

## Tourniquet Conversion

### *A Recommended Approach in the Prolonged Field Care Setting*

Brendon Drew, DO; David Bird, PA-C, MPAS; Michael Matteucci, MD; Sean Keenan, MD

#### ABSTRACT

Life-saving interventions take precedence over diagnostic maneuvers in the Care Under Fire stage of Tactical Combat Casualty Care. The immediate threat to life with an actively hemorrhaging extremity injury is addressed with the liberal and proper use of tourniquets. The emphasis on hemorrhage control has and will continue to result in the application of tourniquets that may not be needed past the Care Under Fire stage. As soon as tactically allowable, all tourniquets must be reassessed for conversion. Reassessment of all tourniquets should occur as soon as the tactical situation permits, but no more than 2 hours after initial placement. This article describes a procedure for qualified and trained medical personnel to safely convert extremity tourniquets to local wound dressings, using a systematic process in the field setting.

*Keywords: prolonged field care; tourniquets; tourniquet conversion; Tactical Combat Casualty Care*

#### Introduction

The use of tourniquets has been controversial throughout military history.<sup>1</sup> As recently as 2003, literature has referenced the tourniquet “as an instrument of the devil that sometimes saves a life.”<sup>2</sup> Although the authors of this article described the “balance of risk [as] unclear” with tourniquet use, they acknowledged the effectiveness of tourniquets in selected tactical situations.<sup>2</sup> Seldom in recent medical history has the medical pendulum swung more extensively than in the use and utility of tourniquets. Fortunately, comments such as the quote above are no longer found in the literature. Research on tourniquet use during the recent military conflicts has demonstrated the effectiveness of properly applied tourniquets. As combat operations shift from Iraq and Afghanistan, evacuation times will become longer and longer due to the immaturity of the medical footprint at the tactical level and the sheer distances that must be traveled, such as in Africa. Future tourniquet training must include discussions relating

to the conversion of tourniquets before definitive care is reached.

In the Care Under Fire (CUF) phase of the Tactical Combat Casualty Care (TCCC) guidelines, liberal use of tourniquets is encouraged on all concerning extremity hemorrhages. In this phase of care, the ability of wounded individuals and medical personnel to safely and accurately complete diagnostic evaluations is nearly impossible due to the ongoing active enemy threat and incoming fire. Life-saving actions take precedence over diagnostic maneuvers. As soon as the tactical situation permits, reassessment of all wounds and tourniquets occurs. For compressible hemorrhage not amenable to tourniquet use, or as an adjunct to tourniquet removal (if evacuation time is anticipated to be longer than 2 hours), the use of hemostatic dressing with direct pressure is indicated. Reassessments of the need and quality of the tourniquet should be accomplished at least every 2 hours during this phase, with the goal of converting the tourniquet to a hemostatic and pressure dressing as early as possible.<sup>3,4</sup>

The safety of this recommendation to place a proximal tourniquet for any significant extremity hemorrhage is reinforced by the lack of documented cases of permanent tissue damage, permanent vascular injury, or permanent nerve injury from a properly applied tourniquet (arterial flow to extremity stopped) in place for less than 2 hours.<sup>5-7</sup> Most complications reported in the literature were the result of improper application. Venous occlusion without arterial occlusion is a major concern that leads to continued bleeding,<sup>7</sup> and is beyond the scope of this paper. In one case-series review of 91 patients, 47% of the tourniquet applications were classified as “not indicated,” a 6.5-cm-wide elastic band was used, and total tourniquet times less than 150 minutes had no documented complications.<sup>8</sup> Not only were almost half of the tourniquets placed not clinically indicated, but the type of tourniquet used exerted more mechanical damage on tissue than the TCCC-approved tourniquets. The risks of *not* using a tourniquet immediately are more relevant than the risks of a properly applied tourniquet in the CUF phase of TCCC.

There is little scientific evidence available to definitely declare the upper time limit of the “safe” amount of time for a tourniquet to be left on. Even a recent extensive review in the orthopedic literature of use of tourniquets in the operating room was unable to definitively answer the question.<sup>9</sup> Several experts feel that conversion may be attempted up to 6 hours after initial tourniquet application.<sup>10</sup> The longer a tourniquet is in place, the more tissue destruction occurs and the higher the risk for reperfusion injury and kidney failure. This time window is influenced by the amount of ischemic tissue distal to the tourniquet (proximal worse than distal and leg worse than arm), the temperature of the extremity (warm worse than cold), and the hemodynamic status of the patient.

