ARTERIAL TOURNIQUETS

FOR POLICE OFFICERS, LAW ENFORCEMENT AND OTHER FIRST-RESPONDERS

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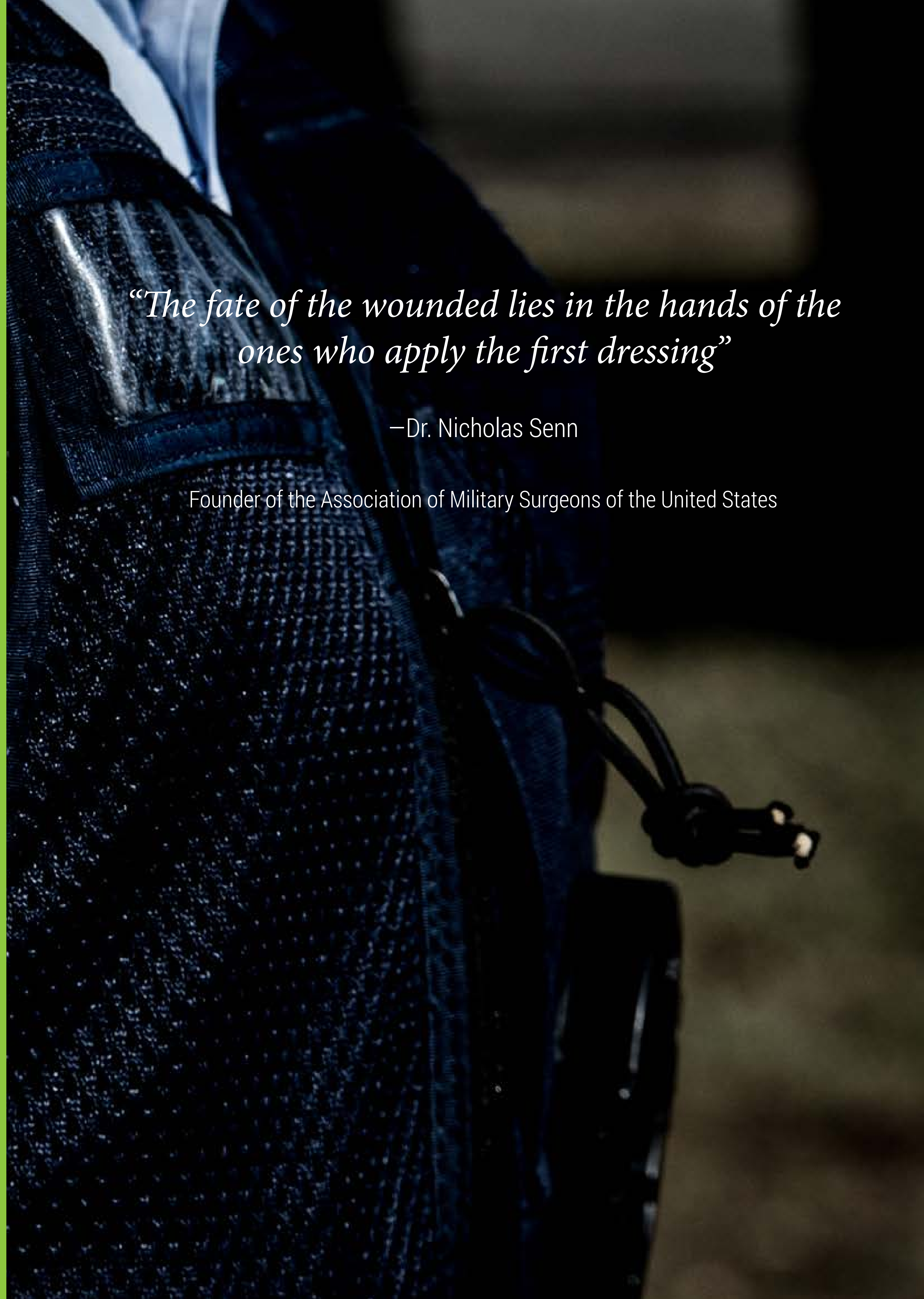
To the men and women of the Police and Law Enforcement who stand ready, so that we might sleep peacefully in our beds at night.

To those who put themselves in harm's way to apply the first dressing, that others may live.



"The fate of the wounded lies in the hands of the ones who apply the first dressing"

—Dr. Nicholas Senn

Founder of the Association of Military Surgeons of the United States

ONE

ARTERIAL TOURNIQUETS EXPLAINED

An arterial tourniquet is a piece of equipment designed to apply increasing circumferential pressure to a limb in order to compress the arteries within the limb. Applied above an arterial bleed, the tourniquet will arrest the flow of blood from the wound.

Figure 1 illustrates a simplified version of the significant structures of the human thigh or upper arm in cross section.

CROSS SECTION OF UPPER ARM OR LEG

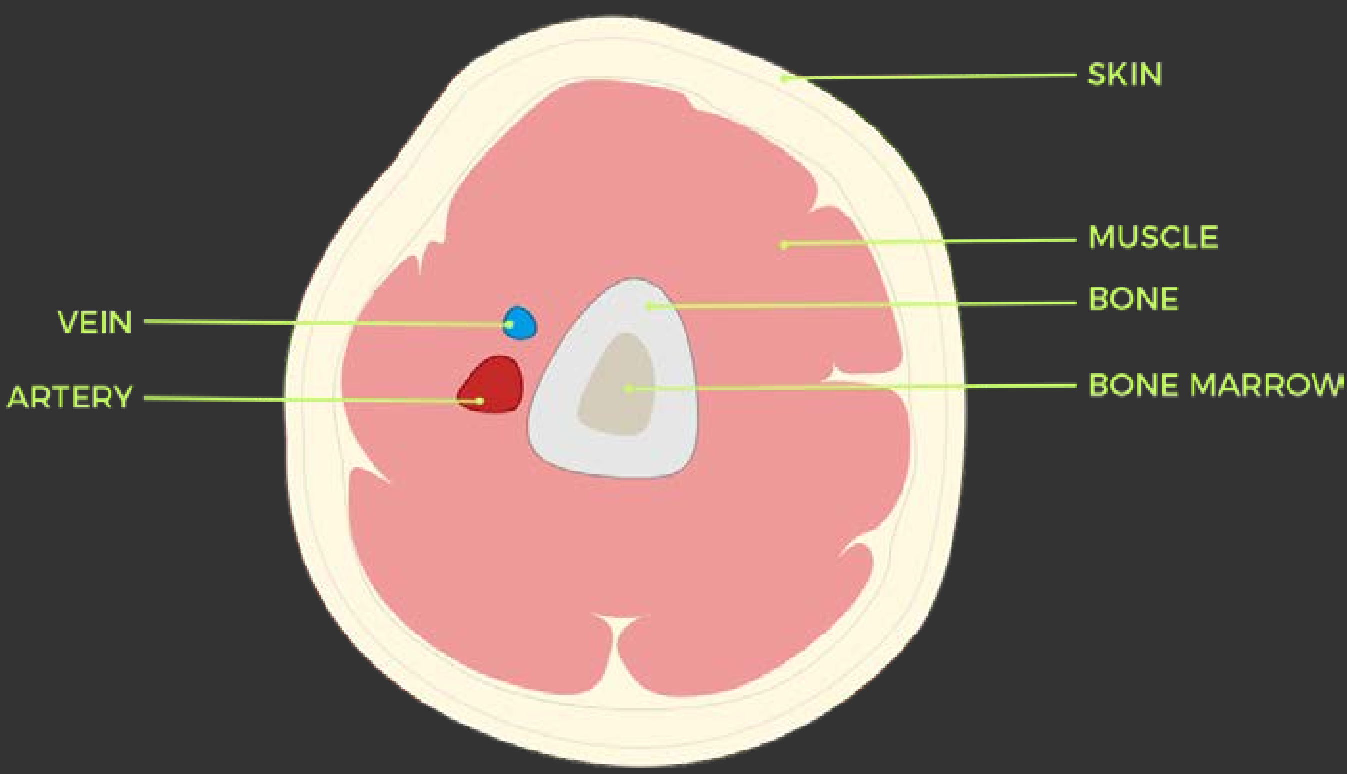


Figure 1

It can be seen that circumferential pressure applied to the thigh will transfer pressure through the muscle tissues, and eventually occlude the hollow structures of the thigh including the veins and arteries, as in Figure 2.

