



Chapter 5

EVTM and REBOA in pre-hospital, transfer and military settings

Thoughts, possibilities and limitations

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The tendency with any new life saving technology is to explore the range in which it can or should be employed. Endovascular principles, and in particular REBOA, are no exception. If a significant portion of deaths after trauma are the result of significant hemorrhage at non-compressible sites (i.e. a place you can't put a tourniquet on or compress effectively to stop the bleeding) – then it makes sense that consideration should be given to moving technologies that can assist in control of these hemorrhage sources as close to the point of injury as feasible and appropriate. What is “appropriate” in this context? This remains a matter of active study. It is clear, however, that there is potential for REBOA to be utilized in pre-hospital settings for patients who would otherwise likely bleed to death before reaching an environment where surgical control of non-compressible hemorrhage (in most cases by an emergent thoracic or abdominal surgery) can be achieved. There are some key questions that need to be answered before we can say anything definitive about the optimal role of REBOA in the pre-hospital setting. What patients need REBOA before transfer to a surgical capability? How do we identify them? What impact does the estimated time of transfer have on the choice to use REBOA in these environments? Who should be doing the REBOA in this setting? What training do these providers need? While we don't have the answers to these questions as of yet – we can identify and discuss a few situations in which EVTm approaches, including REBOA, may prove useful as experience accumulates. So, let us speculate and discuss our thoughts.

Transfer REBOA

We discuss elsewhere in this text the potential for REBOA use in the Emergency Department to prolong the survival of the patient long enough to reach the operating room for definitive surgical control of bleeding. What if the patient presents initially to an emergency room or small medical facility that does not have an operating room readily available? What if, instead of rolling the patients gurney down the hall into a ready operating room, you need to put them in an ambulance and drive them down the road to get to such a facility? The reality of trauma care, even in countries with advanced civilian trauma systems, is that there is not an advanced trauma center with a surgeon on site at every corner. While a good system optimizes the chance that a severely injured patient is delivered from the scene of injury to a center with immediate surgical capability, in practice this is not always the case. Even with expedient transfer practices and mature trauma systems, patients die every year in every country while being transported rapidly from a smaller medical facility without immediate surgical care to a larger one with a ready operating room. Could a rural provider at a small medical center emergency department be trained to place a REBOA device? Yes. Could REBOA keep a patient how is likely to bleed to death quickly alive long enough to survive transfer to a facility capable of immediate surgical hemorrhage control? It is definitely possible for some patients. Could inappropriate REBOA inflation make the patient worse? Yes! There are a myriad of factors that come into consideration – including time of transport – but the feasibility of rural REBOA use is not difficult to conceive.

We outline very well in other areas in this text the specific technique of both REBOA and pREBOA. These would be the mainstays of approaches that could be utilized to facilitate transfer of severely ill patients with ongoing non-compressible hemorrhage. What needs to be better addressed to make this practice optimally feasible in an existing trauma system would be a cohesive arrangement of transfer policies and communication between transferring and receiving centers. Only if all providers are on the same page across a trauma system would this work effectively.

Some degree of common sense would also have to prevail. A patient with a zone I REBOA full occlusion of the aorta for an extended period of time is not likely to survive no matter what is done. While it is not yet known what the



“magic time interval” beyond which total aortic occlusion is futile – is stands to reason that the transport time would need to be extremely short (30-45 minutes) in order to optimize outcomes. **pREBOA** might play an important role here, but again, we speculate.

There are a lot of issues to be addressed to make transfer REBOA a common reality of trauma system care – but it is an important discussion to start. There are other pre- surgical / pre-hospital scenarios where EVTm and REBOA might also prove applicability – and has even already been used with some limited success. Let’s examine these scenarios next.

Pre-Hospital REBOA

EVTm, in particular REBOA, has long been discussed for use in select pre-hospital environments. The London air ambulance experience has demonstrated that a capable provider can be delivered to the scene of injury and place a REBOA effectively and rapidly in this setting. This experience has been instructive, but raises questions about optimal pre-hospital use that must be better examined. Optimally, REBOA in the pre-hospital setting would be reserved for patients who are deemed not likely to survive to reach the hospital without it. But how do we identify these patients most accurately? Ultrasound (FAST) identification of hemorrhage in the abdomen on the scene? Identification of unstable vital signs and an appropriate mechanism? How does one make sure there is no substantial bleeding in the chest? What training level should the provider making this determination and placing a REBOA ideally have? The London experience suggests that capable physicians can accomplish this goal, but can that experience be extrapolated to other environments of care?

The use of REBOA at the scene of injury also must be considered in the context that a severely injured patient with active non-compressible bleeding requires surgical intervention for definitive control. How long should time on scene be extended to facilitate REBOA for most patients? It is likely that the use of EVTm will evolve from an on-scene skill to an “in transit” skillset – with the appropriate provider establishing arterial access and / or REBOA in a helicopter or an ambulance during transfer. In this scenario, no time is lost in moving the patient towards surgical intervention – even as EVTm principles are being used during travel in an effort to promote his or her survival to make it to the operating room or endovascular suite.

Remark:

- » Attempts at arterial access might take more time than you think – if attempting to obtain arterial access in the pre-hospital setting – avoid lingering on the scene to do so. If you are not successful don't delay getting to the hospital. **Never stop the evacuation for any heroic REBOA maneuver.** Explore and rehearse options for obtaining access en route.

