The Occasional

The Occasional limb tourniquet application and tourniquet conversion

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INTRODUCTION

The application of a limb tourniquet is a potentially life-saving intervention in the context of significant limb hemorrhage. It is essential that physicians encountering amputations or wounds with significant hemorrhage can properly perform tourniquet application as well as understand the potential complications of tourniquets and their removal. When a tourniquet remains in place for prolonged periods of time, the complications of the intervention itself can contribute to increased morbidity and even mortality. The rate of complications rises the longer that the tourniquet remains applied. Physicians assessing patients who have had a tourniquet applied in the pre-hospital environment must be familiar with the criteria for determining if an attempt at tourniquet conversion (i.e., removal) is appropriate and have an organised approach to attempting the tourniquet conversion. This is especially important in rural centres, where patients are more likely to experience long transfer times and potential delays in transfers to hospitals with advanced surgical capabilities.

TOURNIQUET APPLICATION

Indication for tourniquet application

The indication for tourniquet application is significant hemorrhage from a limb injury that cannot be immediately managed by other means. Multiple large epidemiologic studies using data from military trauma registries have demonstrated that the application of tourniquets carries a mortality benefit of up to 67% in patients with significant limb hemorrhage.[1,2] The mortality benefit of tourniquet application has been demonstrated in the civilian context as well.[3,4]

Tourniquet site selection

There are 2 methods for selecting the site of tourniquet application [Figure 1]. The *distal method* is traditionally taught to physicians, paramedics and other advanced medical providers. In this method, the tourniquet is applied 2–3 inches just proximal to the site of bleeding, or if this site is noncompressible, then over the next closest compressible site on the limb.[5] Joints are noncompressible, and therefore, tourniquets should

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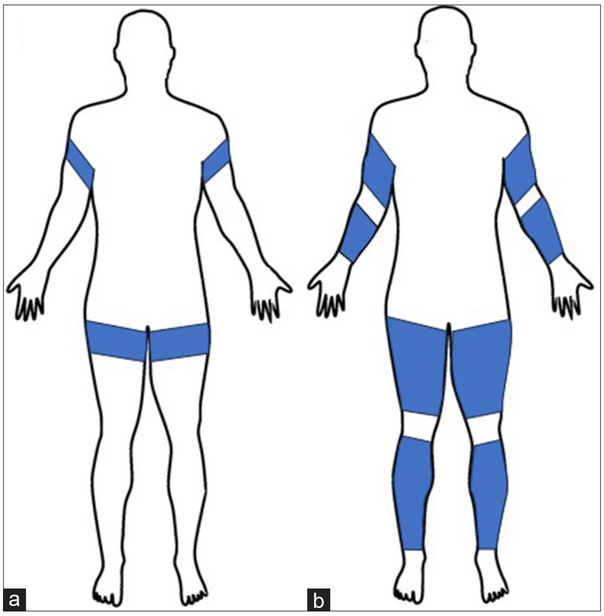

Figure 1: Tourniquet application sites. (a) Represents the application sites described in the 'high and tight' approach to tourniquet application. (b) Represents the application sites described in the 'distal method'.

never be applied over joints.[5] The alternative *high and tight method* is often taught to individuals trained to operate in the pre-hospital environment, such as military medics, police officers and other first responders. In this method, the tourniquet is always placed on the most proximal compressible portion of the injured limb.[6] This method is preferable when the clinician is unable to immediately assess the limb in the pre-hospital environment to determine the site of bleeding, due to external constraints. Physicians managing a patient with a *high and tight* tourniquet should recognise that even if the tourniquet cannot be fully converted, attempts should be made to reposition the tourniquet site more distally on the limb.

Tourniquet application procedure

1. Remove the tourniquet from the manufacturer's packaging
2. Expand the loop to be able to apply to the limb or break the loop completely
3. Slide the tourniquet up the limb to the desired site, or if the loop was removed, wrap the tourniquet around the limb at the desired site
4. Pull the loop as tightly as possible and hold in place with the Velcro on the strap
5. Turn the windlass using both hands to generate enough force to tighten it enough to stop arterial flow. Usually, 3 turns is required to accomplish this
6. Confirm that the bleeding stops and pulses are lost distally
7. Lock the windlass bar in place and cover with the distal part of the Velcro strap
8. Note the time that the application took place by writing it on the tourniquet.

REPERFUSION SYNDROME

While a tourniquet is applied and the flow of blood is restricted, the tissues distal to the device experience ischemia. As the tourniquet application time increases, the degree of ischemia increases proportionally.[7] When a tourniquet is released, and blood flow is restored, the venous return from the limb carries metabolic products caused by cellular ischemia and cell death, which can cause a number of immediate life-threatening effects.[8] These effects are collectively called *reperfusion syndrome*.