TOURNIQUET APPLIED, WINDLASS TIGHTENED

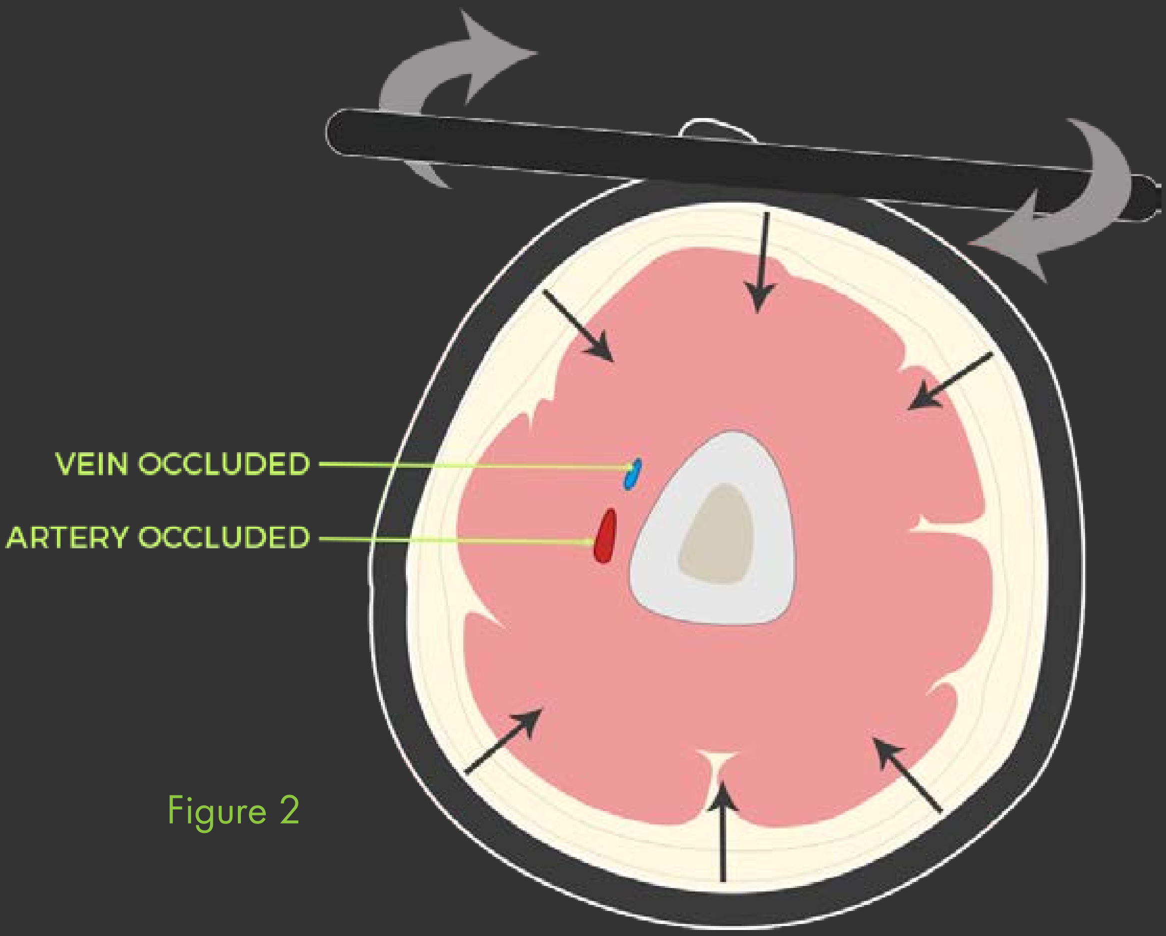


Figure 2

Once sufficient pressure has been applied to the tissues to arrest arterial blood flow, the arterial tourniquet is locked in place until an appropriate time, and an appropriately trained medical person can review the intervention. Whilst life-saving when used appropriately, the arterial tourniquet has proven controversial over the years owing to its potential for significant side effects if used inappropriately or for excessive periods of time.

TWO

DISCUSSION OF ARTERIAL TOURNIQUET USE

Arterial tourniquets have been recognised as a means of controlling arterial bleeding for hundreds of years, with initial applications being in the control of blood loss during surgical amputations (Welling 2006). The earliest documented military application of the device dates back to the American Civil War in 1862 (Gross 1862) with the recommendation that every combat soldier should be issued a tourniquet, and trained appropriately. Since that time arterial tourniquet use for control of life-threatening bleeding has been extensively debated in the literature, with pre-Vietnam opinion of the tourniquets of the day being largely negative (Welling 2006; Wolff 1945).

With advances in tourniquet technology, as well as the development of helicopter evacuation during the Korean and Vietnam conflict, arterial tourniquet use came back into favor, however only as a last resort when all other methods of haemorrhage control had failed (Shackelford 2015).

Analysis of combat deaths from the Vietnam conflict showed that 9% were a result of bleeding out from extremity wounds, and that 88% of those occurred pre-hospital (Bellamy 1984). These statistics reinvigorated interest in arterial tourniquets as a potentially life-saving pre-hospital intervention however, frustratingly, large-scale military tourniquet use was not achieved until well into the recent Iraq and Afghanistan campaigns. Statistics from the early years of both of these conflicts show the leading cause of preventable death on the battlefield continuing to be blood loss from extremity wounds amenable to arterial tourniquet placement (Eastridge 2012; Kotwal 2011; Shackelford 2015).

Led by the US Special Operations community and the Committee on Tactical Combat Casualty Care (CoTCCC), a decade of combined effort in developing evidence base, doctrine, training, policy and implementation has resulted in every deploying US service person trained in the appropriate application of arterial tourniquets (Shackelford 2015). The end result has been demonstrable reductions in preventable death on the battlefield (Eastridge 2012; Kotwal 2011) and thousands of lives saved in combat (Blackbourne 2012).

Disappointingly these military lessons learned have been slow to permeate into the civilian setting, and arterial tourniquets, despite significant improvements in technology, and unquestionable application in life-threatening limb haemorrhage, continue to suffer the antiquated stigma associated with their use. To illustrate this point, the Australian Resuscitation Council continues to list arterial tourniquets as an intervention of last resort, when all other means of haemorrhage control have failed (ARC 2008). This is despite the fact that studies have repeatedly demonstrated the lifesaving benefit of early tourniquet placement (Butler 2015; Kragh, JJ, Walters, TJ, Baer, DG, Fox, CJ, et al. 2008; Kragh, JJ, Walters, TJ, Baer, DG, Fox, CJ, Wade, CE, et al. 2009), and suggested that mortality rates can be as low as 10% with early tourniquet placement, whilst increasing to 90% if tourniquets are placed after the onset of shock (Kragh, JJ, Walters, TJ, Baer, DG, Fox, CJ, Wade, CE, et al. 2009).

Indications from the international civilian pre-hospital community appear more encouraging, with reports of successful early arterial tourniquet use by ambulance officers in the US (Zietlow 2015).

As a generalization, complications of arterial tourniquet placement result from direct pressure at the site of the tourniquet, venous congestion, rebleeding from an ineffective tourniquet placement, and tissue and nerve damage distal to the tourniquet due to lack of arterial blood supply (Shackelford 2015).

Tissue damage both at the site of tourniquet placement, and distal to the device, can affect nerves, blood vessels, or the soft tissues of the limb directly, potentially resulting in long-term deficits following tourniquet use. Confusing the exact statistics on complications resulting directly from tourniquet use is the underlying injury for which the tourniquet was used in the first instance. Studies analysing tourniquet complications report rates varying from 0% (Beekley 2008) to 6.4% with tourniquet times of between 109-187 min (Lakstein 2003). Whilst there is no absolute safe time for an arterial tourniquet to remain in place without long-term complications, it is accepted that risk of limb loss increases after 3-4 hours, and is near inevitable after 6 hours (Shackelford 2015). For this reason the current widely accepted duration of arterial tourniquet placement is 2 hours (Shackelford 2015), with conversion of the tourniquet to a hemostatic or pressure dressing within that time if appropriate (CoTCCC 2015).

Complications from venous congestion in a limb with a tourniquet placed result from the circumferential pressure applied being enough to compress the low-pressure veins in the limb, but not high enough to occlude the arterial flow into the limb. In this instance blood continues to accumulate in the limb, increasing tissue pressures, and the likelihood of complications (Kragh, JJ, Walters, TJ, Baer, DG, Fox, CJ, et al. 2008). Complications relating to venous congestion are avoidable with appropriate training in the application of tourniquets to ensure that arterial flow has been occluded (Shackelford 2015).

