



Chapter 7

Balloon occlusion and EVT/MT at Non-Aortic locations

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REBOA has become a hot term in endovascular trauma applications. Some leading experts, however, have advocated utilization of the simple term “Arterial Balloon Occlusion” (ABO). While a less specific acronym, ABO appropriately reflects the potential of endovascular balloon occlusion to be utilized to control haemorrhagic sources at a variety of anatomic locations – not just at the level of the aorta. To be fair, even ABO is perhaps not a general enough term, since balloon occlusion can also be effectively employed in larger venous structures – such as the vena cava – to facilitate control of bleeding. We are aware of a liver traumatic-bleeding case treated by REBOA and simultaneously a vena cava balloon occlusion (survivor). Regardless of the vascular location at which they are employed, the basic benefits of employing balloon occlusion using endovascular means is straight-forward: Balloon occlusion affords proximal (and/or distal) flow control until a definitive solution can be provided. In some cases, the other end of the “bridge” will be open repair, in other situations

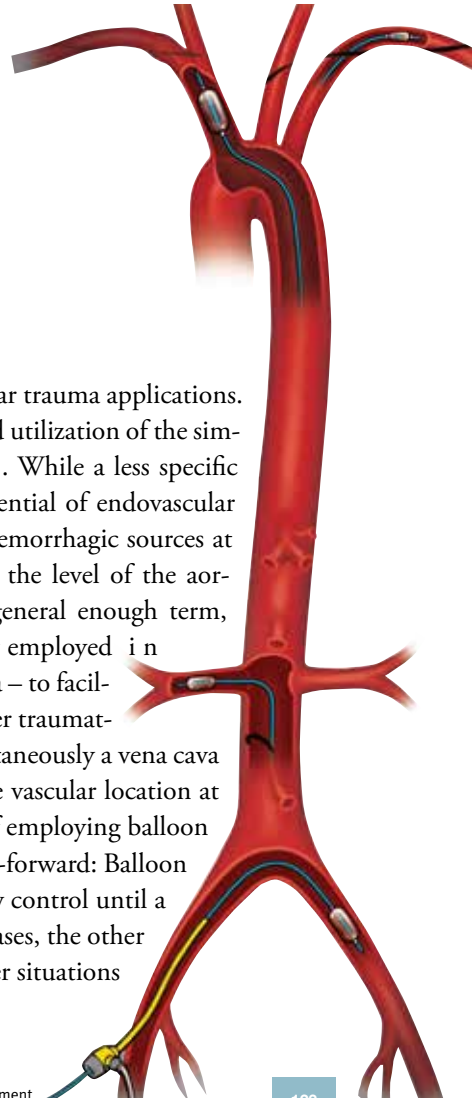




Figure 1: Neck penetrating injury
Zone I



Figure 2.1



Figure 2.2

Figure 2 1-2: CTA imaging with reconstruction demonstrating a right subclavian injury resulting in occlusion. Open or/and endo methods can be used to solve the problem. If extravasation, balloon proximal occlusion might help.

it might prove to be endovascular stentgraft deployment. In selected cases, it might allow more limited tissue exploration, and exposure as well.

Remarks:

- » Balloon occlusion, in any vessel, is only a **temporary solution**. Once occlusive control is achieved (and all other haemorrhagic sources are addressed) – take a deep breath – let anaesthesia catch up with resuscitation as needed, and develop a sound plan for definitive treatment of the injury.
- » Always think of possible organ ischemia when using ABO.

Here is a case to illustrate the potential utility of balloon occlusion at non-aortic locations: A young man arrives at the emergency room with a penetrating wound in the right side of the lower neck just above the clavicle (Zone I neck injury). He is conscious and alert. A medic has been holding a hand over the wound, but when the hand is removed, no ongoing bleeding from the wound is noted. The situation could certainly be worse – right? You may well have treated patients with torrential bleeding from wounds at this location before – definitely a more challenging situation. This stability of this particular patient, thankfully allows us to proceed deliberately in our evaluation. What was the mechanism (knife, gunshot)? Are there other wounds or injuries? Given that he is stable, some imaging is probably appropriate – but what kind?

