

## SURGICAL TOURNIQUET: Current Standard of Care

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### INTRODUCTION

Although members of the Podiatry Institute pride themselves in anatomic dissection as a means to control surgical hemostasis, there certainly are situations where the aid of a pneumatic tourniquet does apply. Tourniquet use in lower extremity surgery is not a benign task, rather it should be a well contemplated endeavor. Despite the Food and Drug Administration's labeling of pneumatic tourniquets as a Class I medical device (the same class as tongue depressors), serious sequelae may result when a tourniquet is used improperly. The purpose of this update is to provide the reader with a basic knowledge base that can be used to prevent unnecessary harm to patients during surgery.

### HISTORICAL REVIEW

The Roman Empire can be credited with the first documented use of a leather padded, bronze strap used as a method to control blood loss during limb amputation, often necessary after traumatic injury. However, the term "tourniquet" was not used until centuries later when a wooden rod was used with a simple cloth turned round and round for compression. Tourniquet is based on the French word *tourner*, which means to turn (Figure 1). During the

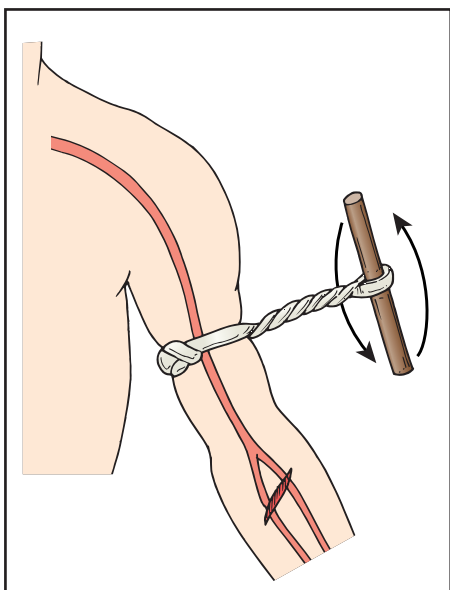


Figure 1. Early tourniquet.

1800s the British surgeon Joseph Lister, considered by many to be the father of modern surgery, was the first to use a tourniquet to provide a bloodless surgical field. It was during that same era that German surgeon Johannes Friedrich August von Esmarch began using an elastic rubber bandage to both exsanguinate and provide hemostasis for limb surgery. The invention of the first pneumatic tourniquet was credited to Harvey Cushing in the early 1900s. Ironically, Cushing was a neurosurgeon. Today's modern automated pneumatic tourniquet was developed and patented by Canadian biomedical engineer, James McEwen, just three decades ago (1,2).

### COMPLICATIONS OF TOURNIQUET USE

All tourniquets, whether simplistic or sophisticated pose the threat of potential complications to the patient. From mild postoperative irritation and pain to nerve palsies and rhabdomyolysis of muscle tissue, the potential for injury is real (3-6). Having knowledge of the most common reactions and complications as well as understanding the risks of more serious damage are essential.

Effects of tourniquet use are related to two main components, ischemia and compression. Together this dynamic duo creates systemic changes as well as localized damage to the tissues, and is largely time and pressure dependent. Systemic effects include possible transient rises in systolic blood pressures, tachycardia, metabolic changes of lactic acid and potassium levels, rise in body temperature, and re-perfusion syndrome. These systemic effects are observed during tourniquet inflation and may also be observed several hours post deflation (7-10). PACU monitoring of your patients after lengthy procedures with tourniquet use is a necessity and allows for optimal recovery from any systemic changes. Local effects of tourniquet use include possible cutaneous abrasions or necrosis, chemical burns, muscle injury or impairment, nerve palsies or conduction delays, and vascular damage of veins or even arteries (11-13). This being said, muscle injury occurs most frequently, followed by nerve injury, and lastly vascular injury. Most injuries have been attributed to tourniquet use outside the recommended time or pressure setting guidelines (14-17) (Figure 2).



Figure 2. Example of tourniquet injury.

## RECOMMENDATIONS FOR SAFE USE

Although no “safe use protocol” will be an exact algorithm applicable to every patient, there are recommendations that have been developed and widely accepted for the majority of patients (1,3,17). The American Academy of Orthopedic Surgeons proposed these recommendations last year after a critical investigation and thorough evaluation of the literature, including evidence-based medicine, from the past 40 years (17) (Table 1). Despite these generalized recommendations, circumstances remain where they may not be applicable or may need modification. Some examples include patients with venous disease, vascular disorders such as Raynaud’s Syndrome, Buerger’s Disease, patients who have had recent lower extremity bypass surgery, severe crush injuries or compartment syndrome, and sickle-cell patients to name a few (18-22).

