranial, from the aorta, and the Shepherd Hook is handy for branches heading downwards. Of course, there are many other catheters: Headhunter, Michaelson, Simmons, SOS Omni and VanSchie just to mention a few. Catheters work in different ways depending on variations in the aorta and their different forms.



Most likely you will change tools on your way to the target. A straight catheter (like Berenstein) will allow a smooth exchange (but, as said, you can use others). An angulated catheter (as Cobra and others), will allow your wire to get into the artery you aim for. There are some catheter sheaths that are long and provide support to embolization or other angiography procedures (all major companies has some of these products). You will get to know them if you train in a IR or vascular unite.

If you try to enter the branches of the aortic arch (carotid, internal mammillary, subclavian or axillary artery), constant perfusion to avoid thrombus in the catheter might be recommended, in principle. However, it consumes time and its use depends on whether your patient is life-threatening or not. Some of us do not use this method, and a majority just flush with saline in the sheaths. If you are not trained in angiography, just aim to get as fast and safely as possible into the target vessel and embolize it.

Tips:

- » We are getting into more advanced angiography methods and you should be aware of it. Train if you can. Call someone experienced if there's something you cannot do. **Don't play around with bleeding patients!** Probably, there are people around you who will do it very fast and safely!



Figure 7.4



Figure 7.5

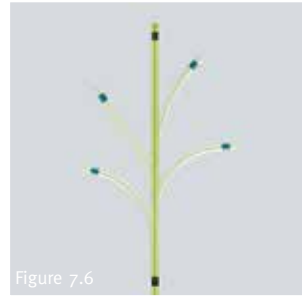


Figure 7.6



Figure 7.7

Figure 7.8

Figure 7 4-8: Some examples of catheters in different forms as well as sheath catheter (courtesy of Cook Medical).

List of some common catheters and wires that can be used in emergency situations:

- 5-7-10Fr sheaths
- Standard Cook or Bentson wire (Standard catheterization)
- Terumo 150cm (or longer) floppy angled wire (selective catheterization)
- Terumo stiff wire, Lunderquist or Amplatzer wire (support for ex occlusion balloons)
- Berenstein (short and long 45-110cm) catheter (selective catheterization and exchange)
- Cobra (selective catheterization)
- Shepherd Hook, reversed tip (selective catheterization, angulated take-offs)
- kink resistant sheaths for catheter support (6-9Fr) 45-90cm
- Sheaths for REBOA support 45-60cm 12-14Fr (depends on your REBOA catheter)

Microcatheters: If you need to go further, more peripheral, micro catheters and micro guide wires will be needed. Various companies offer you many kinds of microsystems. Difficult to say which is the best in which situation. But if you plan to use coils, you have to consider an appropriate combination. If you want to select a small diameter vessel (particularly in GI bleeding or peripheral liver), you should use a “selective” type (2.7 or 2.8Fr) of microcatheter. In general, a microcatheter system is put into a 0.035 catheter that has been placed in the desired main branch from which the more distal bleeding branch can be reached. There are some new smaller catheters on the market and your choice depends on your experience. We will not get into details here as these are advanced methods that should be used by experienced people in our opinion.

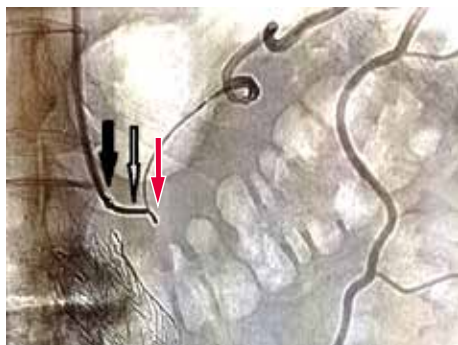


Figure 8: Sheath (black arrow), macro-catheter (black and white arrow), and, inside, a micro-catheter (red arrow) used in an elective case of embolization.



Embolization – what can be used and where?