Whilst there exists some potential for side effects with the placement of arterial tourniquets, it must be kept in mind that they are being used as a life-saving intervention for haemorrhage, and if a patient survives long enough to have complications of tourniquet placement, then it is likely that the device has done its job. The focus should not be on whether or not to use tourniquets, but rather on improved training to minimise use of non-indicated tourniquets, that recognises and corrects ineffective tourniquets, and that focuses on the early review and conversion of tourniquets to hemostatic or pressure dressings when appropriate (Shackelford 2015).

THREE

FROM THE BATTLEFIELD TO THE STREETS OF OUR CITY

In recent years we have seen an increase in acts of terrorism and violence on the streets of our cities worldwide using the same weapon systems encountered on the battlefields of Iraq and Afghanistan. Assault rifles and Improvised Explosive Devices (IEDs) are increasingly being used in civilian contexts, effectively bringing the battlefield to the streets of our cities. Mass shootings and, more concerningly, the detonation of IEDs on the streets of first-world cities are becoming an almost regular occurance. For those countries impacted by these acts of violence, it is essential that lessons are learned from the experience and are integrated into training towards preventing and responding to future events. For the countries such as Australia, who are yet experience the devastation of a large-scale terrorist attack resulting in mass casualties, those countries are in an ideal position to benefit from the lessons learned from international events without suffering the devastating loss of their own citizens.

Recent examples of large-scale acts of terrorism using military-style weapons include the Boston Marathon bombing in April 2013, the Charlie Hebdo, and further multisite terrorist attacks of November 2015 in Paris, and more recently the March 2016 Brussels Airport bombing.

Whist the US had sadly experienced many mass-casualty shootings involving military-style weapons, the Boston Marathon bombing represented "the first major, modern US terrorist event with multiple, severe lower extremity injuries" (King DR 2015). Of the 243 casualties of the Boston Marathon bombing, 29 had life-threatening bleeding from a limb, with 15 casualties having one or more lower limb traumatic amputations (King DR 2015).

https://www.reddit.com/r/news/comments/1cen3t/there_was_just_an_explosion_at_the_boston

In medical response to the Boston Marathon bombings there were 27 tourniquets applied, all of which were improvised presumably due to no commercial arterial tourniquet being immediately available (King DR 2015). When anaylising the lack of availability of arterial tourniquets in the civilian first response King et al. (2015) use the phrase "lost in translation" to describe the complete lack of promulgation of lessons learned by the US military on operations to the domestic civilian first response organisations.

Owing to their multiple mass-casualty shootings and terrorist events, key players in the US Law Enforcement, medical and military communities have convened on multiple occasions, starting in April 2013, in a forum known as the Hartford Consensus (Jacobs LM 2013). Their agenda was to translate military medical lesson-learned from the battlefields of Iraq and Afghanistan in order to optimise civilian emergency response to mass shootings and terrorist events. Amongst other outcomes was the development of the THREAT acronym (Jacobs LM 2013) for approaching such situations, which is as follows:

- **T** = Threat suppression
- **H** = Haemorrhage control
- **RE** = Rapid extraction to safety
- **A** = Assessment by medical providers
- **T** = Transport to definitive care

Fundamental to the THREAT response is the requirement for "definitive control of life-threatening haemorrhage using tourniquets and hemostatic dressings. This must be accomplished as quickly as possible, even if the threat has not been entirely eliminated" (Jacobs 2013, p.950). No longer is the "ambulance will be right outside" approach to casualties acceptable, particularly if Australian Police are to adopt a more proactive response to Active Shooter Incidents.

The US have taken this response a step further in an effort to empower the general public to assist in emer-gency response to mass-casualty events (Jacobs 2015), with the "Stop the Bleed" campaign (Homeland Security 2015) as part of a three-tiered immediate response to casualties (Jacobs 2015).

- Immediate responders: The individuals who are present at the scene who can immediately control bleeding with their hands and equipment that may be available
- Professional first responders: Prehospital responders at the scene who have the appropriate equipment and training
- Trauma professionals: Health care professionals in hospitals with all of the necessary equipment and skill to provide definitive care

STOP THE BLEED

No matter how rapid the arrival of professional emergency responders, bystanders will always be first on the scene. A person who is bleeding can die from blood loss within five minutes, therefore it is important to quickly stop the blood loss.

"Stop the Bleed" is a nationwide campaign to empower individuals to act quickly and save lives.

*Remember to be aware of your surroundings and move yourself and the injured person to safety, if necessary.

Call 911.

Bystanders can take simple steps to keep the injured alive until appropriate medical care is available. Here are three actions that you can take to help save a life:

COMPRESS

Expose to find where the bleeding is coming from and apply **firm, steady, pressure** to the bleeding site with bandages or clothing

TOURNIQUET

If the bleeding doesn't stop, **Place** a tourniquet 2-3 inches closer to the torso from the bleeding. (The tourniquet may be applied & secured over clothing).

Pull the strap through the buckle, **Twist** the rod tightly, **Clip** and secure the rod with the clasp or the Velcro strap.

+ One type of tourniquet is depicted.

COMPRESS AGAIN

If the bleeding still doesn't stop, **Place** a second tourniquet closer to the torso from first tourniquet.

Pull the strap through the buckle, **Twist** the rod tightly, **Clip** and secure the rod with the clasp or the Velcro strap

+ One type of tourniquet is depicted.

The medical response to the large-scale multisite ter-rorist attack in Paris on Nov 13, 2015 was described as a "civil application of war medicine" (Hirsch M 2015). France had learned from previous international terrorist bombings in countries such as Israel, Spain, England, as well as the Boston Marathon bombing, and devel-oped and practiced a comprehensive crisis plan (Hirsch M 2015). Owing to this well-established plan, polished recently by the Charlie Hebdo attacks, the French were able to launch an incredible medical response to the massacre, however were still caught off guard by the number of arterial limb injuries, observing that "the demand for tourniquets was so high that the mobile teams came back without their belts" (Hirsch 2015, p.2).

With these incidents in mind, our civilian first-responders need to be equipped and trained as if they were frontline soldiers in a war zone. It is time to translate our military lessons learned from the last two decades of operations in the Middle East to our Police and Law Enforcement Officers.

