



## Chapter 1

# It is all about the vascular access

*Yosuke Matsumura, Junichi Matsumoto, Lauri Handolin, Lars Lönn,  
Jonny Morrison, Joe DuBose and Tal Hörer*

Modern Advanced Trauma Life Support (ATLS) principles have revolutionized the treatment of trauma patients, providing a common protocol for treatment and diagnosis of the injured. ATLS principles (the ABCs of initial trauma care) emphasize early diagnosis and management of airway problems and major bleeding control, providing a protocolized approach that affords effective initial evaluation and treatment of a wide array of trauma victims. At present, however, ATLS does not provide guidance on the early utilization of evolving endovascular or hybrid management (EVTM) adjuncts to trauma care. For providers with appropriate skillsets and capabilities, EVTMM adjuncts can provide **additional tools** for the early care of the severely injured trauma patient.

As a modification of the traditional “ABCDE” mnemonic advocated in the ATLS protocol approach to initial trauma evaluation and treatment, an EVTMM enabled provider might consider using an “**AABCDE**” (airway **and simultaneous vascular access**, breathing, circulation etc.). Why might the use of the AABCDE-centered thought process prove useful? Very simply: this mnemonic may better represent actual modern trauma practice, including the establishment of vascular access in the peripheral or central veins for the early administration of fluids and medications. It is also important to consider that simultaneous vascular access in the early trauma setting also affords the medical team an opportunity to achieve IV access that may prove critical to patient survival – namely cannulation of the **common femoral artery (CFA)**.



Figure 1.



Figure 2.



Figure 3.



Figure 4.

**Figure 1-4:** Vascular arterial access in place with 5Fr sheath in trauma patients, on arrival as part of the EVT/M concept. Arterial femoral line seen in Figure 4.

While venous access is often critical in obtaining blood samples and facilitating life-saving blood product and medication administration, early arterial access may also provide crucial additional capability and should be routinely considered. Vascular arterial access enables the use of a variety of diagnostic and therapeutic adjuncts pertinent to trauma care – including **REBOA** (Resuscitative Endovascular Balloon Occlusion of the Aorta) and a variety of diagnostic and therapeutic capabilities. Continuous invasive central arterial blood pressure monitoring can significantly aid the assessment of hemodynamic stability, as can serial arterial blood gas chemistry. Arterial access can also permit formal angiography, affording precise and effective localization of the bleeding focus. In addition, arterial access can provide a platform from which to deploy a variety of hemorrhage control maneuvers, including REBOA, angioembolization and stent graft deployment. In extreme cases, arterial access can even be utilized for fluid administration (though this pathway is not as effective as venous administration). So, the femoral artery (and vein) can prove to be a critical pathway to your patient's cardiovascular system and subsequent patient salvage. Try to remember the last significant trauma case you helped care for – were the common femoral artery and vein accessed during the primary survey? It is likely the answer is no – and an opportunity to promote an improved outcome may have been missed.

**Tips:**

- » Consider early arterial (and venous) femoral access. Use it for blood sampling and blood pressure monitoring once gained. Avoid access on injured side if possible.

The common femoral artery is relatively easy to access, is commonly characterized by a uniform anatomical position, and is typically reasonably sized (around 6-9 mm but depends on hemodynamic status and age). This vessel is relatively easy to access in young patients, and when done correctly, access is a relatively low risk endeavor – the term “relative” is emphasized here. Every procedure performed at the initial phases of trauma is associated with some risk. These include bleeding, arterial dissection, and thrombus formation. However, when a patient presents in hemorrhagic shock, the risk-benefit ratio is firmly on the side of expeditious and direct intervention. Femoral access can provide a platform from which to tackle some of the most challenging injuries as we mentioned above.

The general relationships of the femoral vasculature are fairly consistent from individual to individual. The femoral vein lies medially to the artery and both are relatively easy to control by compression, provided they are healthy. We will discuss the anatomy and specific concerns of arterial access: not only how to establish access, but also how to utilize it, maintain it, and close the site safely when vascular access is no longer needed. While our discussion will be thorough, we encourage you to seek out additional anatomical details from any of the established textbooks or atlases on the topic as you see fit. With that said, let us start our discussion by thinking about how “vascular access” can be incorporated into the early care of the bleeding patient – be it bleeding from trauma or other non-traumatic etiologies (gastro-intestinal, iatrogenic, post-partum etc...)

**How to identify the femoral artery and access guidance techniques**

The first rule in establishing vascular access is to avoid puncture on the side of any significant lower extremity injury if possible. Access on the contra-lateral side is preferable, but if the injury involves both inguinal areas, there are other solutions that we will discuss later. You also must consider if there could be a vascular injury ABOVE the site you intend to puncture. If so, access may not only prove useless (for example, infusing fluids through a vein that is lacerated

just above the injury site) but may prove outright dangerous (advancing a wire from the femoral artery into a dissected proximal iliac artery or aorta, for example).

**Ultrasound (US) guided puncture:** This is a very useful tool for all kinds of things in medicine, but its Achilles heel is “inter-user variability” – not everyone is able to obtain the same quality images in the same patient. As a first step, you must understand how your department’s machine works – at minimum, how to engage a vascular setting, and how to set the depth (how far the scan will penetrate) and the gain (the greyness of the screen).