To demonstrate the difficulty in defining a definitively safe time limit for conversion, there is a case with documented total tourniquet time of up to 16 hours. In this case, the extremity was exposed to the cold environment and the tourniquet was placed distally on the upper extremity. This patient had residual motor and sensory deficits but no systemic complications of reperfusion.<sup>11</sup>

Conversion is the deliberate process of trying to exchange a tourniquet for a hemostatic agent or a pressure dressing. Conversion is an essential skill for all medical personnel to learn. Tourniquets cause pressure injury to the tissue that is being directly compressed and ischemic injury to the tissue that is no longer perfused. Conversion has been advocated since at least World War II<sup>12</sup> and since the start of TCCC development,<sup>13</sup> but a step-by-step algorithm for military personnel has not been updated since 2005.<sup>10</sup> Since 2003, hemostatic agents have been developed and have evolved significantly,<sup>14</sup> as has the published literature on the use of tourniquets. Articles from 2007 and 2008 discussing the use of tourniquets in the civilian setting provided a more comprehensive algorithm for tourniquet conversion but did not account for military-specific concerns relating to: prolonged transport times, the need to reattempt tourniquet conversion during patient re-evaluations, and the potential for tourniquet failure if retightening is needed.<sup>15,16</sup> Our paper also introduces the concept of the “Plus-1” tourniquet to the algorithm of treating any patient to whom a tourniquet is applied.

### Tourniquet Conversion Procedures

When should tourniquet conversion occur? The definitive answer to this is unknown, but generally:

- Conversion should be attempted as soon as tactically appropriate, but no later than 2 hours after initial tourniquet application.
- Conversion should be attempted with each progressive movement to the next level of care, but not for

tourniquets that have been in place for more than 6 hours, unless at a definitive care facility.

In addition,

- **Less than 2 hours after application is considered safe** (attempt conversion)
- **2–6 hours is likely safe, but the upper safe limit has not been scientifically determined** (attempt conversion)
- **More than 6 hours requires caution** (field conversion not advised)<sup>10</sup>

### Plus-1 Tourniquet

Add one loose tourniquet to each extremity to which a tourniquet has already been applied (“Plus 1”). This is done for two reasons. The first is if the tourniquet that is already in place breaks during the conversion process, there is already a backup in place ready to be tightened. Tourniquets are subject to environmental degradation<sup>17,18</sup> and significant wear and tear during application.<sup>19</sup> In a recent After Action Report distributed with the 2014 Committee on TCCC meeting minutes, 10% of the tourniquets used in a six-patient casualty incident broke while being applied. The second reason is that it is difficult to determine where the patient is on the resuscitation curve. Administration of fluids (crystalloids, colloids, or blood) and/or ketamine has the potential to raise blood pressure beyond the hypotensive target. A second tourniquet in place reduces bleeding time if bleeding suddenly recurs (Figures 1 through 7).

With the Plus-1 tourniquet in place, loosen the first tourniquet. If no bleeding from the wound is noted, then leave both tourniquets in place but not tightened and dress the wound. If bleeding is noted, apply a hemostatic

**Figure 1** A simulated patient with a single tourniquet placed over the thigh. The tourniquet is placed high and tight in a proximal position, emphasizing the need for immediate hemorrhage control in the Care Under Fire stage. Diagnostic maneuvers such as exposure and wound examination are reserved for the Tactical Field Care stage. The tourniquet remains visible and is marked with time of application.



**Figure 2** For instructional purposes, the same tourniquet is shown without uniform pants. The simulated injury is to the distal thigh (red marker). No active bleeding is noted and the distal pulse is confirmed absent.



**Figure 3** The next step is placement of the “Plus-1” tourniquet proximal to the original tourniquet. The Plus-1 tourniquet is not tightened.



**Figure 4** Attempted conversion to hemostatic agent. The wound is inspected, the original tourniquet is loosened, and a hemostatic agent is applied with manual pressure for 3–5 minutes.



**Figure 5** The hemostatic agent is secured with a pressure dressing. If no further bleeding is noted, both the original and Plus-1 tourniquets remain in place completely loosened.



**Figure 6** Conversion fails and the wound bleeds through the hemostatic agent/pressure dressing.



**Figure 7** The original tourniquet is moved as close to the wound as possible and retightened. The Plus-1 tourniquet is left in place completely loosened. If bleeding recurs, the Plus-1 tourniquet is already positioned for rapid tightening.



agent and hold pressure for 3–5 minutes. If no further bleeding is noted, leave both loose tourniquets in place and dress the wound. If hemostatic agents fail to control the bleeding, tighten the original tourniquet in as distal a position as possible to control the bleeding. Ensure the distal pulse is absent. Leave the Plus-1 tourniquet loose and proximal to the tightened tourniquet.