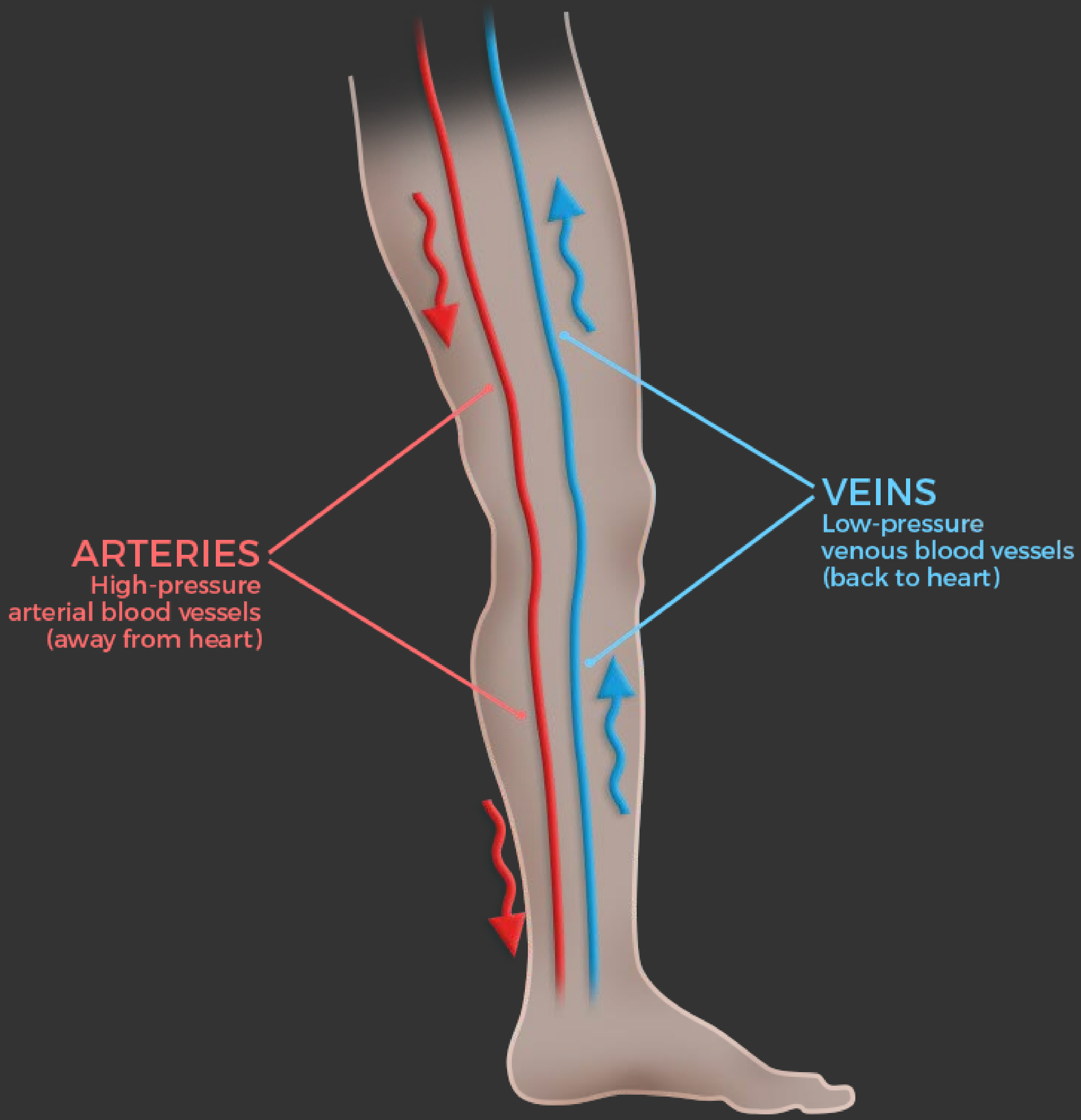
FOUR

THE ANATOMY OF A HUMAN LIMB

To understand what we're trying to achieve by using an arterial tourniquet, it helps to have a basic understanding of the anatomy of the blood vessels in human limbs.

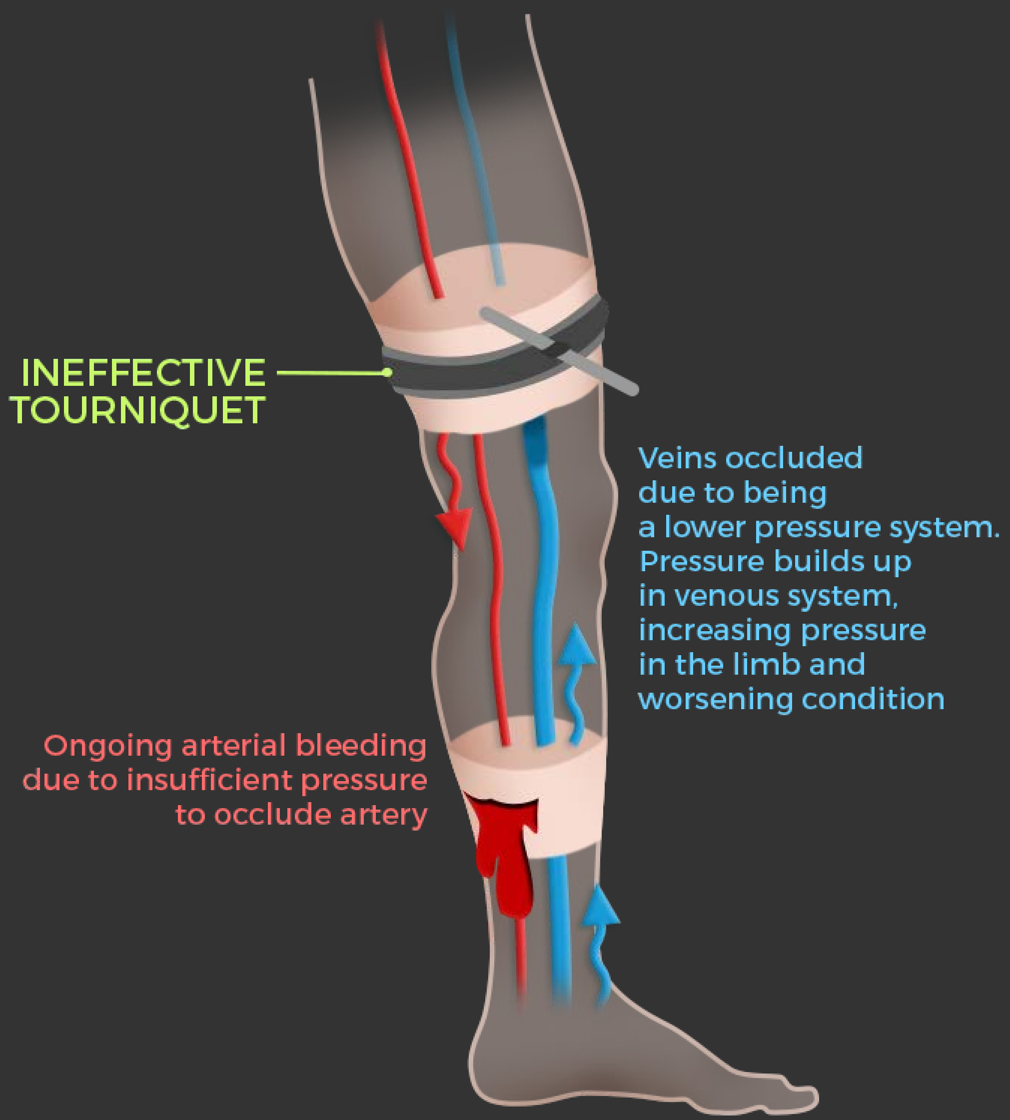
There are two major types of blood vessels in the human body, the arteries; which are high-pressure, pulsatile vessels that carry blood away from the heart, and the veins; which are lower-pressure blood vessels that carry blood back to the heart (Figure 3).

Figure 3. Vascular supply to the lower



Both vessel types are important to the discussion of arterial tourniquets for different reasons. It is the arteries that are of primary concern, as it is the high-pressure arterial bleeding that can potentially cause a casualty to bleed out and die in a matter of minutes if not controlled. This is where the arterial tourniquet is a life-saving piece of equipment, however, only if applied with appropriate tension. Take the example illustrated in figure 4 below, where an arterial wound has been treated with a tourniquet of insufficient pressure, perhaps an improvised tourniquet made from someone's belt or shirt tied around the limb, such as what was seen following the Boston Marathon bombings. We know that the systolic blood pressure pushing blood into the limb and out of the arterial wound is going to be somewhere around 120-200mmHg in the instance that a casualty is in pain, and studies have demonstrated that improvised tourniquets are unlikely to occlude arterial pressures of this magnitude (Altamirano MP 2015), with the maximum pressure realistically achievable by a tight pressure dressing being around 90mmHg (Naimer 2000).

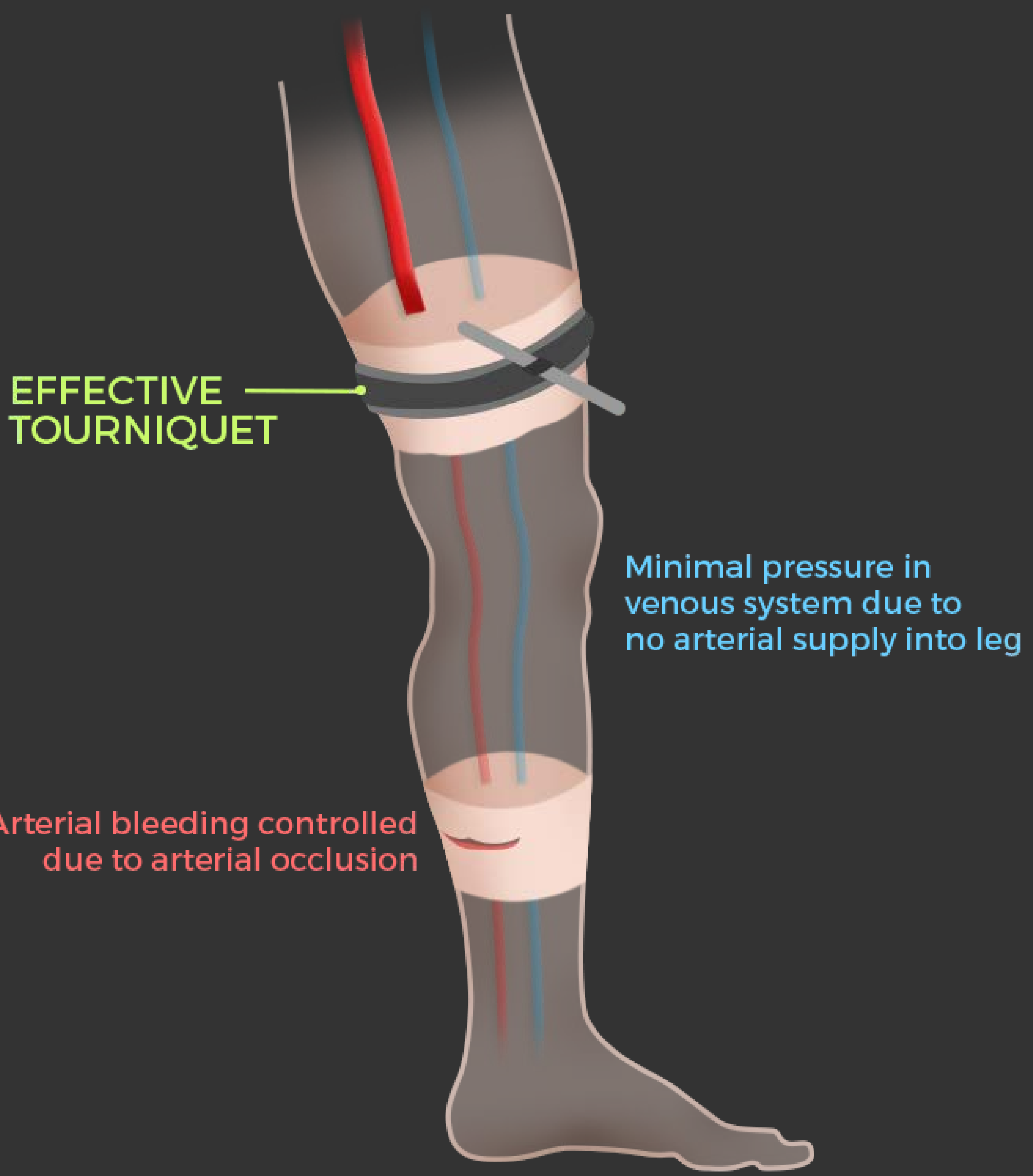
Figure 4. Lower limb arterial bleed with ineffective tourniquet