We would recommend that you go on a formal course or train with people who are familiar with ultrasound and FAST scanning. Doing it 10-15 times will give you basic (!) knowledge on how to recognize the structures and, most importantly, on whether you are following the procedure in a safe way. There is a learning curve, and we believe that this is highly dependent on your motivation and not your profession! (We know great cardiologists who can obtain vascular access faster than the blink of an eye...).

So, again, especially in emergency cases, when you have someone that can do it better or faster (or just an experienced colleague next to you), ask him or her to do it. Trauma bay patients are not training cases and you need a functional and safe access now. Again, do not let your ego rise, **do the right thing for your patient**, which may involve calling on your colleague.

**Advice:**

- » Start training in an elective setting before working up to the critical patient.

In terms of practical approach, we would recommend the following sequence:

1. Check the US probe orientation. Does the left side of the probe correlate with the left side of the screen?
2. Scan the groin in a transverse view, where the vein should be medial and compressible. The artery should be pulsing – but not always! Ideally, you should also be able to identify the division of the common femoral artery (CFA) into the superficial (SFA) and deep/profundal (PFA) branches. This is an important landmark!



3. Turn the probe into a longitudinal view and see if you can obtain an image that demonstrates the external iliac coming up out of the retroperitoneum, the CFA with the femoral head behind it, followed by the division of SFA and PFA. Your ideal puncture zone is in the CFA, over the femoral head. While this view sounds complicated, it is great practice to get into the habit of seeking out all these structures.
4. Having picked your puncture zone in the artery, make a skin incision below (not all of us do that in acute settings) and insert your needle using the technique described above. You can see the needle in either longitudinal or transverse probe view. The longitudinal view is good if you can get comfortable with it, but the transverse view is what most people use.
5. Once you get a flashback, put the probe down, but do not discard it. Advance the wire into the vessel – if it travels in easily, great, discard the probe. BUT, if it does not travel easily, put the probe back on the patient and have a look. If you can see the “J” tip of the wire is clearly in the lumen, then great, but chances are you are not intra-luminal. Not sure? Time to think again!



**Figure 5:** Ultrasound assisted puncture in a trauma patient.

#### Tips:

- » Get to know the ultrasound in the ER and make sure it's “on” in the trauma bay. It is a powerful tool when used for FAST but you can use it for arterial or venous vessel puncture.
- » The ultrasound should be on and ready 24/7, with a vascular probe at hand.
- » Make sure you use an “echogenic” needle – these are designed to stand out on the screen and make the procedure easier.
- » Train US guided puncture! It's a great tool. The more you train, the better you become.

## Access without imaging, or the “blind” puncture – how to do it

In the modern era, ultrasound guided access has emerged as the safest and most effective means for accessing the common femoral artery and vein – even in emergency situations. Ultrasound should always be considered an invaluable tool when attempting vascular access for trauma. If you have it available in a timely fashion, USE IT!! As mentioned, when using ultrasound to support access, the bifurcation of the SFA and deep femoral artery is typically easily visible, allowing identification of the CFA. This imaging modality may not be available when needed, however, for a variety of potential reasons. If ultrasound is not available, be aware of common placement pitfalls. Without ultrasound, a precise appreciation of anatomic relationships becomes paramount to successful venous and arterial access in the groin.

The inguinal ligament can typically be palpated and distinguished at the thigh upper border (although this may be more challenging in obese patients). You do not want to puncture too high, or above the ligament. You can palpate the iliac crest on the lateral side, and the pubic bone on the medial side, to identify the origin and insertion of the inguinal ligament in most patients. Punctures above this ligament might result in damage to both intra- or extra-peritoneal structures such as bowel injury or retroperitoneal hemorrhage. High punctures also complicate closure – making arterial repair challenging and time-consuming. We would suggest staying approximately **two fingers below** (distal to) the inguinal ligament with puncture attempts. As a reminder, the femoral vein will be located medial to the artery.

When attempting an arterial puncture, if you inadvertently access the vein, do not be discouraged; the placement of a 5-7Fr sheath in the vein may be of great benefit to your patient. This large vein access can prove very useful in the resuscitation of trauma patients. It is important to remember that communication and appropriate labeling of all placed sheaths is also important – **your team must know which sheath goes where.**

### Comment:

- » When we speak about the access “sheath”, it is synonymous with “introducer” – meaning a catheter with valve that is a working entrée tool to the vessel.



Another piece of useful advice – if you access “something”, but are not sure if it is successfully in the artery or vein, **leave the sheath in place** and try again with a new puncture. **You can remove the faulty access later**, after the chaos of the initial situation is resolved. If you take it out in the midst of trying to obtain emergent vascular access, the site might bleed and contribute to additional blood loss. Any attempt to hold pressure at this site in these situations takes hands away from tasks that might be useful at other locations – i.e. you cannot hold pressure and get vascular access at another site at the same time.

**Advice:**

- » Leave the sheath in place even if unsuccessful (it might bleed). Deal with it later in the ICU or in the OR.