The elements of reperfusion syndrome include acidosis, cardiac arrhythmias, hypothermia, hypotension and acute kidney injury. The acidosis is mostly caused by the circulation of lactic acid released by ischemic tissues. Cardiac arrhythmias are precipitated both by the acidosis and by hyperkalemia. Hyperkalemia occurs because ischemic and dying cells release intracellular stores of potassium. Hypothermia occurs through 2 mechanisms. The blood that had been sequestered in the limb behind the tourniquet is cool, and when it returns to the core, it causes an immediate drop in core body temperature. More significantly, the tissues distal to the tourniquet are also cool, so the limb itself acts as a heat sink for the fresh circulating blood perfusing the limb after the tourniquet conversion. Hypotension occurs after a tourniquet is taken off, and there is a sudden increase in the amount of tissue the body's circulating volume must perfuse. Hypotension can be worsened by inappropriate vasodilation in the affected limb due to ischemia-caused impairment of the nerves involved in sympathetic vasoconstriction. An acute kidney injury is caused by the impact of myoglobin and other metabolic products on the proximal tubule.[9] The elements of reperfusion syndrome are summarised well in an online medical blog post by Weinrauch.[10]

The different elements of reperfusion syndrome can be pretreated by applying the ABCDE approach presented by Weinrauch, where each letter represents an intervention to be performed.[10] A stands for (inducing) Alkalosis, B stands for (raising the) Blood pressure, C stands for (administering) Calcium, D stands for (applying) Defibrillation pads and E stands for both Electrolyte (meaning lowering serum potassium) and Environment (meaning hypothermia prevention). These interventions and how to perform them are described in detail in Table 1.

TOURNIQUET CONVERSION

Tourniquet conversion refers to the process of taking off the tourniquet and converting to another form of hemorrhage control. The term 'tourniquet conversion' is recommended over 'tourniquet removal' because it emphasises that the clinician must have a plan to transition to another form of hemorrhage control before taking off the tourniquet. Other methods of controlling limb hemorrhage include direct pressure, wound packing, balloon catheter tamponade, vessel ligation or vessel clamping.

In the pre-hospital management of trauma, there are often multiple competing priorities, including the need to initiate patient transport and ensure scene safety for both the patient and responders. A patient may therefore have a tourniquet applied in the pre-hospital environment, even though the hemorrhage could be effectively controlled with other methods once the patient arrives at a higher level of care. Studies from both military and civilian contexts have shown that between half and three-quarters of tourniquets can be successfully converted to another form of hemorrhage control.[4,11,12] Given the high rate of successful conversion, clinicians should consider tourniquet conversion in every patient with a tourniquet to avoid preventable morbidity and mortality caused by an unnecessary prolonged tourniquet application.

When attempting a tourniquet conversion, the alternative method of hemorrhage control should be applied before the tourniquet is loosened. The goal is to prevent the recurrence of bleeding, rather than manage the recurrence of bleeding after the tourniquet is removed. If wound packing is going to be employed as a method of hemorrhage control, the wound should be packed and direct pressure applied for 3 min before tourniquet removal.[6]

Table 1: ABCDE approach to managing reperfusion syndrome

	How to perform	Purpose
Alkalosis	Administer 1 ampule (50 ml) of IV sodium bicarbonate 5 min before TQ conversion In mechanically ventilated patients, hyperventilate patient to induce a respiratory alkalosis targeting an end tidal CO_2 of 33–35 mmHg	Counteracts the acidosis caused by the return of lactic acid from the affected limb after TQ release
Blood pressure	Resuscitate the patient with crystalloids, blood products and vasopressors if required	Raises the systolic blood pressure high enough to accommodate the anticipated sudden drop that occurs immediately after TQ release
Calcium	Administer 1 ampule of IV calcium gluconate 2 min before TQ conversion	Stabilises cardiac myocytes to counteract the dysrhythmic effects of hyperkalemia and acidosis Calcium also functions as a cofactor in the activation of multiple coagulation factors
Defibrillation	Apply defibrillation pads to the patient before completing TQ conversion	Be prepared to manage unstable arrhythmias which may develop
Electrolyte	Administer 10 units of IV regular insulin along with 1 ampule of D50 Repeat as required, targeting a serum K level of 3.5 mEq/L prior to TQ conversion	Lowering the serum potassium allows for accommodation of the anticipated sudden raise in serum potassium that occurs after TQ release
Environment	Warm the affected limb with warmed blankets and forced warm air prior to TQ conversion	Prevents hypothermia caused by the return of cold blood to the core immediately after TQ release and from the affected limb acting as a heat sink as it is reperfused

