

Use of Tourniquets in Limb Trauma Surgery

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KEYWORDS

- Tourniquet • Exsanguination • Orthopedic limb trauma • Tourniquet design • Cuff pressure
- Cuff width

KEY POINTS

- Tourniquets are frequently used in both upper and lower extremities, usually without significant complications.
- Optimal pressure is still unknown, but using limb occlusion pressure rather than systolic blood pressure may be better for decreasing the risk of injury.
- No specific tourniquet design has been proven superior, but recent data points to assessing limb circumference when choosing a tourniquet.
- Protocols and guidelines for tourniquet use, taking patients and the type of procedure into consideration, are needed.
- Tourniquets are not benign and have been associated with fatalities, so the surgeon must remain vigilant and knowledgeable about their risks and benefits.

INTRODUCTION

A tourniquet is a device used to halt blood flow to an extremity. In the modern surgical theater, tourniquets of various designs are used in more than 15,000 procedures every day.¹ The goal of tourniquet application is most often to create a bloodless field; it is, however, also used to assist with limb anesthesia (ie, Bier block), venipuncture (to enlarge blood vessels), and control of catastrophic blood loss in an acute setting.²

The historical use of tourniquets dates back to the ancient Romans who used them in amputations,³ but the actual term was coined in the 1700s by Jean Louis Petit from the French term *tourner* ("to turn").¹ His simple device was a screw-type mechanism that was revolutionary in not requiring an assistant to keep the pressure constant. Lister performed the first nonamputation surgeries with a tourniquet, combined with

limb elevation for exsanguination. Later, Esmarch created the flat rubber bandage that now bears his name. In the early 1900s, Cushing developed the pneumatic tourniquet, a variant of which is still used today.^{1,3} This design was perfected in the 1980s by McEwen, who invented the modern microcomputer tourniquet, which monitored not only pressure but also leakage, inflation time, and other parameters. It also estimated the limb occlusion pressure (LOP) (the minimal pressure required to halt blood flow) and protected from both depressurization and overpressurization.²

Although tourniquets have been in use for many decades, definitive protocols are still lacking; physicians' knowledge of the risks and benefits of this device remains subpar. A study of residents and operating room (OR) assistants used a questionnaire that assessed their knowledge of tourniquet use, including repositioning, correct cuff size and

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shape, contraindications, safe inflation time, and other facts. The average test score for residents was 41.3% and 46.7% for assistants. The investigators cautioned that surgeons must be knowledgeable in the application and indications for tourniquets, particularly for medicolegal reasons.⁴ It is also important to note that most tourniquets are placed by assistants and not by the surgeons themselves, further divorcing the tourniquet from being an essential part of the case.

Formal protocols on tourniquet use in the United States vary greatly in scope and application, particularly in the prehospital setting. Eighty-four percent of states have statewide emergency medical systems (EMS) exsanguination protocols; only 35% have very clear, detailed instructions on when and how to use tourniquets. This factor likely results in suboptimal and sporadic use.⁵ The Eastern Association for the Surgery of Trauma has published a management guideline for penetrating lower extremity trauma that contains a section on tourniquets and states that a tourniquet can be used if direct pressure fails to control bleeding.⁶ However, this guideline is listed as level 3, which is defined by a lack of formal evidence.

Generally, no standard exists for tourniquet use; the decision rests with the individual surgeon. This decision is largely based on personal preference and several factors, including procedure duration, technical difficulty, blood loss, and the location of the injury on the body. Recently published articles summarize the various issues in tourniquet application.^{1,7} The goal of this work is to review the current literature on indications, technique points, and complications of tourniquets in limb trauma, both in the acute and elective setting.

PREHOSPITAL AND EMERGENCY TOURNIQUET USE

Although most of the literature on tourniquets in trauma focuses on elective procedures, some studies deal specifically with the prehospital setting. Much of what we know of tourniquet use in this setting comes from military experience. In the 1600s, French army surgeon Etienne Morel was one of the first to use tourniquets on the battlefield to treat extremity wounds.⁸ In the 1950s and 1960s, Vietnam War casualties often died of massive limb hemorrhage, leading to an increased interest in tourniquets as a life-saving measure.⁹ The explosive weapons of modern warfare in Iraq and Afghanistan also added to the experience of tourniquet use in soldiers.^{5,10}

On the battlefield, the Combat Application Tourniquet (CAT; www.combattourniquet.com) involves a simple windlass mechanism that can be applied one-handed with good results. A 4-year study of military prehospital tourniquet use in 550 patients at an average ischemic time of 83 minutes showed 78% overall effectiveness, 94% in upper limbs and 71% in lower limbs. No patient died of hemorrhage.⁹ Another prospective observational study of both civilian and military casualties in a Baghdad hospital assessed tourniquet use in the prehospital versus the emergency department (ED) setting. In 232 patients, the mortality rates were 11% in the prehospital group (n = 194) and 24% in the ED group (n = 38). Transient nerve palsies occurred in 1.7%. Prehospital use of the tourniquet was weakly associated with survival; the absence of shock with tourniquet use was also associated with survival. The study also matched a group of patients for the Injury Severity Score and Abbreviated Injury Scale scores. Patients who had a tourniquet placed were matched with those who had compressible limb injuries and would have benefited from a tourniquet but did not get one because of availability or medic decision. All patients in the latter group died (0% vs 77% survival rate).¹¹

The frequency of tourniquet use in the military has not translated to the civilian sector, largely because of the faster access to definitive care in the case of civilian trauma.¹² Some investigators state that a tourniquet should never be used as a first-aid measure,³ but literature exists to counter that position. Civilian settings where tourniquets may be useful include penetrating trauma, such as stab and gunshot wounds, terrorism incidents, rural or wilderness medicine, limb entrapment with an inaccessible bleeding site, industrial or machinery accidents, and extreme or life-threatening situations.⁸ One study examined injury patterns and outcomes in 14 civilians who died of exsanguination of an isolated extremity injury. It showed that only one patient had some attempt at bleeding control before EMS arrival, and intravenous (IV) access was not obtained in 71%. This study suggested that aggressive attempts to control limb hemorrhage, such as with a tourniquet, may prevent death from exsanguination.¹³

A retrospective review of 87 civilian patients looked at tourniquet use (primarily with the CAT) in the prehospital, ED, and OR settings. Half of the cohort had tourniquets applied in the prehospital time period, mostly on upper extremities. The Mangled Extremity Severity score and the rate of limb loss did not differ between

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