A common “failure” in groin puncture is the puncture that is undertaken too low / distal – usually in the case of arterial access this results in a superficial femoral artery (SFA) puncture. The SFA might be palpable and you might think this is the CFA, but you should rely on the external landmark mentioned above, more than just palpation. Large-bore sheath placement in the SFA (a smaller-diameter vessel than the CFA) may be associated with a greater risk of leg ischemia, especially in a patient in profound shock. Got a functional access? Use it and worry about these details later, but don’t forget it.

When utilizing anatomic landmarks as the primary means for facilitating

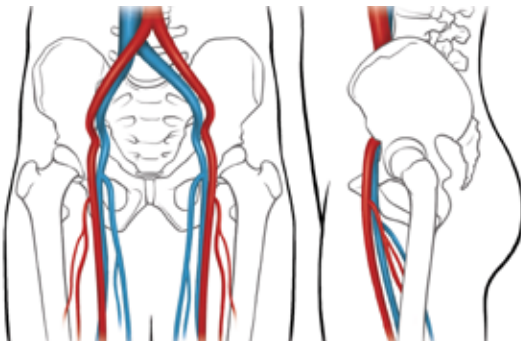


Figure 6.1



Figure 6.2

**Figure 6 1-2:** Anatomy of the inguinal region showing the vein and artery localization relative to the inguinal ligament, iliac crest and pubic bone. Your access site is about two cm distal to the inguinal ligament. 3D-reconstruction CTA. Notice the angulation of the iliac vessels as they dive into the retro-peritoneal space.



**Figure 7.1:** Palpation of the CFA on the left side of the patient (during elective endovascular surgery). Parallel puncture on patient's right side. Blind puncture and angiography assisted.



**Figure 7.2:** Landmarks for vascular access. Inguinal ligament (upper) and inguinal fold (lower) marked. In young and slim patients, this is obvious but less clear in obese or older patients.

#### Practical tip:

- » Use two fingers to palpate the pulse and arterial structure. Move in lateral-medial directions slowly (side to side) to catch the area of maximal pulse. Yes, test it on yourself!

vascular access in the groin, it is of vast importance to appreciate common pitfalls and how to avoid them. You may be too high, too low, outside, or too deep even when you are using only palpable arterial pulsation to guide placement – particularly if the patient is hypotensive and the pulse is difficult to palpate. A useful approach is to start puncture attempts at a point 1/3 of the way down the inguinal ligament from the pubic bone, approaching laterally to the vein (if the vein has been identified by access), 2 fingers from the pubic bone edge – the artery is typically at this location.

If the patient has an appreciable blood pressure, palpate and find the strongest pulse impulse. Keep in mind that, in older patients, pronounced calcification of the artery may make the vessel more easily palpable, but it also should raise suspicion of potential access challenges in the vessels (heavy calcifications). If your patient has acceptable blood pressure (e.g., > 80mmHg), you might feel the pulse, see the pulsation with your ultrasound, or hear the sounds on hand-Doppler. If your patient is skinny, you are lucky – it is much easier than in obese patients. Furthermore, be conscious of the longitudinal (cranio-caudal) anatomical direction and continuity of the artery to ensure that you stay luminal. Try to imagine the “3D course” of the artery as this will help you to “catch” the vessel.



## Puncture methods and blind puncture

There are several ways to get access to the femoral artery or vein, but in our view the safest method is an **ultrasound-guided single puncture technique**. The principle of access is to introduce your needle into the vessel, so-much-so that you obtain a “flash-back” of blood, whereupon you can advance a wire into the vessel lumen. The needle ideally should penetrate the vessel as close to the 12 o’clock position (i.e., most anteriorly) as possible. The wire is used to secure luminal access and to guide endovascular devices into position (sheaths, catheters, balloons etc.). This method is referred to as the “**Seldinger**” (or **over the wire**) technique, in deference to the interventional radiologist that to who described this method in the fifties.

The “flashback” of blood is important to observe as this tells you a lot about the vessel you have punctured, as well as the state of your patient. A flashback of cherry red pulsatile blood is clearly arterial; however, that is rarely the whole story. In the setting of a bleeding patient, who is hypotensive, the pulse may be weak and the blood may be dark or non-pulsatile. It is important to hold your nerve in such circumstances and to proceed with obtaining access in the vessel you have punctured. If you have punctured a vein – then use it for IV access (both sampling and resuscitation) – your team will thank-you. A venous puncture is usually dark and continuously flowing.

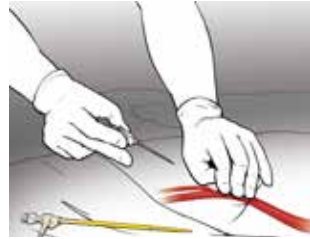


Figure 8.1



Figure 8.2

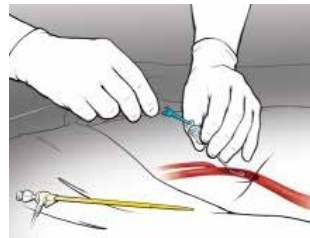


Figure 8.3



Figure 8.4

**Figure 8 1-4:** Main steps in the Seldinger (over the wire) method. You can also find some videos and other material on the [www.jevtm.com](http://www.jevtm.com) or other sites. The Seldinger method described in the text below.