Battlefield / Military applications

The considerations for battlefield use of EVTM and REBOA are in many ways similar to those of the civilian sector – with several unique considerations. In both settings the providers performing REBOA must be appropriately trained. They must consider if REBOA is likely to be beneficial – or if its use warrants a potential delay in transfer. Could REBOA make the patient worse?

The differences in the two settings, however, are dramatic. Military settings are often associated with the “tyranny of distance” – meaning that the transfer times to a surgery-able setting may be more prolonged. The time on scene may also be affected by other factors unique to the military setting – namely, do the local conditions even permit evacuation of the casualty immediately? If active fighting is still ongoing, the medical team may be called upon to issue prolonged field care until casualty evacuation can be safely undertaken. There is also data to suggest that the majority of potentially preventable deaths occurring after modern combat injury are the result of hemorrhage from non-compressible locations – a scenario perhaps ideally suited to REBOA utilization. These considerations – the preponderance of death due to non-compressible hemorrhage and the challenges of casualty evacuation – make REBOA a significant **potential tool** for military use. How might pre-hospital REBOA be used in the military setting work? Let's look at a potential scenario that serves to outline important considerations in this setting:

Here is the hypothetical situation. You are on a military mission as part of a front line medical support unit. Suddenly you are called forward to care for a wounded soldier who has sustained major blast injuries. When you get to the wounded soldier, he is still conscious. Obvious bleeding sites are controlled – including tourniquet placement on both severely injured lower extremities. Clinically you can determine that his blood pressure is likely getting



low – as he has weak pulses, appears pale and clammy and is becoming confused and somnolent. A number of fragmentation wounds on his torso suggest that he probably has ongoing hemorrhage within his abdomen or perhaps chest – although his lung sound is clear bilaterally and you have already performed bilateral needle decompressions to exclude tension pneumothorax as a cause. He needs evacuation – but you are told that there are enemy identified in the area and that it is not safe to move the casualty at this time. You prepare to do the best you can – administer fluids and tolerate some degree of hypotensive resuscitation – but the patient continues to appear in an advanced level of shock.

Sounds like a situation in which REBOA might buy a little more time? Maybe the use of this technology could help you keep the patient alive long enough to get him out of the zone of active combat and to a location that can better deal with his non-compressible hemorrhage by surgical means. The principles of REBOA in this setting are similar to those of the in-hospital setting – but the situation is dramatically different. Sterility is compromised, as may be visibility – there may even be mortar rounds or gunshots landing nearby.

One of the challenges in this setting, similar to that of the civilian pre-hospital setting, is to define what you might need to do REBOA in this setting. Weight is an issue – as you most likely brought all the medical supplies you could in a pack on your back. You won't be able to fit a fluoroscopy machine in there!! An ultrasound? That technology is certainly getting more compact, lighter and more portable. Durable small ultrasound machines are already in use in military field hospitals and among elite medical units of the military of multiple countries. You may not have this capability either...in which case anatomic landmarks or a femoral cutdown will be required –these approaches are discussed in earlier chapters in this text – but require appropriate training to complete. The key here is that the use of REBOA is possible in this setting – given appropriate training, equipment and system-wide planning. One positive thing (and the only one) is that in young, well trained soldiers, your landmarks are easier to find compared to a 75 year old man with calcifications and round belly...

The reality is that REBOA is already a capability of select medical units of various militaries and that experience with this adjunct is emerging. It can be employed by an advance surgical team far forward of a true hospital envi-



Figure 1.1



Figure 1.2

Figure 1 1-2: Military training on REBOA. Sheath and balloon marked with arrows.



ronment, or even during military casualty evacuation by advanced capability air platforms such as the UK Medical Emergency Response Team (MERT) – whose medical providers have advanced clinical training and appropriate equipment for many en-route interventions. Modern large-body helicopters, such as CH-47 Chinook, have sufficiently large interior space what allows gaining good access to the patient and facilitate environments capable of these interventions.

The full spectrum of EVTΜ and REBOA utilization is perhaps most extreme when considered directly at the scene of injury or during initial casualty evacuation...but these technologies are also becoming a critical part of military combat support hospitals, also known as Role 2 or Role 3 environments of care. As the casualty moves further along the evacuation chain, increasing EVTΜ capabilities can be brought effectively to bear in combating the sequelae of injury. Recent experience by US military medical systems has demonstrated that fluoroscopy capabilities at Role 3 facilities can afford the endovascular treatment of a variety of traumatic pathologies – including the formal angiography, the use of angioembolization and even endograft coverage of injuries.

With advancing time and experience, technologies will become more facile and portable. These advances will likely bring EVTΜ capabilities further forward in the treatment of the critically injured – in both civilian and military settings. In the interim, other challenges will need to be overcome – including the optimal identification of patients likely to benefit from EVTΜ in these settings, protocols for cohesive EVTΜ use across civilian and military trauma centers and determining the appropriate training required for their employment. Through increasing experience and study – EVTΜ applications may transit from the realm of theory to that of routine practice in the coming years.

Warning

- » We are strong believers in REBOA, but as this is an evolving issue, one must stop and think- Can REBOA save life in these settings? When should it not be used. More clinical data is needed before we can recommend the usage of REBOA in the field.