Adapted from Weinrauch[10]. D50: 50 g dextrose in water, TQ: Tourniquet, IV: Intravenous

Contraindications

There are 3 contraindications to attempting tourniquet conversion.[6] The first contraindication is if the patient is clinically in shock. Since an attempt at tourniquet conversion could fail, clinicians must not attempt the procedure in patients who cannot reasonably tolerate the effects of further blood loss without becoming critically unwell. Patients who are in shock should be resuscitated first, and then, conversion can be considered once they are hemodynamically stable. The second contraindication is if it will not be possible to monitor the patient following the proposed tourniquet conversion. It would not be appropriate to perform an intervention that could result in the recurrence of bleeding or other complications if it won't be possible to monitor for those complications. Practically speaking, this could arise when space restrictions limit access to the affected limb during an interfacility transfer or when a patient is taken to another area of the medical facility where they will have a lower level of monitoring (e.g., the radiology department). The third contraindication is if the tourniquet is on a limb that has been amputated. The goal of tourniquet conversion is to avoid a prolonged tourniquet time that could affect the health of salvageable tissues sequestered behind the tourniquet. If the limb has been amputated, there is no longer any salvageable tissue present, and therefore, the goal of tourniquet conversion is unachievable.

Timeline

The goal is to limit tourniquet application time to <2 h.[5,6] If a tourniquet is successfully converted in <2 h, there is unlikely to be any significant damage to the distal tissues due to the ischemia. There has also not been sufficient ischemia to precipitate the elements of reperfusion syndrome [Figure 2]. It is therefore safe to convert a tourniquet within 2 h without treating for any of the elements of reperfusion syndrome [Figure 3]. If the patient can be transferred to a surgical centre within 2 h of tourniquet placement, then tourniquet conversion should only be attempted if it will not delay the patient transfer.

Once a tourniquet has been applied for more than 2 h, there has been significant ischemia to the distal tissues. Between 2 and 6 h of tourniquet time, it is anticipated that there will be some permanent damage to the ischemic tissues, but the limb is potentially salvageable. There is also a moderate risk of precipitating a reperfusion syndrome by taking off the tourniquet within this timeframe. These tourniquets are the most urgent to convert, since the ischemic tissue damage is worsening the longer the tourniquet is applied. However, due to the risk of reperfusion syndrome, these tourniquets should only be removed by a team capable of ACLS level of care that is prepared to treat for reperfusion syndrome.[5,6]

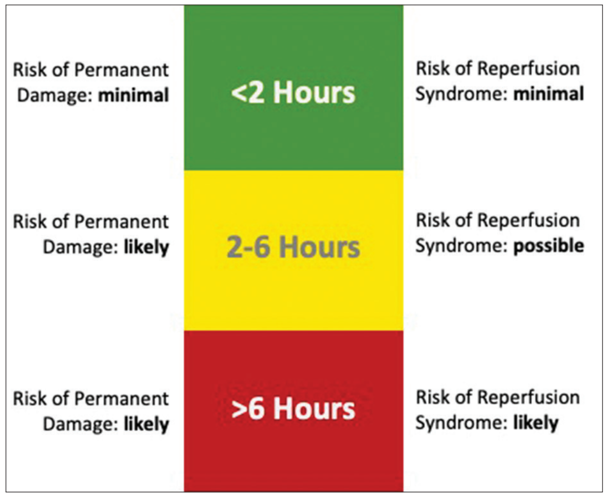

Figure 2: Risk of tourniquet application based on tourniquet application time. Adapted from Weinrauch.[13]

Once a tourniquet has been applied for 6 h or more, it is anticipated that there has been a significant amount of damage to the distal tissues. These limbs are unfortunately at high risk of undergoing a delayed amputation due to the damage caused by the tourniquet. It is therefore less urgent to convert a tourniquet that has been on for more than 6 h, as there is a limited likelihood of benefit to the distal tissues. Removing a tourniquet that has been applied for more than 6 h will, however, likely cause a significant reperfusion syndrome.[5,6] These tourniquets should only be removed in a surgical facility once the patient has been pretreated for all the elements of reperfusion syndrome.[10]

CONCLUSION

The majority of tourniquets that are applied to manage hemorrhage can be successfully removed without the resumption of life-threatening