**Remark:**

- » Yes, it's bleeding from the needle and you lose some drops until you get the wire in. This is negligible now and usually not more than some 10-20ml blood. So do not get stressed now, continue and get the wire in! As long as blood is flushed out, you are in the lumen.

In trauma, the majority of clinicians would use a big needle (18G) with a reasonable sized wire (0.035"), but you could consider a micro-puncture set. This generally consists of a 21G needle, followed by a narrow 0.014" wire. In the bleeding patient, some experienced providers would encourage the use of the larger needle (18G), as it provides a more brisk and re-assuring flashback of blood – making it more likely that you have performed a “good” puncture and will secure access easily. The use of a micro-puncture set can be challenging as the flashback is often less brisk. We can't get a consensus on that yet, but at least for REBOA it seems that the big needle wins.

**Tips:**

- » Make sure your needle is clean and washed with sterile water after every puncture or change needle! Make **slow movements** when you puncture. and once there is a flow of blood, try not to move the needle and get the wire in. You don't have flow suddenly? You are not in or against the vessel wall. Manipulate the needle **slowly and carefully** to restore flow. Not sure? Go to plan B (the other side? ask for help?)

## In terms of the puncture, there are two main methods described

**Single wall puncture:** This is probably the most intuitive technique, where the needle is introduced at around 40-45 degrees to the vessel. Remember that due to this angle, the skin puncture and vessel puncture are not at the same location! That is why we recommend staying 2 cm distal to the inguinal ligament. Once you see the flashback, lower the hub of the needle somewhat to bring it near parallel to the vessel and advance **a couple of millimeters** (different ways to do it. Some of us do not move the needle when there is good flow). Keep the needle stable, confirm a constant flashback of blood, and advance your guide wire into the vessel. Yes, it is bleeding through the needle, but this is a negligible volume of blood and you must be sure that you are in the vessel! The risk of this technique is that, if the needle has not cleanly penetrated the anterior vessel wall, when advancing the guidewire, it can trav-



el into the media of the artery, dissecting the arterial wall. This can create a major ischemic problem, especially if you follow the wire with a sheath. The “quality” of the flashback is key to avoiding this; if it is clearly strong, then the risk of dissection is likely minimal...perhaps easier said than done in a hypotensive trauma patient.

#### Tips:

- » Try puncture on different training models (plastic, simulator or whatever). It will give you an idea how it feels when you are in with the needle and how the wire feels when advancing!
- » **Never force you wire in.** it should glide in and if it does not, you are not in the luman.

**Double wall puncture:** This is a slightly less controlled method of arterial access – when the flashback is observed, deliberately advance the needle until the blood flow stops. Then reduce your needle angle (as described above) and withdraw slowly. If you are using a small syringe with the needle, pull back on the plunger of the syringe to apply slight negative pressure. After getting a flashback again, advance the guide wire. The needle is more stable in the vessel with this approach, so it may prove a more useful when employed for access of small or collapsed vessels. Although passage of the wire through the artery is a concern with this method – it rarely occurs when done correctly. More common perhaps is the risk of posterior hematoma made from the posterior puncture hole – which can result in retroperitoneal hematoma.



Figure 9.1



Figure 9.2



Figure 9.3

**Figure 9 1-3:** Puncture in an elective endovascular case: Palpation and orientation. Needle 45 degrees in; when blood flow is stable, the guide wire is inserted, while the needle can be redirected to a more horizontal position.

More material and videos can be found on [www.jevtm.com](http://www.jevtm.com)

So, to summarize about blind puncture:

The idea is to locate the vessel with your fingers and puncture as mentioned above. Blind puncture is not optimal, but knowing how to do it might save you when the US is not available or in panic situations...

Some of us are using blind puncture as routine in acute situation, but we do recommend US if possible.

## Cut-Down

Arterial or venous cut-down – or open exposure of the vessels can be an approach of either first or last resort – Some providers use this procedure as the first resort in the critical trauma patient. If you think that a puncture will be difficult, it may be prudent to go straight to a cut-down. Do not try and do something that you think will have a low chance of success in a critical patient – get the odds on your side – cut down early is a good advice.

When conducting open cut-down it is important to remember **this is not elective groin surgery**; this is a dying patient. In a crisis, accept that there may be no time for optimal sterility or local anesthetics; however, if you can have a pre-prepared cut-down pack, which has everything, then all the better. Get a surgical knife, do a 5 cm longitudinal cut on the medial-central side under the inguinal ligament, and get down with the knife or Metzenbaum scissors, while palpating your way to the CFA. When you have dissected down onto the artery, it can typically be palpated and, ideally the anterior wall can be visualized for puncture. You do not need full proximal and distal control now; puncture the artery as described above, and get a wire into the lumen. A small self-retaining surgical retractor often helps with the exposure.

### Remark:

- » Let us add a word of caution – this might be a stressful situation and you should avoid doing any further damage! You don't want to have a new arterial bleeding or dissection now!

## X-Ray guided puncture

Another described technique that may prove useful to know involves the use of portable x-ray (static images) or fluoroscopy (dynamic images) to help guide the puncture; however, such support is rarely available quickly in acute



Figure 10.1



Figure 10.2



Figure 10.3



Figure 10.4



Figure 10.5



Figure 10.6



Figure 10.7

**Figure 10 1-7:** Cut-down arterial access on a cadaver model from left to right. Dissection by landmark and palpation, exposure of the anterior vessel wall. Puncture by Seldinger method, wire and sheath. The puncture done here is percutaneous but can be done directly in the anterior vessel wall.