Whilst the arteries haven't been occluded in this setting, the lower-pressure veins will be. The end result is ongoing bleeding from the arterial wound, coupled with a buildup of pressure in the venous system of the limb, which not only worsens the bleeding from the wound, it compounds the injury to the limb by increasing tissue pressures and therefore the pressure on nerves and other structures of the damaged limb.

For the tourniquet to be effective, it must be tight enough to occlude the arterial supply to the damaged limb (Figure 5), which will in turn cut off any ongoing venous flow from the limb due to blood no longer getting past the tourniquet. A degree of venous blood will be trapped in the limb with no place to go, and will likely end up oozing out of the wound. This doesn't represent tourniquet failure, as long as the bright red bleeding has ceased, and a pulse is no longer palpable in the limb (assuming it is still intact).

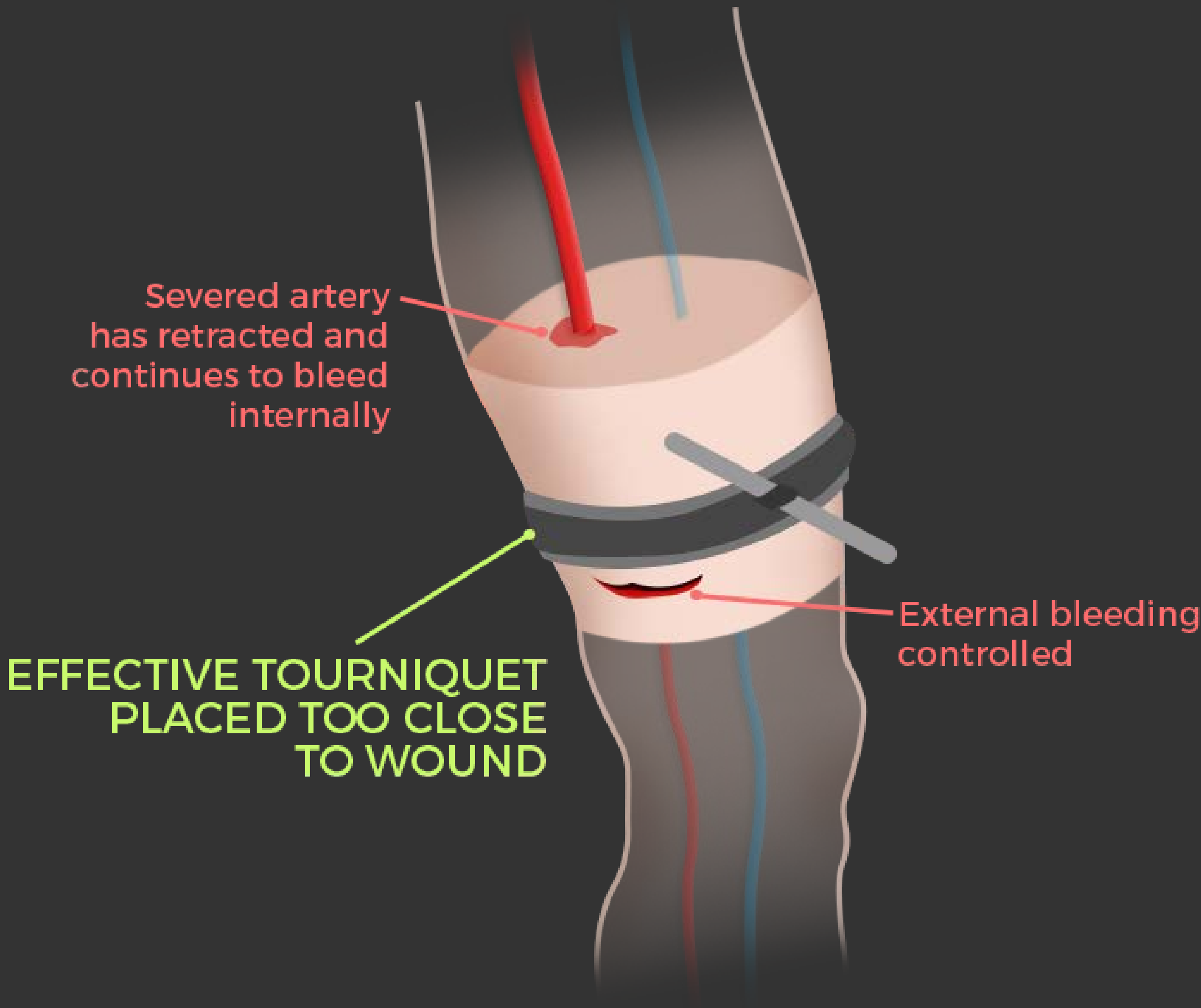
Figure 5. Lower limb arterial bleed with effective tourniquet



