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BRIEF REPORT

Which Improvised Tourniquet Windlasses Work Well and Which Ones Won't?

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Objective.—Improvised tourniquets in first aid are recommended when no scientifically designed tourniquet is available. Windlasses for mechanical advantage can be a stick or pencil and can be used singly or multiply in tightening a tourniquet band, but currently there is an absence of empiric knowledge of how well such windlasses work. The purpose of the present study was to determine the performance of improvised tourniquets in their use by the type and number of windlasses to improve tourniquet practice.

Methods.—A simulated Leg Tourniquet Trainer was used as a manikin thigh to test the effectiveness of improvised tourniquets of a band-and-windlass design. Two users made 20 tests each with 3 types of windlasses. Tests started with 1 representative of a given type (eg, 1 pencil), then continued with increasing numbers of each windlass type until the user reached 100% effectiveness as determined by cessation of simulated blood flow. Windlass types included chopsticks, pencils, and craft sticks.

Results.—Effectiveness percentages in stopping bleeding were associated inversely with breakage percentages. Pulse stoppage percentages were associated inversely with breakage. The windlass turn numbers, time to stop bleeding, the number of windlasses, and the under-tourniquet pressure were associated inversely with breakage. The windlass type was associated with breakage; at 2 windlasses, only chopsticks were without breakage. Of those windlass types that broke, 20.7% were chopsticks, 26.1% were pencils, and 53.2% were craft sticks.

Conclusions.—A pair of chopsticks as an improvised tourniquet windlass worked better than pencils or craft sticks.

Key words: first aid, resuscitation, damage control, hemorrhage, trauma, shock

Introduction

First aid tourniquets have become more commonly used, for example, in the aftermath of the Boston Marathon bombing in 2013.[1] After more than a decade of war, with more veterans returning to the United States with tourniquet experience, and increasing media publicity of civilian use of tourniquets in the United States, the potential benefits to the civilian sector are becoming recognized. To control hemorrhage from compressible extremity wounds, improvised tourniquets are recommended when no commercially designed tourniquet is available.[2] Preliminary evidence from war indicates that improvised tourniquets challenge the user to make them both safe and effective.[2] The common type of improvised tourniquet is of a band-and-windlass design where a band is twisted and tightened by a rodlike windlass. The windlass gives mechanical advantage in tightening the band. Types of windlasses may include sticks and pencils, which can be used singly or multiply. However, evidence of efficacy of improvised tourniquets is based mostly on opinions of clinicians with experience in tourniquets.[2] We were unable to find datasets from which the US Army's lesson plan for improvised

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Table 1. Effective tests by windlass type, windlass number, and user

Windlass type	*Windlass number*	*Tests per user (n)*	*Effective tests, user 1 (n)*	*Effective tests, user 2 (n)*	*Effectiveness percentage (total tests, n)*
Chopstick	1	20	10	7	42% (40)
	2	20	20	20	100% (40)
Pencil	1	20	19	2	52% (40)
	2	20	19	18	92% (40)
	3	20	20	13	82% (40)
	4	20	NA	20	100% (20)
Craft stick	1	20	0	0	0% (40)
	2	20	12	12	60% (40)
	3	20	20	18	95% (40)
	4	20	NA	20	100% (20)

NA, not applicable.

tourniquet use was developed. Although the Army's lesson plan is detailed in technique steps, and many of the claims seem like common sense, we wished to empirically explore the issue of improvised tourniquet use to identify opportunities for improved care.

There is very little literature available for the layman outdoor enthusiast concerning use of improvised tourniquets in the field.[3–8] Hence, the purpose of the present study is to provide new knowledge to both the novice and to professionals for use and performance of improvised tourniquets by testing various types and numbers of windlasses.

Methods

This study was conducted under a protocol reviewed and approved by the regulatory office of the US Army Institute of Surgical Research. Tourniquet users were a pair of investigators familiar with military tourniquet training and clinical use of tourniquets. Both investigators were experienced in tourniquet research and the use of the manikin.

The investigators used the HapMed Leg Tourniquet Trainer (CHI Systems, Fort Washington, PA, USA)—a right-thigh body segment (leg number 000F) with an amputation injury just proximal to the knee—in a manner similar to previous reports.[9,10] The medial hip–pelvic area had a computer interface that included a smart-phone-like touchpad software (version 1.9) internal to the manikin. This device allowed the leg to be used independently and to be operated by user input through finger touch on the pad.

The system reported blood loss volume as calculated using a linear equation from the arterial capacity and number of pulses before hemorrhage control. The touchpad readout of each iteration showed the results, which included effectiveness of bleeding control as evidenced by the above-noted light display, time to hemorrhage control, pressure exerted under the tourniquet, and volume of blood loss. Time to hemorrhage control started when the iteration began, and stopped when the manikin sensed that the thigh was losing no more blood or when the windlass broke. Complete effectiveness (100%) was considered to be cessation of blood loss and the termination of a distal pulse of the affected extremity.

The tourniquet was an improvised tourniquet involving a band-and-windlass design in which the band was a triangular (37 × 37 × 52 inches) cloth made of cotton (muslin; Elwyn Inc, Elwyn, PA, USA). This bandage is a common US military item used for multiple first aid purposes (NSN 6510-00-201-1755). After removing it from its package, the users would partially unfold the olive drab bandage until it was 3.5 inches wide and 52 inches long. Users tightened the tourniquet around the thigh until distal simulated bleeding was believed to have stopped, based on visual inspection of the lights and palpitation for the distal pulse in the device. One windlass turn was a 180º arc, which is the limit of wrist supination in turning the windlass.

The present study was an experiment to determine tourniquet performance as differentiated by type of windlass and the number of that type needed to be effective. We selected windlass types that varied in shape, size, and toughness so as to see potentially varied performance. Windlass types included bamboo chopsticks, pencils, and craft sticks (also known as Popsicle sticks). Tourniquet users tested performance in sets of 20 iterations. Each set of 20 iterations of testing was per user with each type of windlass. Users started with 1 windlass for each type. To determine when