Figure 10.9



Figure 10.10



Figure 10.11



Figure 10.12



Figure 10.13



Figure 10.14



Figure 10.15

**Figure 10 9-15:** Cut down REBOA in a trauma case. Seldinger technique used. From left to right puncture, wire, sheath in place. Last photo shows suturing of the artery to remove the sheath.



Figure 11.1



Figure 11.2

**Figure 11 1-2:** Cut down vascular access on an obese patient for RE-BOA. Access might be (and was) very challenging in this patient.

#### Advice:

- » Sometimes, you will need to take the wire out and start again or do a new puncture. This is a minor failure. If you need to perform a fresh puncture, take your time. Compress your previous site, and freshen up your needle by flushing and cleaning the needle before attempting puncture again.

situations. X-ray imaging is used to locate the femoral head (caput), where the **artery will be on the medial side**, mid-caput – that is your puncture site! X-ray imaging can be used as an adjunct to support both percutaneous and open access and has the advantage of allowing the procedures that follow to be conducted with x-ray guidance. It is mainly used in the angiography or surgical suite but can be used in the ER in select settings.

#### Comment:

- » When using x-ray guidance in an emergency situation, do not forget radiation safety. The ER (or OR) often has a lot of people coming and going, and not all will have lead ware on. Use any ionizing radiation sparingly and communicate with your team before you “press-the-button” to ensure that all precautions have been followed. In some centres, we all wear protection gear when entering the surgical suite with trauma cases.

### Ok, you are in? What to do and what to use now?

Once you have obtained needle access to the vessel, **do not move the needle** and get the wire into the needle and vessel! Keep your left hand on the patient's body to maintain a secure and stable needle position. The choice of wire is important as they all have risks and benefits. A safe wire is a short 0.035” “Starter-J” wire, which is introduced straightened; the “J” tip re-forms in the vessel, presenting a benign profile when advanced. A more advanced option is a Bentson, which has a straight, floppy tip,



**Figure 12:** Sheath “half way in” over a wire – be careful not to push it without the inner part (dilatator); you might cause vessel damage or dissection.

but has a greater risk of side branch cannulation – ideally, this wire would be observed with x-ray guidance. **Advance the wire slowly and stop if there is any resistance.** You must “feel” the wire, as sometimes you may not see it, if you do not have fluoroscopy. Before the wire gets into the needle, you might change the needle angulation to be more parallel to the vessel, and continue checking for resistance. If things do not feel right, use available imaging adjuncts, such as x-ray or US, to help you.

Once your wire is in at least 20cm, it is time to take the needle out and position the sheath. **Ensure that the sheath diameter is big enough to accommodate what you are planning on doing** – a 4 or 5Fr sheath will permit most diagnostic maneuvers, but a larger size is needed for stents and balloons (>6 or 7Fr). Remember to check that the sheath has been prepared properly before insertion – in an acute setting, it is best to do it yourself! Generally, a sheath comes with a dilatator and both components need to be flushed with sterile saline before inserting the introducer into the sheath. Make sure the introducer “clicks” into the hub of the sheath – you do not want the introducer to be pushed out of the sheath as you advance it into the patient.

You should not use long sheaths (25-30cm) without confirming by fluoroscopy or ultrasound (due to risk of dissecting the aorta), so use the short



ones (11cm usually). Guide wires that have advanced smoothly may not be positioned in the iliac or aorta – there is always the risk of an aberrant side branch cannulation. A short sheath should permit safe access into the common femoral and external iliac, but not beyond. Short sheaths are the safest choice in blind cannulation in the ER. Once your sheath is inserted, this is your entry to the vessel – take good care of it!

So, now you have a 5Fr (or 7Fr) sheath in place – great, you have a vascular access. Do not forget to flush it with sterile saline and now you can use it (upgrade for the REBOA or fluids, or just connect to the blood pressure module for monitoring). Take a skin stapler or do a 3.0 skin suture – just **make sure it stays in place!** Do not forget to secure the sheath with a suture, staples or a viscous tape at least before moving to another department (CT/angiography suite/OR) or connecting to an arterial line. This is crucial as iatrogenic withdrawal might cause severe bleeding that you cannot afford now! Do not forget to **inform your colleagues** about the access – which sheath goes where if there are multiple devices. If the sheath is not to be used in the coming hours, keep it in connected to the arterial blood pressure set, or flush it with around 10-20 drops/min (or just a slow flush) saline to prevent thrombus formation.

Here comes a table that shows what you might need for simple femoral artery or vein access. You should have multiple sets in place since you might need both arterial and venous lines and both for possible failure. The costs



Figure 13.1

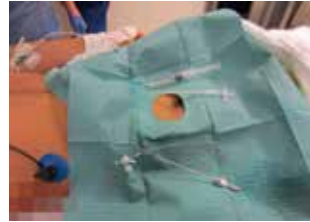


Figure 13.2



Figure 13.3



Figure 13.4

**Figure 13 1-4:** Preparation and sheaths in place (5Fr) in trauma patients and acute bleeding patient before laparotomy.