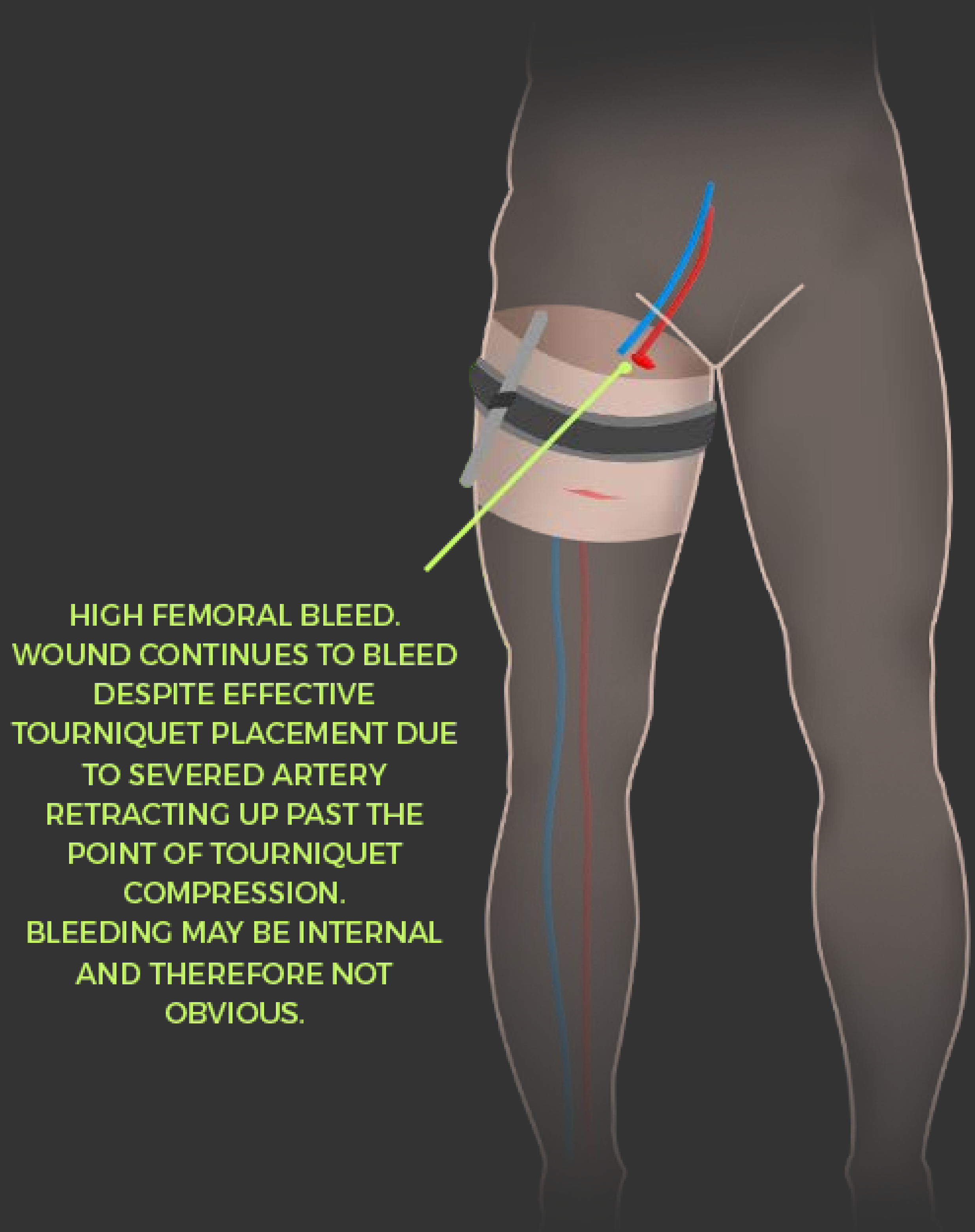
FIVE

CLOSE TO THE WOUND VERSUS HIGH-AND-TIGHT

There has been argument over the years as to whether applying an arterial tourniquet as close to the wound as possible is a better option to high and tight on the limb, or vise versa. Either way, it is accepted that you don't want to apply a tourniquet any closer than about 10cm (2-3 inches) to the wound, on account of the fact that if the artery has been completely transected; it may have retracted a small distance due to the elasticity of the vessel. In that instance, if the tourniquet is applied immediately above the site of the wound, the bleeding artery may have actually retracted up past the tourniquet and continue to bleed internally.



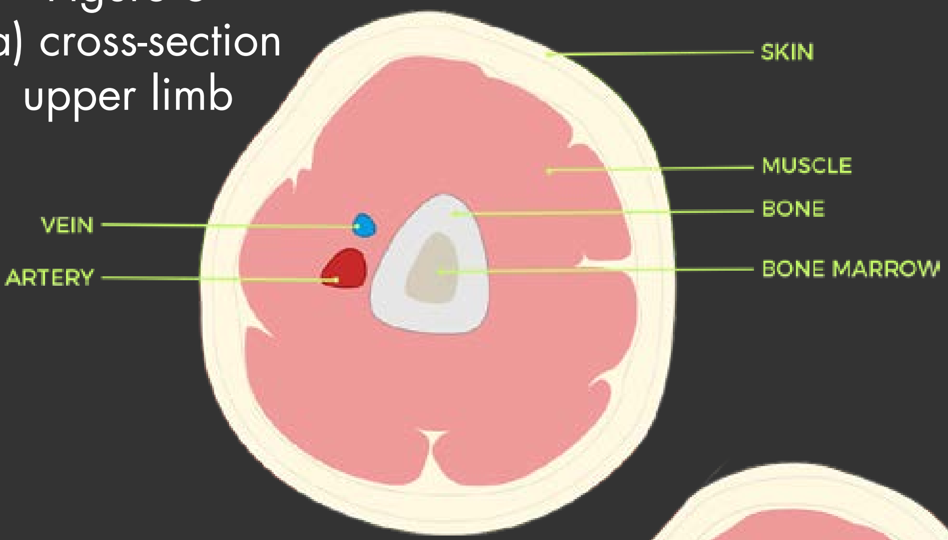
Likewise, if an arterial wound is high up in the groin or towards the armpit, and you can't place a tourniquet the requisite 10cm (2-3 inches) above the wound, it may be more appropriate to pack the wound as opposed to using a tourniquet.

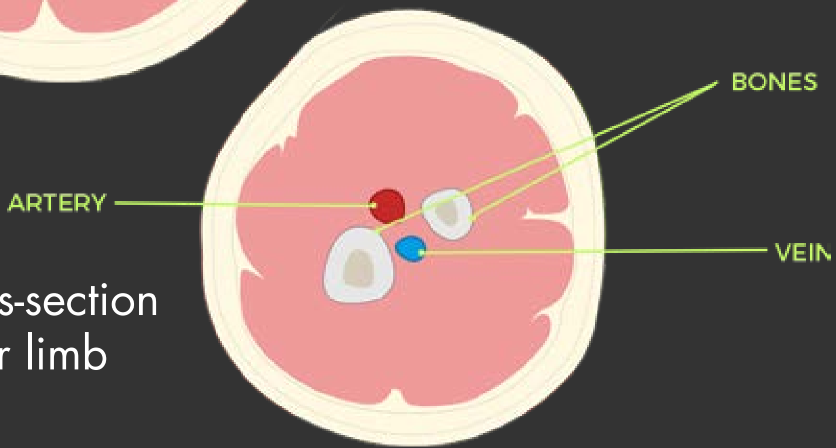


What is universally accepted however is that a tourniquet should never be placed over a joint such as the elbow or the knee.

Let's take the example of a mid-shin/forearm amputation to illustrate the pros and cons of above and below-knee/elbow placement of a tourniquet. Figure 6 shows a simplified representation of the relevant above-knee/elbow anatomy (Figure 6(a)) and below-knee/elbow anatomy (Figure 6(b)). As can be seen, the significant difference between the two is the presence of a single bone above the joint, and two bones below the joint, with the major arteries and veins located in between the two bones in the lower limb. With this knowledge, it can be seen that it is easier to occlude the artery in the upper limb by compressing it directly against the bone with an arterial tourniquet than it is to compress all the tissues surrounding the artery in the lower limb to transmit enough pressure to achieve occlusion.

Figure 6
(a) cross-section upper limb





(b) cross-section lower limb

The argument against using an upper limb tourniquet for a lower limb amputation or arterial injury is that you are unnecessarily cutting off arterial supply to a section of viable tissue between the site of the tourniquet and the site of the injury.

With all of those arguments in mind, the Committee on Tactical Combat Casualty Care currently recommends tourniquets be placed over the casualty's clothing 10cm (2-3 inches) proximal to the wound, irrespective of if it is above or below the joint, with the caveat that if the wound is not immediately apparent to place the tourniquet as proximal as possible "high and tight" on the limb (CoTCCC 2015).

SIX

ARTERIAL TOURNIQUET TYPES

Regarding an appropriate arterial tourniquet for field use, it is accepted that to be effective, the tourniquet will preferably have a minimum width of 4cm, and must have a windlass device of some sort to generate the pressure required to occlude arterial flow (Altamirano MP 2015; Quin 2014). Furthermore, the tourniquet must be rugged enough to be usable in the field environment. Applying these criteria, and drawing on over a decade of accumulated data on field tourniquet use, the CoTCCC (2015) recommends four appropriate devices, being the Combat Application Tourniquet (CAT), the Special Operations Forces Tactical Tourniquet (SOF-TT), the SOF-TT Wide, and the Emergency and Military Tourniquet (EMT) (Drew 2015).

Figure 7. CoTCCC approved arterial tourniquets. (A) CAT, (B) SOF-TT, (C) SOF-TT Wide, and (D) EMT (Drew 2015).

Whilst all four devices have been proven to be effective at occluding arterial blood flow, they differ slightly in their individual characteristics. Firstly, the EMT costs roughly 10 times the price of the other devices, making it immediately less appealing for use in individual first aid kits. Furthermore, whilst no literature exists to suggest field failure of its pneumatic pump system, reliance on such a device for a life-saving intervention, when a simpler mechanical system exists, may introduce unnecessary risk of equipment failure.