Advanced Trauma Life Support (ATLS)



principles are paramount here. ABCs are effective principles for a reason – they work. Address airway, breathing and hemorrhage control just as you should for any trauma patient. As you get through your primary and secondary survey with no other findings – make sure you incorporate a focused ultrasound sonography for trauma (FAST) and plain radiography (in this particular case, a chest X-ray). All indications in these evaluation in this particular patient were negative, except for a possibly diminished radial pulse on the right. Obviously, you must communicate with your anesthesiologist during this process while considering when to intubate the patient and how to proceed.

What now? A computed tomographic angiographic (CTA) exam, or a CT with protocolized angiographic contrast, is a very appropriate choice here. A CTA answers a lot of questions with high fidelity and will exclude also pneumothorax/hemothorax. The CT should be done with IV contrast, at **both the artery and late (vein) phases**, to improve detection of injuries to both arterial and venous structures. See the figures here that illustratedifferent injuries patterns. CTA imaging here allows you not only to identify the injury and exclude active hemorrhage (no extravasation), but also to afford measurement of the proximal artery for determination of optimal balloon and/or stent graft sizing. Don't forget to include both the entire neck and the chest in the scanned field, particularly for gunshot wounds. Just because the wound is located in



Figure 3: BCT (Brachio-cephalic-trunk) injury with extravasation. PTA balloon in place before open exploration. Balloon control can be accomplished via either femoral artery access or brachial/axillary artery access. The aortic arch is marked.



Figure 4.1



Figure 4.2

Figure 4 1-2: Multitrauma CT with occlusion of the right subclavian artery. This imaging demonstrated occlusion and no active extravasation. Open arterial reconstruction was performed. Endovascular recanalization can also be performed in selected patients. There was no need for balloon occlusion in this case.

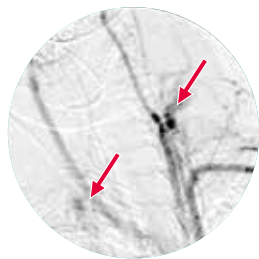


Figure 5: Knife left carotid injury Zone II injury patient's right side. Note extravasation from the BCT (right) as the knife penetrated the neck down towards the chest. Balloon occlusion and open exploration might be useful here!

Zone 1 of the neck, does not exclude injury to an important structure higher or lower than this internally.

It is key here to remember that sending the patient to the CT scanner requires appropriate caution. Always consider what you will do if the patient suddenly decompensates. It may be a better course of action in such instances to abort the scan and proceed to the OR. This depends also on whether you have a CT in the ER (even in the trauma bay/CT on rails) or it is somewhere else in the darkness

of the radiology department. If you plan for the worst mentally, and develop what your response to a decompensation will be, you will be prepared. Verbally communicate this plan to the entire team – so that they are on the same page and are alert to the concerns that you have. As mentioned, there are now some new “CT on rails” that can be used in the trauma bay, which might make it easier to do the scan.

Word of advice:

- » Plan the CT examination: Do you have all you need? Is it safe to proceed with CT?
- » Always have a “plan B”.

Back to the basics and the EVTm concept; if you are concerned the patient may decompensate or may potentially benefit from the use of endovascular trauma adjuncts (balloons, angiography, stent grafts, etc.), consider rapid placement of a femoral arterial line prior to movement to the scanner or OR. Arterial access is far easier to accomplish in a patient who is stable, and can prove exceptionally challenging after they decompensate. Even small caliber access (a standard femoral arterial monitoring line, around 4Fr) is easier to upsize rapidly than to establish de novo access when a patient decompensates. Follow the principles outlined in the access chapter of this text.

So, for the particular patient discussed above, let us say that a BCT injury is identified on CTA. The patient is still quite stable – normal blood pressure, normal heart rate, no breathing difficulties, alert and oriented. What to do now?