**Figure 14:** Puncture set and REBOA kit (ER in Örebro, Sweden). This is only an example how you can have it, but build it to be functional in your hospital.



Figure 15.1

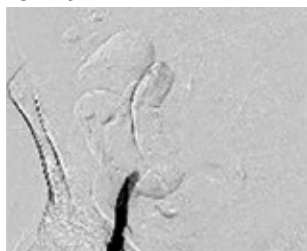


Figure 15.2

**Figure 15 1-2:** Access through a dissection on prior puncture. A Bolia catheter was used to verify the placement (upper foto) and change to a new sheath. The dissection (contrast) seen even later as it stays in the vessel wall after C-arm angiography.

are not dramatic and every intervention department/vascular department can help you pick them to be available in the trauma bay. We recommend having an **“ACCESS kit”** and with it, separately, a **“REBOA kit”**.

### Your vascular ACCESS kit (should be marked as one)

- Local anesthetics (Carbocaine) and 2x10ml syringe/needles
- Puncture needle (18G or another that can take the wire)
- Standard wire (i.e. Cook) or Bentson wire (0.035inch)
- 4-5-7-10 (and 12) Fr sheaths (i.e. Cordis or Cook) (>12Fr for certain REBOAs)
- Sterile water and 10-20ml syringe
- Skin stapler, 3.0 skin suture and skin tape
- Simple drape (with hole preferred)
- Contrast material and some extra 10ml syringe
- REBOA kit (different companies available, with different sizes of sheaths)

### Tips:

- » Build your own kit based on what you have or your experience. Keep it fresh and available at all times. You and the team must know what is in it and how to use it!

## Troubleshooting Access

You think you are in with the wire, but you are not certain? Take a small catheter (such as a Bolia catheter, which is a small, 4Fr short catheter, easy to use) and push it in over the wire to verify that blood is coming out, or



that contrast is seen on angiography if available. Then push in a 0.035 wire when you know you are in the lumen and to upgrade. Get it up, take out this small catheter and position a sheath. Any resistance should raise suspicion of malposition. This small catheter will usually not do major damage to the vessel, even if dissected, but be careful. If there is a problem, try a new puncture, use the ultrasound, or ask for help from a colleague who has just arrived. Don't waste time! You need this access now. Your colleagues are busy intubating and getting brachial venous access. The patient needs you now, so take a deep breath, a new needle, and get the work done! You might even leave a failed introducer in place for now. You can take it out later. If you have taken out the needle, compress with your hand or ask someone else to do that, and change your strategy.

### **What about the timing of the vascular access?**

If you feel your patient is hemodynamically unstable, now is the time for vascular access. Even if the patient has no obvious ongoing bleeding, consider femoral access, EVTm has a lot to offer your patient. Especially if he deteriorates later on.

Some decisions can be made even before patient arrival, judging from mechanism of injury, vital signs, and evaluation by paramedics as reported before arrival. If your patient has good vital signs, getting access might be easy. However, some hemorrhagic shock patients are compensated at the early phase. Your patient seems “stable” looking at blood pressure, but might have ongoing bleeding and collapse within the next few minutes! As we said before, an arterial sheath is useful for various reasons, such as arterial invasive pressure monitoring, access for IR or REBOA, and, of course, you can take a blood sample. Don't hesitate to get early access. Do it while the patient is being intubated or during primary survey by the ATLS (anyway, nobody is working on the inguinal area at this time point).

If you judge that your patient not an “easy access case”, you can ask your colleague to support you on the other side and place bilateral sheaths. If your patient has a pelvic fracture and embolization is required, bilateral access will reduce your procedure time. If the patient needs REBOA, arterial pressure monitoring from a counter side sheath is helpful to assess distal perfusion during partial occlusion (pREBOA). It will be difficult to position another



**Figure 16:** REBOA in place under T-pod pelvic binder. The patient has also a femoral 5Fr sheath on the left side.



**Figure 17:** Manual compression and Femo-Stop (St. Jude Medical). Most of us will use it up to 8Fr sheath size but it has been used even with ECHMO 18-20Fr sheaths. **Be careful** and think before using it- do I trust this to work in my patient?

arterial sheath after REBOA insertion. You will no longer feel an arterial pulse at the patient's groin. Therefore, if you consider using REBOA, try bilateral accesses at both groins simultaneously. You can stabilize your patients by REBOA and embolize for pelvic fracture from a contralateral side introducer. If using a T-pod or any other pelvic stabilizing instrument, make sure you puncture site can be seen. Lift the T-pod a bit and make room. Let everyone know that you have a sheath there.

### How and when to remove the sheath?

Well, the easiest answer would be: when the patient is hemodynamically stable, with a normal coagulation profile and needs no more interventions. The problem is that you never know. It might be a venous bleeding, or something else missed on CT like intermittent bleeding. We have seen stable patients with no ongoing extravasation of CT that had later major bleedings! A small-size sheath (5-7Fr) can be placed overnight (sometimes for several days, but we do not recommend such an approach). Large size sheaths (10-12-14Fr) **should be removed as soon as possible** after essential procedures to avoid ischemia and thrombus complications. But, in patients who are unstable, you can leave the sheath in place if you make sure you flush it as mentioned previously. Assessment of the peripheral circulation should be done hourly (!) and before you remove the sheath, aspirate blood. If you see a clot on aspiration, think thrombus and potential embolization. In this setting, it is



best to go on with open femoral artery exploration and embolectomy if needed.