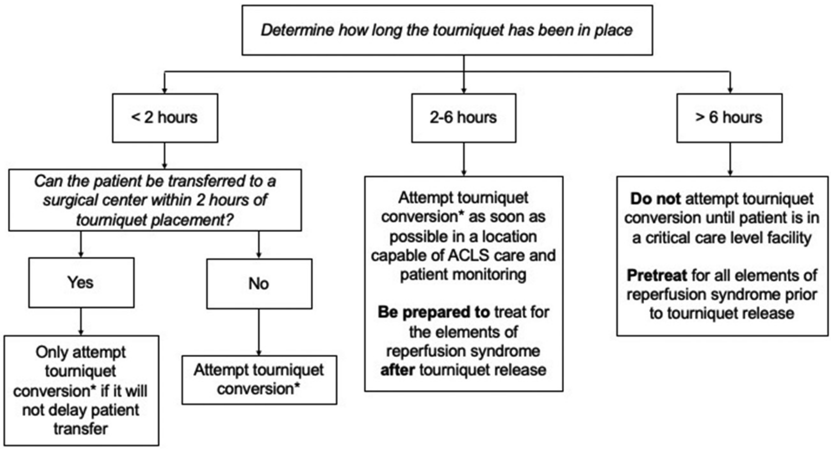

Figure 3: Approach to initiating tourniquet conversion based on the duration of tourniquet application. Adapted from Jerome.[14] *Tourniquet conversion should only be attempted if no contraindications are present. The contraindications are if the patient is in shock, the tourniquet is managing a traumatic amputation or the team is unable to closely monitor the patient after tourniquet removal.

hemorrhage. There are 3 contraindications to tourniquet removal – if none of these are present, the goal is to limit tourniquet application time to <2 h. Tourniquets that have been applied for 2–6 h are the most urgent to remove, since the degree of permanent damage is increasing within this timeframe. When clinicians are removing tourniquets that have been applied for a prolonged period of time, they should be aware of and prepared to manage the elements of reperfusion syndrome.

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REFERENCES

1. Kragh JF Jr., Littrel ML, Jones JA, Walters TJ, Baer DG, Wade CE, *et al*. Battle casualty survival with emergency tourniquet use to stop limb bleeding. J Emerg Med 2011;41:590-7.
2. Kotwal RS, Montgomery HR, Kotwal BM, Champion HR, Butler FK Jr., Mabry RL, *et al*. Eliminating preventable death on the battlefield. Arch Surg 2011;146:1350-8.
3. Teixeira PG, Brown CV, Emigh B, Long M, Foreman M, Eastridge B, *et al*. Civilian prehospital tourniquet use is associated with improved survival in patients with peripheral vascular injury. J Am Coll Surg 2018;226:769-76.e1.
4. Kue RC, Temin ES, Weiner SG, Gates J, Coleman MH, Fisher J, *et al*. Tourniquet use in a civilian emergency medical services setting: A descriptive analysis of the Boston EMS experience. Prehosp Emerg Care 2015;19:399-404.
5. Deployed Medicine. Joint Trauma System. Tactical Combat Casualty Care (TCCC) Guidelines 2024; 2024. Available from: https://deployedmedicine.allogy.net/learner/collections/11/contents/40. [Last accessed on 2025 Jun 03].
6. American College of Surgeons. Advanced Trauma Life Support Course Manual. 11th ed. Chicago: American College of Surgeons; 2025.
7. Joarder M, Noureddine El Moussaoui H, Das A, Williamson F, Wullschleger M. Impact of time and distance on outcomes following tourniquet use in civilian and military settings: A scoping review. Injury 2023;54:1236-45.
8. Kalogeris T, Baines CP, Krenz M, Korthuis RJ. Cell biology of ischemia/reperfusion injury. Int Rev Cell Mol Biol 2012;298:229-317.
9. Hebert JF, Burfeind KG, Malinoski D, Hutchens MP. Molecular mechanisms of rhabdomyolysis-induced kidney injury: From bench to bedside. Kidney Int Rep 2023;8:17-29.
10. The Cove. Weinrauch P. The Reperfusion Toolbox: How to Resuscitate a Casualty in Preparation for Tourniquet Removal After an Extended Duration of Application; 2023. Available from: https://cove.army.gov.au/article/reperfusion-toolbox. [Last accessed on 2025 Jun 03].
11. Lakstein D, Blumenfeld A, Sokolov T, Lin G, Bssorai R, Lynn M, *et al*. Tourniquets for hemorrhage control on the battlefield: A 4-year accumulated experience. J Trauma 2003;54:S221-5.
12. Yatsun V. Application of hemostatic tourniquet on wounded extremities in modern “trench” warfare: The view of a vascular surgeon. Mil Med 2024;189:332-6.
13. The Cove. Weinrauch P. The Tourniquet Traffic Light; 2023. Available from: https://cove.army.gov.au/article/tourniquet-traffic-light. [Last accessed on 2025 Jun 03].
14. Jerome D. In response to implementing tourniquet conversion guidelines for civilian EMS and prehospital organizations by Standifird *et al*. Wilderness Environ Med 2025;36:139-46.