This injury clearly requires repair – and does remain potentially life threatening. It will need some form of definitive surgical repair, either endovascular or open. At this stage, it would be wise to activate the proper resources. Notify the operating room staff – and let them know that endovascular capabilities (C-arm, hybrid suite) should be included in their preparation for urgent operation. Prepare a radiolucent table (angiography or sliding table if possible). Would additional technical expertise prove useful? Now is the time to muster the providers with the right skillsets to be of use at your specific facility (interventional radiologist, vascular surgeon, cardiovascular surgeon). This is highly dependent on where you are and your assets. Get every aspect of care moving expeditiously but smoothly towards getting the patient to definitive care.

What are the repair options for this BCT injury patient? From an open perspective, a midline extended sternotomy would probably be the gold standard exposure for repair, but opening the chest near a vessel with active extravasation (near the aortic arch) is likely to invite torrential bleeding. It might be manageable with your great surgical hands and experienced anesthesiologists, but you will probably need massive transfusions and more. Endovascular stent graft coverage may be an option, but that would require traversing the region with a wire, which may disrupt any semblance of clot formation near the vessel or even worsen the arterial injury itself while trying to cross the injury. Regardless of open or endovascular repair selection, proximal control before getting too far would be ideal in lowering the risk of significant bleeding or death. It sounds like a balloon occlusion option would, indeed, be useful to accomplish this objective.

Remark:

- » As you noticed, we used the word “option” – **it’s a tool to consider**. Think before making any decision and do not hesitate to use the best tools you have.
- » Balloons are only a bridge to definitive treatment.

In the particular BCT injury case demonstrated here, common femoral artery access provides passage of a wire into the aortic arch. The wire can then be carefully directed across the area of injury – using a variety of different guide catheters or long sheaths as needed (in this particular case, time of vascular

access to wire in place took around 1 minute). Once you have a wire across the injury, it is a simple matter of selecting the correct balloon shaft length and balloon diameter to cover the arterial injury (remember the CTA we got – you already know the balloon size needed if you took some seconds to measure arterial diameter just proximal to the arterial injury. If you do not have prior imaging to delineate the size of the vessel, you must rely on known estimated diameters of the vessel being occluded. “Phone a friend” if need be – many experience endovascular providers commonly have a reasonable starting range for each particular vessel in their head from past experience. Remember that this access route is used for carotid stent grafts in elective surgery.

In the case of the brachiocephalic artery, the normal diameter is around 8-12mm in men, and somewhat smaller in woman (age dependent!). That gives you diameter, what about length of the balloon? Use shorter as a start – remember initially you may only need proximal occlusion, not a balloon that extends the whole length of the injury. A longer balloon (40-60mm) may be nice to have, but is harder to fit in the space needed – which may not be clear on the basis of pre-operative imaging (if you even have it).

What about the type of balloon to utilize? Compliant or non-compliant? Which manufacturer? Does it need a special coating? In the context of trauma and emergent hemorrhage control, keep it simple. Use a percutaneous transluminal angioplasty (PTA) balloon of the most common variety on your shelf that fits the dimensions you need. You might be able to use any other elastic balloon, but there is limited experience with that. No need for anything fancy – just something that works. Don't get bogged down in the vast number of options available.

Word of caution:

- » Aggressive oversizing or over-inflation of the balloon might cause further injuries to the vessel. **Inflation and deflation should be done slowly**, and using tactile sensation. Try to “feel” the arterial wall resistance as the balloon inflates to touch the arterial walls – stop at the very first sensation of any resistance. You don't need to get more than 4-6mmHg to get most of the balloons inflated to fill the artery lumen.
- » Consider using manual hand-syringe inflation and not using an inflation device (Manometer) if you are not experienced with that. Manual inflation will allow you to “feel” the resistance of the artery. Use always Stop-Cock/Luer-Lock.



Back to our BCT injury patient, introduction of a balloon into the brachiocephalic origin afforded safe control of a major arterial injury and facilitated open repair. You are likely to have encountered a patient where such an approach may also have been useful. If not, the fact that you are reading this text suggests that it might cross your mind in the future. It is not hard to consider that the basic principles of balloon occlusion can be afforded at a wide variety of locations in the vasculature – it is a key tool to have in the potential “trauma tool kit” of any capable provider. Remember – while the balloon does buy you time and provides an opportunity to take a breath and allow resuscitation to “catch up” as needed – don’t spend too much time patting yourself on the back. You should be moving expeditiously to plan the next step. What other injuries might need to be addressed before repair of the injured vessel? Are there other bleeding sources that need to be stopped? What type of repair are you going to select? Open or endovascular? Other chapters in this text will help you with some of the thought processes that might define the applicability of endovascular definitive repair options – but for the purpose of moving forward after balloon occlusion of any vessel – you need to do so purposefully.