**Word of caution:**

- » A sheath is a source of emboli/thrombus as long as it is there...

When you remove the sheath, you can use one of several different methods: external compression (by hand or device), closure device, fascia suture, or direct surgical repair.

**External Compression:** This is appropriate up to a 7Fr (some say 8Fr) sheath size, and can be accomplished manually or via a device. However, if the patients become coagulopathic, there is a risk of re-bleeding. Make sure that your staff examine the puncture site at least every hour (yes, we repeat that!) and **don't cover the puncture site in the first hour** (if possible). You don't want to lose your patient due to femoral bleeding when you have just saved him. Mechanical devices are available, such as the Fem-Stop, but only use these if you are very familiar with them.

**Closure Device:** Various devices are available, such as the Perclose, Starclose, Exoseal, Angioseal or others. All of these devices require formal training and cannot be just picked up and used. If you are familiar with the deployment of such devices, then excellent – but do not give your first patient a high-risk puncture! See IFU of each device to know what sheath size they can manage!



**Figure 18:** Fascia closure. A small skin incision done, the subcutaneous fat retracted and the fascia palpated. One gliding suture is used. The details about the method are published elsewhere. This method can and have been used in the OR or ICU. Works in trained hands but should be considered if to be used before applying it.

**Fascial Suture:** This is a practical method (formally described in the literature), and it is a useful skill to have. It can be done in the ICU in selected patients and can be used also for downsizing sheaths (e.g., from 12Fr to 5Fr). The idea is to open the skin and feel the femoral fascia. Then place a suture around the sheath with a gliding knot. **This requires training** and we will not describe it here in details. Excellent method in selected situations.

**Direct Suture Repair:** This is a gold standard; although it requires an OR and a vascular surgeon. Formally dissect and control the vessel and place interrupted 5/0 prolene sutures in the arteriotomy. The advantage of this approach is that you can assess the back bleeding and perform an embolectomy if required. You can also do control angiography and get some additional information.

So, again, “if there is doubt, no doubt”- **Do a full cut-down and check the vessel flow.** Use a Doppler at the end to be sure you have good flow. Not sure? Angiography and embolectomy might be indicated. Use open surgery and do not avoid it!



**Figure 19:** 5Fr sheath in a trauma patient (left to right). Thrombus and ischemia after REBOA later on with 11Fr sheath. The patient was hypovolemic and you can see the size differences: Left and middle photos first CT during hypovolemic shock, on the right side, the vessels at their normal size, on CTA after resuscitation.

## Upsizing your sheath

If you decide to place a large endovascular device, such as a REBOA catheter, you will likely need a larger sized femoral sheath. Sheaths between 7-12Fr are used in clinical practice and depend on available REBOA catheter size.

**Tip:**

- » Remember that the sheath can take a certain diameter of catheter or REBOA. If you want to use it for flushing or angiography, you will need a bigger sheath in diameter than the REBOA catheter. It is not always so bad to have a bigger sheath that you can flush. When you really need it, the size of the sheath matters!

Before upsizing, fill up the sheath's lumen with saline, put the dilator in the new large introducer. Insert the guide wire to the aorta and **DO NOT LOSE THE WIRE POSITION!** The guidewire should be at least twice the length of the introducer in order to swap the smaller sheath for the larger access device using an over-the-wire exchange technique. Usually you already have one in the introducer kit. Insert the guide wire to the aorta, then the dilator and introducer. When using the dilator, you will feel resistance against soft tissue, but this is ok – do not rush! You don't want to deviate from the correct way. To avoid kinking the dilator and guidewire, grab the dilator 2-3cm above the skin. Twist the dilator, and keep moving the guide wire to and from. Don't push the dilatator or introducer blindly. Moving the guidewire smoothly means the dilator will follow the guidewire appropriately. Gently pushing the dilator in a stepwise fashion will also help you (some of us call it the “Parkinson maneuver”).

**As a word of caution, watch out for hydrophilic coated guidewires**, as they can easily migrate without your knowledge during these maneuvers. Your partner should grab the guide wire so as not to change its tip position. Unfortunately, you must perform all the procedure by yourself, to make sure the wire will not be removed when you withdraw the dilator. This is the most dangerous point. Unexpected removal of the guide wire will induce hemorrhagic disaster.

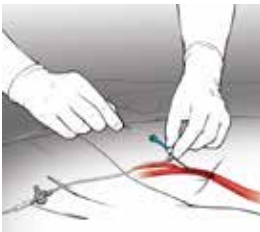


Figure 20.1

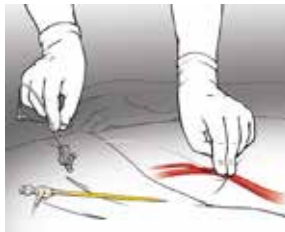


Figure 20.2

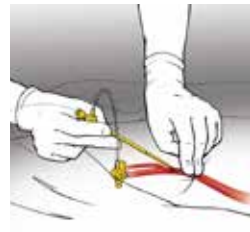


Figure 20.3

**Figure 20 1-3:** Upsizing your sheath. You change your sheath over a wire.

## Maintaining a vascular access

You really do not want a clot in the sheath or around the catheter. After insertion, flush with saline. If you use this sheath for angiography or embolization, periodic flushing will help you avoid any clot in the sheath. We might be repeating here, but it is for a reason – been here, done that! Cloth formation might be a problem.