Your catheter is in the target vessel. You check by contrast injection (fluid a bit diluted, 70/30) that you are near the target. Which embolic material do you use? You have many options. In a trauma setting you must consider “time”, “coagulopathy”, “difficulty of the material”, “your skill”, “catheter position” and “bleeding point”. You also have to know – what do you have? What is best for this patient? **What can you do?** As a general principle there is a balance between more proximal and “safe” embolization (plugs, coils), which lowers perfusion pressure in the bleeding area, and a more effective but risky distal embolization when using smaller particles. These might cause ischemic damage in the target area. Embolization in general may cause target organ ischemia and it is better to do super selective embolization if possible. We will discuss different products and possibilities. Their usage depends on experiences and availability as well as the situation.

Gelatin sponge particle: Gelatin sponge (GS) is probably the most common embolic material in embolization globally. Particularly in trauma patients, you can prepare and embolize quickly and it is cheap. GS is a kind of temporary embolic agent. It is easier and quicker to place than coils, and it is easier to control than liquid embolization agents such as NBCA or Onyx. GS is appropriate for pelvic fractures and liver injury (without AV shunt). Some example are Gelfoam, 20×60×7mm and Spongel 2.5cm×5cm×1cm. GS is “solved” in a contrast-saline mix of about 50/50. The volume depends on the amount of GS used.

There are two types of GS preparation: Cutting method and pumping method. With the cutting method, you can make GS fragments in any size you want but it takes time, up to around 5 minutes. Usually you slice the GS cube into 2 or 3 layers, and then cut into 0.5mm to 2mm squares. Using too small a particle size will require more GS injection volume, and the small particles migrate more distally, and might induce excessive ischemia like gluteal necrosis. With the pumping method, you can perform the task in a much shorter time, within a minute or so. 5-time pumped is used for a 4 or 5Fr catheter, and 20-time pumped is used for a microcatheter (one reciprocation is counted as two pumps). Is there any advanced evidence for this pumping time? No. But if you fix your pumping time constantly, you will recognize the appropriate injection amount more easily.

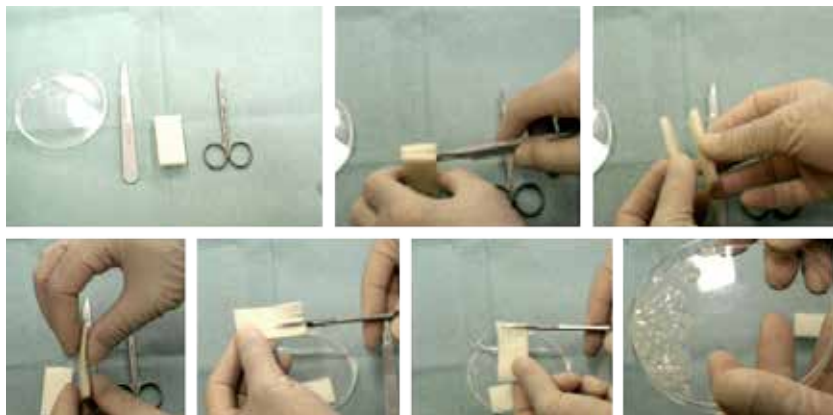


Figure 9: Gelatin sponge preparation for use in a cutting method. Slice the gelatin sponge into 2 or 3 layers, then press and flatten. Using scissors, cut it to target size (usually 0.5 to 2mm squared). Dip the GS fragment into a 50/50 mixture of saline and contrast agent.

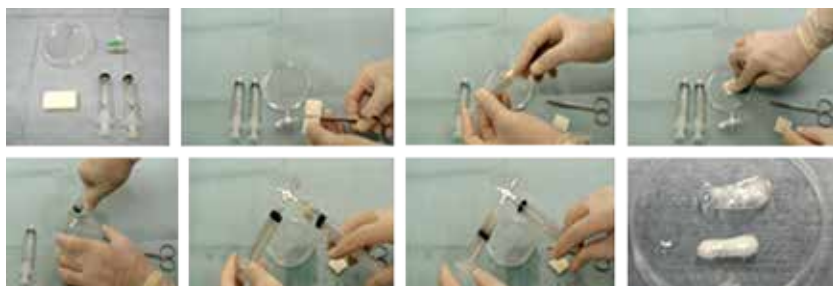


Figure 10: Gelatin sponge preparation for use in a pumping method. First, you need to cut the GS cube in half, then soak it in contrast and push it to remove the air (flip it over, and do that again) for about 20 seconds. The GS cube will become like “soft jelly”. Pull out the plunger from the 10 mL syringe with lock, and put the “jelly like” half GS cube into the syringe from the back side. Then fill up the syringe with contrast (or 50% diluted contrast) to up to 5mL. Using a three-way stop cock and a 5 or 10mL syringe, pump and crush the jelly into particles.