### Contraindications for Tourniquet Conversion

When should tourniquets not be converted? There should be no attempt to convert tourniquets used for amputations. The tourniquet should be placed 2–4 inches above the amputation, avoiding joints, but proximally enough to prevent bleeding. Another contraindication



to tourniquet conversion is the inability to monitor the patient directly. The inability to observe the casualty in the event of rebleeding is a contraindication to conversion. This includes patients wrapped in blankets or other hypothermia-prevention materials. Conversion should not be attempted if the extremity cannot be observed for active rebleeding.

Conversion should not be attempted on a patient in shock. This concern has been documented as far back as 1945. Wolff and Adkins reported on an alert but tachycardic and hypotensive patient who lost an estimated 100ml of blood during removal of a tourniquet before a new one could be placed. He showed immediate clinical signs of worsening shock and a systolic blood pressure of 80 mm Hg.<sup>12</sup> With any concern for hemorrhagic shock, resuscitation must be initiated prior to attempted tourniquet conversion.

Should tourniquets be periodically loosened to give the tissue oxygen and blood? A tourniquet should never be periodically loosened for this purpose. This results in “incremental exsanguination.”<sup>12</sup> In other words, the patient is bled to death in short bursts. A tourniquet should only be loosened during conversion.

Are there additional reasons that tourniquet conversion is important? Independent of hemodynamic and tissue preservation considerations, tourniquets are very painful when applied. Any intervention that decreases pain in wounded personnel is not only tactically important (cooperative patients are safer to transport) but medically and psychologically important (pain can cause tachycardia and improved pain control may contribute to lower incidence of posttraumatic stress disorder).<sup>20</sup>

## Conclusion

Arguably, the US military has become the leading authority in battlefield trauma care with the experience of combat operations over the last 10-plus years. A continuous quality assurance program using the Plan-Do-Study-Act methodology, with the institution of the robust Joint Theater Trauma System and the progressive development of the TCCC Guidelines has led to evidence-based trauma care that has improved survivability and decreased morbidity. In particular, the increased use of tourniquets for severe extremity wounds has contributed significantly to these improvements.

The haphazard release of a tourniquet without use of proper procedures can result in increased hemorrhage, morbidity, and mortality rates<sup>12</sup> within seconds. This illustrates a significant potential complication of the procedure, and we propose a valid approach to be adopted in future protocols: to apply at least one additional

tourniquet (Plus 1) loosely over the extremity to prevent additional bleeding from becoming clinically significant.

Tourniquets are essential tools in the initial treatment of exsanguinating extremity injuries, but adverse effects of tourniquet application can result in significant morbidity. Early conversion to hemostatic agents and/or standard wound dressings should be attempted by qualified and trained medical personnel in a controlled and systematic manner to avoid further complications and potentially reduce morbidity.

## Disclaimer

The views expressed in this article are those of the author(s) and do not necessarily reflect the official policy or position of the US Department of the Navy, US Department of Defense, or the US Government.

## Disclosure

The authors have nothing to disclose.

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**CDR Drew** is a staff emergency physician at Naval Medical Center San Diego, a Core Residency Faculty, assistant professor of Military and Emergency Medicine at the Uniformed

Services University of the Health Sciences; a Fellow of the Academy of Wilderness Medicine; the director of the Military Unique Curriculum and the Austere and Wilderness Medicine Curriculum; and has six deployments to Asia, Afghanistan, Iraq, and Africa. E-mail: [brendon.g.drew.mil@mail.mil](mailto:brendon.g.drew.mil@mail.mil).

**LCDR Bird** is a certified physician assistant, and a former SEAL and Special Operations Independent Duty Corpsman with Naval Special Warfare. He has nine deployments to Iraq, Afghanistan, and Africa.

**CAPT Matteucci** is a staff emergency physician at Naval Medical Center San Diego, the Emergency Medicine Residency program director, assistant professor of Military and Emergency Medicine at the Uniformed Services University of the Health Sciences, a Fellow of the Academy of Wilderness Medicine, and has four deployments to Iraq, Afghanistan, and Africa.

**COL Keenan** is a board-certified emergency physician and is currently serving as the 10th Special Forces Group (Airborne) surgeon. He has previously served as a battalion surgeon in both the 1st and 3rd SFG(A). He is a Fellow of the American Academy of Emergency Medicine, volunteers as one of the coordinators for the SOCOM Prolonged Field Care Working Group, and has five deployments to Afghanistan, Iraq, and the Philippines.

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