## ADDITIONAL FACTORS INFLUENCING SAFE USE

Tourniquet design, positioning and skin-tourniquet interface play a role in safe use in addition to the standards of time, pressure and re-perfusion recommendations. Multiple studies have demonstrated that the use of wider cuffs creates less tissue damage and can be more effective even at lower pressures (23-25) (Figure 3). Lower, effective occlusion pressures are safer for patients and less likely to cause muscle and nerve damage. Limb occlusion pressure can be used to determine safer inflation pressures when concerned with procedures longer than 2.5 hours. This is done with a Doppler probe on the distal pulse listening for absence of a pulse as you dial up the pressure on the machine. There is a safety margin of an additional 40 mm Hg to account for physiologic fluctuations during surgery (17,25,26).

Cuffs that have a contoured shape have also been proven to be safer and cause less tissue damage than non-contoured. This is thought to be due to the pressure



Figure 3. Various sizes of cuffs.

Table 1

### JAAOS RECOMMENDATIONS

Inflation Time	Inflation Pressure	Reperfusion
< 2.5 hours	< 300mmHg	Assess at 2h mark
> 2.5 hours	Consider *LOP &Wide Cuff Do Not Exceed 300mmHg	<b>10 minutes</b> at 2.5h mark & 10 minutes for every hour beyond that

gradient effect at the edges of the cuff (26). Non-contoured cuffs have been shown to have up to a 90% pressure difference from the proximal edge of the cuff to the distal edge of the cuff due to patient’s anatomical shape. If there is only a small area of the cuff providing the majority of the compression the patient is more likely to have deep tissue injury. A means of calculating pressure gradient is found by dividing the pressure by the width of the cuff in centimeters. The lower the gradient, the better (Figure 4).

The cuff should be applied with gentle, even force (23-26) and should never be applied to bare skin (27-29). Various materials are available as a means of skin protection under the tourniquet, including cast padding, stockinette, ACE bandage, and cotton sleeves. The literature recommends a thin (1-2 layer) smooth layer that extends beyond the cuff at both ends. Care should be taken to not allow prep solution to soak the material under the tourniquet as this may lead to severe chemical burns when under occlusion. There are no studies supporting the idea of a thick layer of padding to prevent tissue injury, the only thing this will accomplish is the need for a higher tourniquet pressure to achieve occlusion. When applying the skin protection layer, as well as the tourniquet, any compression force of greater than 20 mm Hg is enough to occlude venous flow

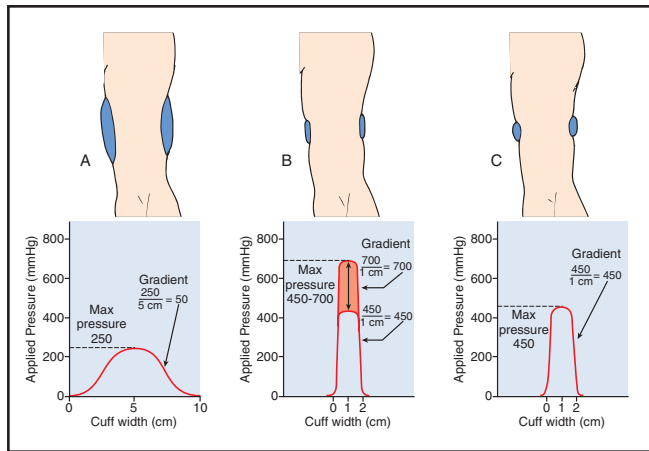


Figure 4. Calculating the pressure gradient.

in most patients (17,28,29). Occlusion of venous return may hinder you by preventing complete exsanguination prior to tourniquet inflation, which means bleeding during the surgery. Blood pooling and excessive bleeding during tourniquet deflation for re-perfusion breaks in long cases is also an effect of occlusion of the venous return (27-30).

It is far easier to be knowledgeable and foresee potential tourniquet injuries and stop them from occurring, than to bear the burden of lengthy, costly recuperation from an injury that was preventable. By following accepted recommendations for safe use as well as being conscientious of tourniquet width and contour, skin protection, and application, we can help promote the overall safety and well-being of patients.

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