The main differentiating factor between the CAT and the SOF-TT, and SOF-TT Wide, is the use of a plastic windlass mechanism and buckle in the CAT as opposed to metal parts used in the SOF-TT variants. Whilst failure rates due to the plastic parts of the CAT are rare if it is properly applied, it is the author's personal experience that this can occur with the CAT, but has not been experienced with the SOF-TT variants. In differentiating between the SOF-TT variants, the SOF-TT Wide is generally considered as the preferred tourniquet of choice owing to its robust construction, its additional width over the SOF-TT, and the absence of the locking screw, which adds an additional step in the application of, and point of potential failure for, the SOF-TT.

Illustrated in figure 8 is the SOF-TT Wide, which is considered by TacMed Australia to be the most appropri-ate arterial tourniquet for pre-hospital use. Whilst the finer points of the SOF-TT Wide may differ from other tourniquets on the market, the fundamental concepts of how they all work remain the same.

Firstly, all arterial tourniquets have a strap that forms a loop around the injured limb, and can be tightened initially to a moderate degree of tension. This strap will either need to be fed through a buckle system, as in the CAT, or use a clip as in the pictured SOF-TT Wide below. The tourniquet can be looped over the end of the injured limb, or opened up, wrapped around the limb at the appropriate position, and then clipped back together or fed through, to create the loop. Once in place, the outer loop should be pulled tight enough so that it is hard to force two fingers in between the strap of the tourniquet and the casualty's limb. As described above, this pressure in itself will not be enough to stop arterial flow, but by getting the initial loop as tight as possible, it reduces the amount of turns you need to make on the windlass before the artery will be occluded.

As can be seen in Figure 9, the system that allows pressure to be generated by turning the windlass in a SOF-TT Wide results from a strap that is anchored at the buckle, then passes through the windlass, and finally is continuous with the strap of the tourniquet secured around the injured limb. It can be appreciated that by turning the windlass the strap will begin to be pulled through the body of the tourniquet, shortening it with every turn, and providing concentric compression on the limb. The length of strap that is pulled through will bunch up under the windlass of the tourniquet, which is why it is important to ensure that the outer loop is sufficiently tight before starting to turn the windlass, as to minimise the bulk of strap accumulated under the windlass by the time the tourniquet is tight enough to occlude arterial flow. Once the bright-red blood flow has stopped, and pulses are no longer palpable in the damaged limb, one of the notches on the ends of the windlass is engaged into the windlass locking tri-ring to prevent the tension in the windlass being lost by it unwinding under tension. The CAT utilises the same concept, however has a slightly different locking mechanism, with a c-shaped cup that holds the end of the windlass in place, and a Velcro strap to retain it. The effective tourniquet is then appropriately in place.

SEVEN

WHEN TO USE AN ARTERIAL TOURNIQUET

If you're even thinking that you might need a tourniquet to control a bleed then you should probably use one. It's always much better to use a tourniquet for a wound that didn't absolutely need one, and then revise it in a timely fashion, than to not use a tourniquet when it was absolutely needed and have the casualty bleed out.

As a rule of thumb, any traumatic amputation or arterial bleed above the knee or elbow will need a tourniquet applied. If the injury is down around the hand or foot, the arteries at that level may be small enough to control the bleeding with a tight pressure dressing, and a tourniquet may be unnecessary. That said, in the setting of say an amputated foot, if rapid control of the bleeding cannot be achieved by direct pressure, application of a tourniquet 10cm (2-3 inches) above the wound is indicated.

As stated above, if the wound is high up in the groin or armpit and there's not 10cm (2-3 inches) above the wound to place a tourniquet, consider packing the wound instead. This is due to the fact that the artery may have been transected and retracted into the groin or armpit, and may continue to bleed internally above the site of tourniquet placement.

Another appropriate use of an arterial tourniquet is to control bleeding quickly in a setting where it may not be tactically appropriate to explore the wound to determine whether it is arterial or not. In this setting, a rapid tourniquet should be applied high and tight on the limb of the casualty, and the wound reviewed, and tourniquet revised if appropriate, once the tactical situation has been brought under control. The same may apply if it is too dark to adequately review the wound and use of light is not tactically appropriate. In this setting a tourniquet should be placed, and the casualty moved in a timely fashion to an appropriate area to use light to explore the wound and reassess the requirement for tourniquet use.

EIGHT

STEPS IN APPLICATION

Once the decision has been made to use an arterial tourniquet, the first step in application is to position the tourniquet at the appropriate height on the limb. This can be achieved either by looping the tourniquet over the limb and moving it up into position (Figure 10), or opening the tourniquet up and re-clipping it at the desired level (Figure 11). These pictures illustrate a high-thigh placement that might be used for an arterial bleed just above the knee.

Figure 10

Figure 11

Once at the correct height, the lose tail of the tourniquet strap should be pulled tight to close the loop onto the limb snugly, and minimize the amount of necessary turns on the windlass to occlude the artery.

Figure 12. Tighten the outer loop of the tourniquet until it is snug on the limb. Try to apply the tourniquet as straight across as possible on the limb, and not on an angle.

Once the outer loop has been tightened on the limb, the windlass can be turned until the bright-red bleeding has ceased. Once the bleed is controlled, lock the windlass in place using the respective locking mechanism, in this instance the windlass locking v.

Finally, with the tourniquet in place, another check should be made that the bleeding is controlled, and that if the limb is intact, that the pulses are no longer palpable. Ideally it is good practice to then document the exact time that a tourniquet has been applied, however this is a one-percenter, and in the heat of the moment is easily forgotten.

NINE

HOW LONG IS TOO LONG?

The duration that a tourniquet can safely stay in place has been another topic of significant discussion over the years. Naturally tissues need blood flow to provide vital oxygen and other substances, and to remove waste products from the area. Once an arterial tourniquet is applied this process is interrupted, and the stopwatch starts towards tissue death. That said, human tissues have a remarkable ability to remain viable for hours without a blood supply, as is the case when an arterial tourniquet is applied.

As discussed in the introduction, it has been demonstrated that a tourniquet time greater than 3-4 hours is likely to cause irreversible damage to the limb (Shackelford 2015). The best recommendations come from the CoTCCC (CoTCCC 2015) and are as follows:

Tourniquets should be converted to hemostatic or pressure dressings as soon as possible as long as the following criteria are met:

- The casualty is not in shock
- It is possible to monitor the casualty for bleeding
- The tourniquet is not being used to control bleeding from an amputated limb

If the tourniquet has been left in place for more than 6 hours, it should not be removed unless the casualty is in a medical facility where they can have blood tests done and be closely monitored (CoTCCC 2015). The reason for this is that toxic metabolites including potassium will have built up in the tourniquet limb, and when the tourniquet is released, these metabolites will travel back to the heart of the casualty potentially causing cardiac arrest.

TEN

WHERE DO I KEEP MY TOURNIQUET?

When considering the best location for your tourniquet you need to keep the worst-case scenario in mind, in which you need to apply a tourniquet to your own arterially bleeding arm. Generally the best location to cater for this situation is to have the tourniquet attached in the centre of your upper chest, or in an Individual First Aid Kit (IFAK) somewhere on your rig that is reachable with either hand. This worst-case scenario also has implications as to how you attach the tourniquet to your rig. For example, whilst zip-ties are an outstanding way of securing kit, they're not the things you want holding your tourniquet on when you're trying to get it in a hurry one-handed!

Naturally there is a lot of equipment competing for real estate on the front of a tactical rig, including extra ammunition, communications kit and other mission essential items. In the author's experience it is easy for an operator to relegate their "lower-priority" medical equipment to less accessible areas on their rigs, such as on their backs (Figure 13).

Figure 13

Now I need to be quite clear that I am not judging the placement of the trauma dressings and IFAK in Figure 13, as these operators may very well have medical equipment on the front of their rigs, and what we are seeing in the photo are spares. That said if these items are their primary medical supplies, they are working on a very dangerous assumption that the next guy in the stack will stop and assist them in the instance that they get seriously wounded. Naturally, if there is a tactical situation unfolding and an officer is down, it may be more appropriate for the next guy in line to move straight past the casualty and continue on to neutralise the threat. It may also be that the next guy in the stack has been injured by the same blast or burst of gunfire that injured the first casualty. In these settings it is expected that the casualty will attempt to manage their own wounds, and this would be terribly difficult to achieve if their medical kit is located in between their shoulder blades!

In the setting that your tourniquet is going to be part of a medical kit, such as in a vehicle, the same concept applies with regards to having it readily accessible. Figure 14 shows an image of a small medical grab bag used on operations, with all the equipment required in a hurry attached to the outside, including arterial tour-niquets (in the pouches), trauma shears, nasopharyn-geal airways, chest decompression needles, and Sharpie permanent markers.