The situation becomes more complex when you have no flow in the vessel and a large sheath. This is the case during REBOA, where your sheath might occupy the entire lumen in the CFA lumen – such an arrangement is at high risk for clot formation and ischemia of the leg. Slow and continuous saline flushing by pressure bag might help prevent the thrombus. Local heparin might be useful but is problematic in trauma/bleeding patients due to general coagulopathy, and we cannot yet get a consensus on that, so make your own choice. We can say that you should remove the large-bore sheath as soon as possible. Again, if you don't want to remove it, take care of it as your best friend. It might save you that night, but when the next day comes, it might bring you some problems. So, again take care of it!

There are some advanced methods to downsize the sheath with the help of fascia suture. You can use this method to maintain a vascular access with a 5 or 7Fr sheath but it is doubtful if it has a place in trauma management. Take it out when you don't need it anymore.

## Other vascular accesses (veins, brachial, axillary)

As we mentioned, CFA access is essential for severe trauma patients. But at times your catheter will be placed in the femoral vein, unexpectedly. Don't remove it! Femoral vein access gives a good route for resuscitation fluid. Always remove some blood for lab work if you can, just take a 10ml syringe and aspirate. However, if your patients have severe pelvic fracture, assume common iliac vein injuries. Femoral vein access will not work well, but in selected cases might be used for endo repair as well as being your highway to the vena cava and liver (via portal vein) or even a vena cava filter later on. In general, though, femoral vein access is safe and can be removed with manual compression, even with very large sheaths (some of us do manual compression on 18-20Fr venous sheaths).

The subclavian vein can be used as a good venous access without removing



neck color. Of course, you must assume the risk of iatrogenic pneumothorax. The axillary vein can be accessed by ultrasound puncture. We will not deal so much with these access possibilities, since they are widely used and you can read about them elsewhere.

On the arterial side, the brachial artery is an option. There are cases of REBOA performed via brachial or axillary access, but the majority of the modern endovascular surgeons dealing with trauma prefer the CFA. Why? Well, the brachial artery is easy to expose (not so easy to puncture, as it is small, around 3-4mm). The problem is that you have to manipulate it across the subclavian artery into the aortic arch and then downstream to the descending aorta. For this, in general, you need fluoroscopy and it is time-consuming to place the REBOA using this route as well as problematic in unstable patient requiring airway attention. Dealing with the arch might be challenging and there is a risk of emboli going up the carotid. You will find some more information and illustrations in other places in this manual.

All methods have merits and demerits, and you should use the method you are comfortable with. Initially train on models, progressing to elective arterial punctures, before you throw yourself into the ring with a bleeding and hypotensive patient. Access, as part of the EVTm concept is vital – do what you do best and if a colleague next to you can do it better or faster, let him or her do that. This is no time to play around, you can do it next time!

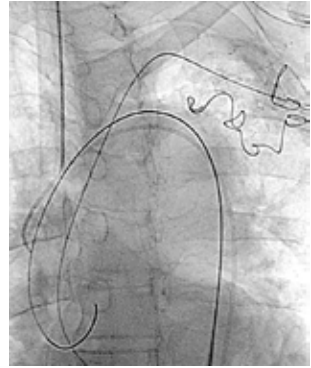


**Figure 21:** The aortic arch with wires from the femoral artery and brachial artery. Observe the tracheal tube and the anatomical complexity. An elective TEVAR case.

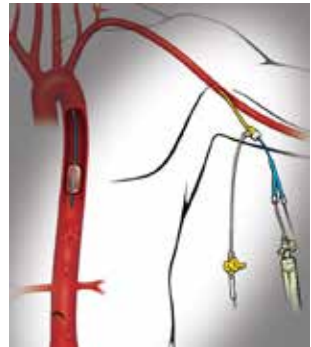


**Figure 22:** REBOA with axillary access. Most of us do not recommend this approach in trauma, but at times it might be useful.

When some of us teach REBOA or discuss these issues, we recommend as a first step to do femoral A-lines or small sheaths in some patients (elective cases or trauma cases when clinically indicated). Succeeding with femoral artery and vein placement of sheaths will make it much easier for you to place a REBOA when needed. There has been a tremendous amount of publicity regarding REBOA these days but remember: **“It’s not the REBOA, it’s all about the vascular access”!**

**Some summarizing tips:**

- » Get your access early; Some of us think that every major trauma patient should get it during the primary survey as AABCDE!
- » Get a femoral vein access as well if possible and time allows it.
- » Take care of the access – suture or hold. Communicate about it. You have a powerful tool in your hand.
- » **Think before using it** – what do I need. What’s best for the patient NOW?
- » Don’t forget the risks – embolization, bleeding, dissection etc.