Remarks:

- » If some of the tips here feel too advanced, your feeling is probably correct. Some of these methods need advanced training and experience.



Coils: In general, coil embolization takes longer to perform than when liquid material is used. You will deploy the coil to make sure it forms tightly in the vessel. Coils do not work well in coagulopathy, but you can embolize in an accurate vessel position. The method is usually considered good for gastro-intestinal bleedings, isolation of pseudo-aneurysm, and pinpoint embolization. If the coils do not occlude flow, small amounts of GS or liquid agents can be added, combined with the coils. In life-threatening condition, you will need to choose the fastest and most effective embolic method. There are now available micro coils that are pushable, detachable, and many different types with different characteristics.

Tips:

- » Check what items are available within your institution and get to know how to use them.

New coils are constantly being designed and put on the market. Pushable coils have been standard, conventional and cheap. However, once you put the coil in the catheter, you can only push it forward. Even if your coil will not form tightly, or is not optimal (under or oversized for the vessel), or is placed in an undesired position, you cannot pull it back. A migrated or displaced coil can cause unwanted embolization and disaster. If you use a detachable coil, you can pull it back or remove it, and start over again. Selection of best coils size that fits target vessels is an art to be learned. Undersized coils lead to distal migration, and oversized coils will not form



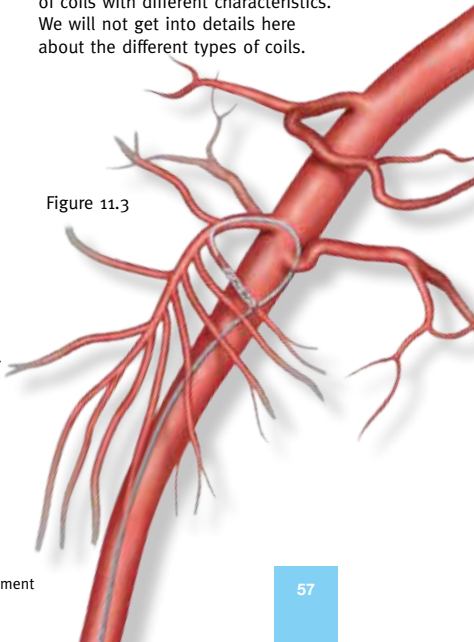
Figure 11.1



Figure 11.2

Figure 11 1-3: Coils (Courtesy of Cook Medical). There are many types of coils with different characteristics. We will not get into details here about the different types of coils.

Figure 11.3



tightly in the vessel. A tip for determining coil size lies in the “+3 rule”. You can measure vessel size in the DSA image calibrated with the catheter size (or in the CTA you did before). You may have a wide variety of sizes, i.e. diameters and lengths. Adding “3” to the vessel diameter gives the proper diameter. If the diameter of the splenic artery is 5.2mm, choose a 8mm diameter. Even if you do make the wrong choice, retractable coils will give you and the patient safety and security. Device development is rapid, so speak to your friends in the IR department. It’s all about collaboration.

Tips:

- » For selective and super selective coil embolization, use microcatheters. A coil-pusher is recommended.
- » You have to choose coils of an appropriate size not only for the catheter but also for the vessel to be treated! Look at the package to find out what size of catheter is needed (or ask someone who knows!). Choose coils that are somewhat bigger than the vessel.
- » If coil placement has to be accurate or the catheter is in an unstable position, use detachable coils.

Vascular plugs

A vascular plug consists of a tight nitinol mesh and its delivery mechanism is controllable. The plugs are suitable for large and high-flow arteries, like the splenic and the hypogastric arteries. In hemodynamically unstable, high grade splenic injury patients, proximal splenic embolization is acceptable. If you cannot use NBCA or Onyx for coagulopathic pelvic fracture, a plug might be helpful (practically, combined with GS). An Amplatzer vascular plug cannot be delivered through a micro catheter. If you fail to advance the catheter to the target region for any technical or anatomical reason, you cannot use it. Vascular plugs are delivered through a catheter or guiding catheter. The delivery sheath varies in size depending on the size of the plug. The effect of vascular plugs is, as with coils, dependent on whether the patient has coagulopathy. In a trauma setting, **you have to consider procedure time**. New micro-plugs (3-5-7mm, by Medtronic) can be delivered through micro catheters, and may be very useful as they can be inserted into smaller vessels and plug them fast and effectively.