Figure 14

ELEVEN

THE IMPORTANCE OF REALITY-BASED TRAINING

We often hear the old adage train as you're going to fight, but how many of us actually apply it to our role?

Equally as important as being issued the right tourniquet is the correct training in its use. For the same reasons that Police Officers aren't just given a handgun without detailed training on its safe and proper use, they shouldn't be given a tourniquet without equal emphasis on its proper use. The handgun is designed to take lives if required, and the tourniquet is designed to save lives if required. The end result of the inappropriate use of either is exactly the same, being a potential death that should not have occurred. When the tourniquet is seen in that light it can be seen that just having one sitting on your rig is not enough, you must know how to use it in anger, and have practiced it repetitively in realistic scenarios.

Like any skill set, the initial training in arterial tourniquet use should be done by reading material such as this E-Book, and in the classroom where the student can get familiar with the individual components of the device, and the application of it on their own limbs and those of others. From there however it is critical to progress rapidly to reality-based scenario training (Murray 2006), wearing and carrying the exact kit that is worn and carried on the job, and applying the tourniquet to realistic training mannequins or simulated human casualties.

When learning any skill, there are four levels of inte-gration during its acquisition (Grinder cited in Murray 2006, p. 25):

- Unconscious Incompetence
- Conscious Incompetence
- Conscious Competence
- Unconscious Competence

Put simply, this translates as follows:

- You don't know what you don't know
- You know what you don't know and can't do it
- You can do it, but have to think hard about it
- You can do it on autopilot

Ideally when training, a high-fidelity scenario will be generated to get the blood pumping and the adrenaline flowing, as to program the muscle memory of applying a tourniquet under duress. Because guess what? That's exactly what it will be like on the day, multiplied by 100! Train like this at every available opportunity, and build casualty scenarios into your regular tactical training.

Train in lowlight conditions, in the rain, in the stinking heat and in the freezing cold, and when the time comes to apply a tourniquet for real you'll be unconsciously competent, so that it will happen on autopilot, and before you know it you will have effectively stopped an arterial bleed and saved a life. It all comes back to the discipline of training as you're going to fight.

A video of Care Under Fire training by Special Operations medics, including arterial tourniquet application, can be found at the fol-lowing link:

https://www.youtube.com/watch?v=q5qGYw7xF8A

TWELVE

THE IMPORTANCE OF COMMAND-DRIVEN MEDICAL TRAINING

Back in 1998 when the then Colonel Stanley McChrystal was commanding the 75th Ranger Regiment, he instituted medical training as one of his "Big Four" major training priorities (Kotwal 2011). To put some perspective on that, the remaining three training priorities were marksmanship, physical training and small unit tactics. Resultantly, the men of the 75th Ranger Regiment were all trained in the use of arterial tourniquets through reality-based training. Fast-forward about a decade, and 419 battle casualties later, the 75th Ranger Regiment was able to demonstrate that their command-directed medical training and casualty response had statistically significantly lowered the Regiment's battlefield death rates when compared to those of the wider US Army (Kotwal 2011). Furthermore, the Regiment had not sustained a single fatality that could have been saved by improved pre-hospital care.

The take-home point here is that command-driven medical training saves lives. If you are a commander yourself, or have the ear of one, I implore you to look up the Kotwal paper and read it. You can make a difference to the survivability of your men and women who put themselves in harm's way. Even if you're not in a position of higher command, or if your commander is not receptive to tactical medical training, use whatever command you have to influence those you can. If you command a section, platoon, squad, team, or even just your partner, grab some tourniquets and find someone appropriate to train you to use them.

THIRTEEN

CASES FROM THE FIELD

The following two photos illustrate examples where arterial tourniquets have been used in the pre-hospital setting by the first responder with life-saving effect. In both instances the casualties sustained bilateral lower limb amputations from IEDs however, due to the rapid application of tourniquets, were alive at the receiving medical facilities where these photos were taken. The tourniquets have all been placed high and tight on the amputated limbs.

The next two photos are of a traumatic arm amputation from an IED, and illustrate an example of an injury that was too high on the arm for an arterial tourniquet to be effective. In this instance, a tourniquet was placed, however the first-responder quickly realised that the wound continued to bleed due to the artery in the injured limb retracting up into the armpit, and above the applied tourniquet. Packing the wound with gauze, and applying a pressure dressing over the top eventually controlled the bleeding. In the second image it can be appreciated that there was no way a tourniquet could have been placed 10cm (2-3 inches) above the wound.

A final case study worth mentioning in this chapter comes from the hills of Afghanistan, where a pair of Special Forces soldiers were engaged with small arms fire whilst manning an Observation Post. During the firefight, one of the soldiers received a through-and-through gunshot wound to one of his upper forearms that whilst not obviously bleeding arterially; the other soldier rapidly applied an arterial tourniquet to. This allowed the uninjured soldier to immediately return to the firefight and gain control over the tactical situation. As soon as the threat was neutralised, the gunshot wound was closely inspected and deemed not to be arterial. A pressure dressing was applied and the tourniquet was removed.

Whilst this theoretically represents an inappropriate placement of an arterial tourniquet, owing to the inability of the first-responder to assess the wound thoroughly at the time of injury, an arterial tourniquet was used just in case, and then quickly revised after the firefight ended. There was no damage done by the temporary application of the tourniquet, however if the wound had have been bleeding arterially, that extra 4-5 minutes whilst the tactical situation was being controlled could have meant a significant amount of blood loss for the casualty if a tourniquet had not been used.

FOURTEEN

TOURNIQUET JUNGLE TIPS

• Arterial tourniquets are painful! Applying a tourniquet to a conscious casualty is being cruel to be kind, and expect the casualty to be in severe pain from the device. Don't be tempted to release it on account of pain if the casualty has an arterial injury. Use pain relief if you have it and if it's appropriate, otherwise reassure your casualty and get them to a surgeon quickly. They won't thank you at the time, but they will thank you later.

• Check your tourniquet regularly after application, and especially after every move of the casualty, to ensure it hasn't loosened and is still working, and that the casualty isn't re-bleeding.

• If you've applied a tourniquet to an amputated limb, the bone marrow down the centre of the stump may continue to bleed. Use a pressure dressing and elevation to control this.

• Make sure to check for pulses in the limb that you've applied a tourniquet to. If you can still feel a pulse, your tourniquet needs to be tightened further.

• When applying a tourniquet it is a good habit to get into to practice keeping the tail of the tourniquet strap facing away from the body. Whilst not essential, that way it is often easier to tighten the strap appropriately without getting caught up in the groin or armpit.

• Remember when applying a tourniquet to keep the windlass on the outside of the limb where you can get to it. Once again, it is terribly difficult to tighten the windlass when it is tucked into the groin or armpit

• Apply the tourniquet as straight as you can across the injured limb. If the tourniquet is applied at an oblique angle, for example higher at the back than the front, it will tend to work its way loose and be-come ineffective.

• Never use your operational tourniquet for training. Once a tourniquet has been tightened once it will stretch slightly and there's no guarantee that it will work effectively again.

• Keep a supply of specific tourniquets for training, and make sure they are clearly marked as such. For example, use the commercially available blue SOF-TTs, or otherwise spray paint some old tourniquets a different colour to designate them as training stock. This will ensure that they don't get mixed up with operational ones.

• Try and get into the habit of documenting the application time of tourniquets in training. Whilst this isn't absolutely essential, it is a great habit to be in, and will be useful information to the medical staff on the day when you do have to use one in anger.

• If you don't have a commercial tourniquet available and need to improvise one, the critical part to make it work effectively is the windlass mecha-nism. Wrap something such as a rolled up shirt around the limb, ideally with a width of approximately 4-5cm (2 inches) and then tie it tight. Once in place, find a rigid bar of some description, such as a thick stick, car jack handle, leg from a chair etc. and feed it under the tightly tied loop of fabric. From there, start twisting the rigid bar to constrict the loop of fabric and provide concentric pressure to the limb. Beware that this will pinch the skin under the improvised windlass, and it will hurt. Once the arterial bleed is controlled, it is a matter of improvising a way to lock the windlass in place, or holding it yourself until medical help arrives. It won't be pretty, but it will be lifesaving!

http://tacmedaustralia.com.au/improvised-arterial-tourniquet-using-items-car-boot/

• If there is an ambulance nearby but no commercial arterial tourniquet, a blood pressure cuff can be used instead to control arterial bleeding. At the end of the day, when we take a blood pressure, the first thing that we do is pump the cuff up until the blood flow is occluded.

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FIFTEEN

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