Also important to consider here is that any occlusion results in downstream ischemia. At some locations, where collateral flow is redundant and robust, this may not be a big issue. At others, for example the carotid arteries or a variety of visceral end arteries (renal, hepatic, mesenteric), **once occlusion is initiated a desperate race against the clock to restore perfusion has been started.** Get flow back to anatomical norms as quickly as possible if that is the ultimate plan. Often forgotten in this context are the effects of a long balloon on side branches. For instance, in the brachiocephalic artery coverage patient described in our example, the balloon covering the BCT injury may also cover the right carotid artery (or at least impede flow in this vessel). This will probably be tolerated well by the majority of patients with otherwise normal cerebrovascular collaterals and may be a “necessary evil” in an emergent setting, but should be considered when moving quickly to restore normal flow patterns and avoid potential ischemic stroke.

The described example is of a brachiocephalic artery injury, but can the same principles be employed for injuries at other locations? Absolutely!!! The figures below demonstrate effective utilization of balloon occlusion principles



Figure 6: Iliac bleeding with contrast extravasation in two cases.



Figure 7: Sheath and wire in place to facilitate artery treatment. REBOA has been used in Aortic Zone 3 (the aortic bifurcation) to facilitate control of hemorrhage. Note the large contrast blush on angiography consistent with a significant bleeding source. Non-trauma case.

following an iliac artery injury. Here there is vast experience from endovascular surgery but more limited experience in trauma.

Similar principles can be utilized to approach injuries to peripheral arteries, visceral arteries, or even significant solid organ injury. These may be of particular utility at locations that represent significant challenges for open exposure or open control. If you can cross an arterial injury or place a wire in a proximal feeder artery, then you can place an occlusive balloon to facilitate control. You must understand though, that catheter or wire access to visceral organs might **take some time** and this has to be taken into account when planning the overall management.

It is important to note (again) here that endovascular tools are just that – tools.

Don't forget and use your surgical approach as needed and don't rely on "just endo methods".

As with any tool, you have to use the device that makes sense. Why take the time to walk next door to ask your neighbour if you can borrow their power tools when you have a good old fashioned screwdriver that will do the same job with two turns of a hand and is sitting within arms reach? In the same way, be smart about endovascular utilization. Sometimes open surgery is both more expedient and smarter. Endovascular approaches can take more time and resources to utilize. Conversely, however, endovascular tools often give an elegant solution in situations when time permits and open alternatives are more chal-



lenging. One example would be patients with previous multiple laparotomies, and just doing open hemorrhagic control is usually very time-consuming as well as very demanding. You get the point. You can see some elegant solutions in the figures below. So, proximal balloon occlusion is generally a very useful tool to have at your disposal for the management of vascular injury. It is not the perfect tool for every instance, but can certainly make a tremendous difference in specific patients. We will further discuss more possibilities in other chapters in this manual.



Figure 8.1



Figure 8.3

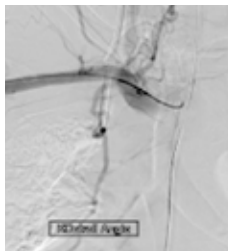


Figure 8.2

Figure 8 1-3: PTA balloon utilization and stentgraft repair of the left subclavian in an extreme obese patient (non trauma). Note the wire position and sizing of the balloon. Balloon occlusion in this instance can be utilized as a temporary bridge to definitive treatment. Completion angio (right side) with stentgraft in place.