NBCA + lipiodol

N-butyl-2-cyanoacrylate (NBCA) is a liquid and permanent embolic agent. This is the original “super glue”, approved for skin wounds and esophageal varices. Injected into the vessel mixed with lipiodol – lipid contrast – you can embolize even under coagulopathy since its embolization capacity is independent of coagulation status. You can extend the reactive time by increasing the lipiodol part of the mixture, then you will embolize more distally and slowly. So, in other words, this is a fluid to inject. It will go downstream and block the bleeding focus. This is a great tool for coagulopathic patients, and essential for damage control interventional radiology in some centers. However, it is difficult to control the embolized area and length. To visualize clearly, DSA images during fluoroscopy during injection helps to establish when to stop the injection. Your catheter tip might be dipped in the cast. An “NBCA package” will help you in urgent situations. The package would contain a 1mL locked syringe (for final injection), a 2.5mL locked syringe (for aspiration of NBCA first, and then for glucose injection), a 5mL locked syringe (for lipiodol and mixing), a 20mL locked syringe (for glucose), an 18 gauge needle (for glucose and lipiodol), a 3-way stopcock (for mixing and injection), and usually a syringe set for angioembolization (e.g., 10mL locked, 5mL locked, 2.5mL locked).

Figure 12.1

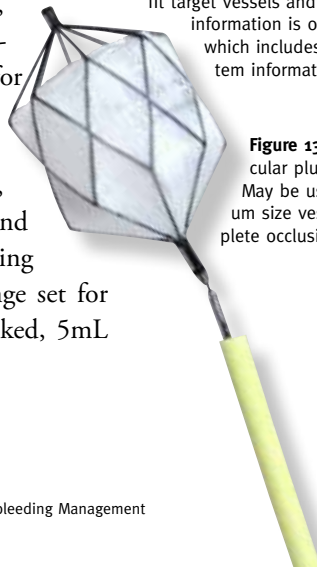


Figure 12.2



Figure 12 1-2: An Amplatzer Vascular plug. There are different sizes to fit target vessels and sheaths. This information is on the package, which includes delivery system information (size).

Figure 13: A micro-vascular plug (Medtronic). May be useful for medium size vessels for complete occlusion.



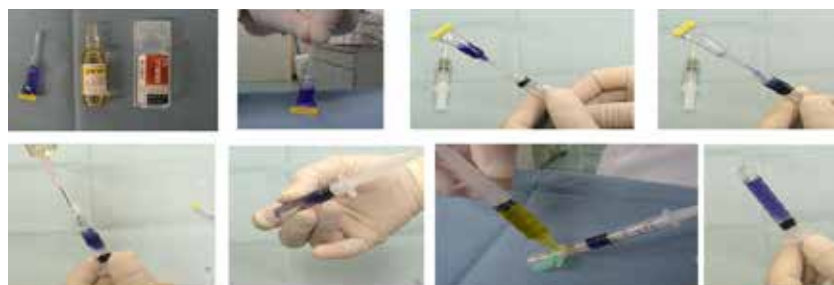


Figure 14: N-butyl cyanoacrylate (NBCA) preparation. You need NBCA, lipiodol and 5% glucose. Cut off the plastic tip of the NBCA bottle, then put it into a locked 2.5mL syringe, and aspirate the blue glue (0.5mL NBCA). Lipiodol sets in the 20mL syringe, and inject the appropriate volume needed (If you want to make 1:4 NBCA/Lipiodol, you inject 2mL lipiodol). Mix it by inversion or pumping with 3-way stopcocks.

Tips:

- » Most of us would consider this is a rather more advanced product that you have to know well for safe usage, but if you know the product well, it is very effective.
- » Under coagulopathy or in most urgent situations, NBCA is a fast and reliable embolic agent. But NBCA is difficult to handle. Be aware of distal embolization and complications!
- » Onyx works as well in coagulopathic patients (see below).
- » Follow IFU!