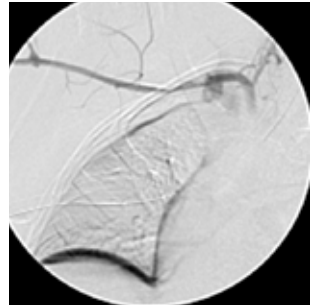


Figure 9.1

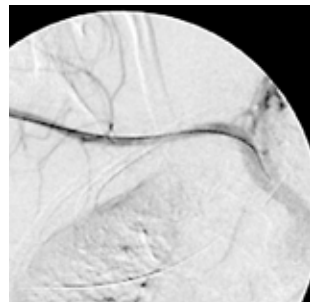


Figure 9.2

Figure 9 1-2: Angiography with extravasation from an injury of the left subclavian artery. Stentgraft in place and completion angio on the right. Balloon occlusion may be useful for proximal control, but careful deployment is required. Over-inflation can make arterial injuries worse.

Here you can see some illustrations of access to the axillar and brachial arteries for angiography and/or balloon occlusion.

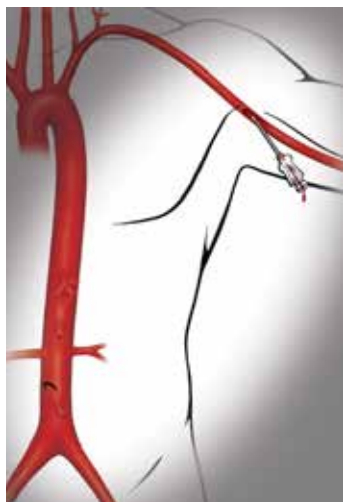


Figure 10.1

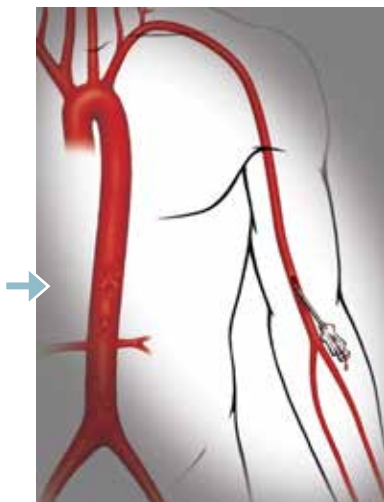


Figure 10.2

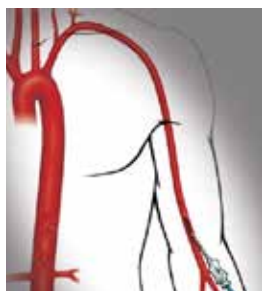


Figure 10.3

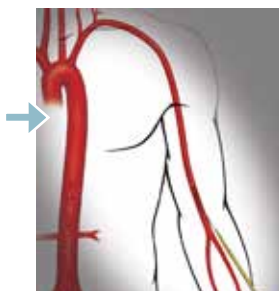


Figure 10.4

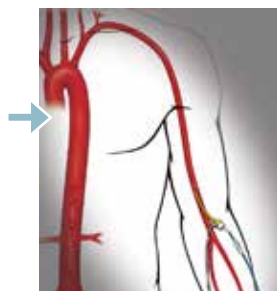


Figure 10.5

Figure 10 1-5: Access to the artery, guide wire and sheath insertion. If you know your wire crossed the lesion (and sure about it using angiography and contrast), you might be able to use a balloon or stent-graft. See also other relevant chapters.



Figure 11.2

Figure 11.1

Figure 11 1-2: An example of a balloon that might be useful for bleeding control, especially the inferior vena cava. As in all products we mention or show, **IFU should be followed**. (Courtesy of Spectranetics).



As a way of reviewing and closing out this issue – some **key points** of emphasis for the use of balloon occlusion at non-aortic sites that you should always remember:

Open exploration and repair often remains the gold standard for a reason. If the patient is crashing, there may not be time to muster resources for an endovascular procedure or balloon occlusion.

You can't use endovascular techniques without having vascular access – consider establishing early arterial access for patients you think potentially need it.

Use your imaging if the patient's condition allows it. CTA can help identify the injury and determine if endovascular capabilities – including balloon occlusion or definitive repair – are useful adjuncts to employ.

When using a balloon – avoid oversizing or over-inflation. You can make a bad situation worse if you ignore resistance.

If heparin use is safe in the situation, use it. You will not regret it when employing endovascular techniques. Especially when dealing with BCT, carotid and visceral arteries.