Onyx

Onyx is a polymer that stiffens in contact with an ionic solution, i.e., blood. It contains tantalum to become visible during fluoroscopy. The substance is injected through macro or micro catheters (2.7–2.8Fr, e.g., Progreat, Terumo). The catheter **must be compatible** with Onyx (e.g., Bernstein catheter). To prevent Onyx polymer getting stiff in the catheter during injection (as should happen when in contact with liquid), the catheter lumen is filled with DMSO solution once the catheter has reached the target area. After the Onyx has been shaken for 20 minutes it is slowly (around 0.3 ml/min as a recommended rate) injected using a 1 ml syringe. As Onyx comes into contact with the blood, when it leaves the catheter tip, it will stiffen and thereby gradually fill and occlude the vessel lumen or pseudo aneurysm. It is important that the injection is done slowly; otherwise Onyx will go with the flow in fragments



to more distal vessels “downstream”. Onyx, like glue, occludes flow even if coagulopathic, but the drawback is that is time-consuming, compared with, for example, GS and coils in patients in severe hypovolemic shock. One advantage, however is that it gradually fills the vessel in a distal direction, so it might reach areas a few cm from the catheter tip that are not reached by the catheter itself.

Tips:

- » Check which catheters you have; are they compatible with Onyx?
- » Slow injection of DMSO in conscious patients is recommended but might cause spasm and pain.
- » Inject the onyx slowly when you are beyond the dead space of the catheter! It might migrate.
- » Always consider the risk of embolization when removing your catheter.
- » You can do control angiography via the macro catheter during the procedure (you will need a Y-connector)!
- » Liquid embolic agents are not easy to use and you should not use them if you are not very experienced with embolization.

PHIL

A new embolization liquid that can be injected directly after DMSO, which is similar in this regard to Onyx, but without preparation time. It is currently being evaluated for bleeding control, so it is hard to give more information at the moment.



Figure 15.2



Figure 15.1



Figure 15.3

Figure 15 1-3: Onyx embolization agent (courtesy of Medtronic). Onyx injected during elective procedure.

Balloon catheter and micro-balloon catheters

Balloon catheters might give you strong support in bleeding control. Of course, you can use an aortic balloon occlusion catheter (REBOA) in refractory hemorrhagic shock patients. But long occlusion at Zone 1 might impose a catastrophic metabolic burden: Excessive ischemia and subsequent ischemic-reperfusion injury. If you can identify the bleeding point, change to a more selective balloon catheter (or micro balloon catheter). It will be safer and more effective. In patients with a hemodynamically stable high grade splenic injury, proximal embolization with a vascular plug is standard in some centers. At times, you cannot get as distal as you want and, while considering what to use or to do, you might have other solutions. Temporary balloon occlusion of the splenic artery may be an option. This may allow you to do open surgical repair with balloon bleeding control. Combined with REBOA or a balloon catheter, intraoperative bleeding might be reduced if patient requires surgery. If your patient has an abdominal blunt injury and catastrophic hemodynamics, emergency laparotomy under hemorrhage control with REBOA will reduce the bleeding amount and transfusion, and you can keep the surgical field dry. You may meet a patient with a subclavian artery injury. If you are familiar with catheterization of the subclavian artery, proximal control by balloon catheter might be useful during surgical repair. However, care must



Figure 16 1-2: Iliac balloon for proximal control in a bleeding femoral artery. A PTA (Cordis 16mm) balloon was used and for this an 8Fr sheath was inserted from the Left side. The balloon was inflated just some atmosphere to get bleeding control and open surgery performed (hybrid concept).



be taken regarding potential cerebral ischemic effects due to the subclavian supply to vertebral arteries and the right carotid artery. Balloon catheters can also be used to occlude a vessel during injection of an embolization agent and decrease distal migration as well. These are advanced methods that we will not be able to discuss in this manual. We will discuss balloons in non-aortic locations in a separate chapter.

So, in this chapter we tried to cover the issues of what to use and how in a basic matter. We do not recommend to use any of these methods without proper training and suggest good cooperation with your IR or vascular colleagues. We should also mention here again that you should follow the IFU (Instructions for use). There are probably more tools to use, in different ways.

**Think before using endovascular and hybrid tools,
and be careful out there!**