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BRIEF REPORT

Just-in-Time to Save Lives: A Pilot Study of Layperson Tourniquet Application

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Abstract

Objectives: The objective was to determine whether just-in-time (JiT) instructions increase successful tourniquet application by laypersons.

Methods: This was a randomized pilot study conducted in August 2014. The study occurred at the Uniformed Services University campus in Bethesda, Maryland. A total of 194 volunteers without prior military service or medical training completed the study. The participant stood in front of a waist-down mannequin that had an exposed leg. An observer read a scenario card aloud that described a mass casualty event. The observer then asked the participant to apply a Combat Application Tourniquet (C-A-T) to the mannequin. Test participants received a 4 × 6-inch card, with JiT instructions, in addition to their C-A-T; controls received no instructions. Participants were randomized in a 3:1 ratio of instructions to no instructions. The study's primary outcome was the proportion of successfully applied tourniquets by participants receiving JiT instructions compared to participants not receiving instructions. Secondary outcomes included the time for successful tourniquet placement, reasons for failed tourniquet application, and participants' self-reported willingness and comfort using tourniquets in real-life settings.

Results: Just-in-time instructions more than doubled successful tourniquet placement. Participants supplied with JiT instructions placed a tourniquet successfully 44.14% of the time, compared to 20.41% of the time for controls without instructions (risk ratio = 2.16; 95% confidence interval = 1.21 to 3.87; p = 0.003).

Conclusions: Just-in-time instructions increase laypeople's successful application of C-A-T. This pilot study provides evidence that JiT instructions may assist the lay public in providing effective point-of-injury hemorrhage control.

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The military has dramatically reduced battlefield deaths by training and equipping troops to use tourniquets.[1–4] Unfortunately many combat-type injuries, such as those seen during the Boston Marathon bombing, occur in the United States.[5] To address this, The Joint Committee to Create a National Policy to Enhance Survivability from Mass Casualty Shooting Events produced recommendations known as the Hartford Consensus I and II.[6] These recommendations emphasize point-of-injury hemorrhage control.[7] The potential for future mass casualty events demands further evaluation of point-of-injury treatment. In describing the Hartford Consensus' work, Jacobs et al.,[7] emphasize that, "the public can and will act as responders." Laypeople could provide a critical link in mass casualty survival.

Stemming from this impetus for layperson response, the federal government convened an internal working group of experts to assess the feasibility of bystander hemorrhage control. We modified preliminary instructions that this group drafted, by including images and condensing the wording, to create a 4 × 6-inch just-in-time (JiT) instruction card for layperson use.

While layperson medical intervention has a record of success, as demonstrated by automated external

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defibrillator usage, similar evidence does not exist for laypeople's ability to apply tourniquets.[8] This pilot study provides evidence that JiT instructions can assist the lay public in providing effective point-of-injury hemorrhage control.

METHODS

Study Design

This pilot study was a prospective randomized study. The Uniformed Services University (USU) Institutional Review Board approved this study as an exempt educational protocol (#404505-1).

Study Setting and Population

Investigators at the USU campus in Bethesda, Maryland, recruited participants via posters asking for volunteers to test a medical device. Data collection occurred in August 2014. Volunteers completed a prestudy questionnaire to determine eligibility, and 194 people completed the study (Figure 1). Comfort levels and attitudes about tourniquets were collected with the prestudy questionnaire. No demographic or personally identifying information was collected. Each volunteer read an information sheet explaining the purpose of the study and asking the volunteer not to discuss the study with others at USU. The study enrolled USU federal employees, visitors, and contract workers such as janitorial and culinary support. USU federal employees are 49% female. A participant was excluded for age less than 16 years old, military service in the past 15 years, prior tourniquet training or use, a history of being any type of licensed medical provider (physician, nurse, medic, etc.), or any medical training taught beyond that taught in a high school health course or basic first aid and CPR training. New first-year medical students, who were in-processing during the study period, were allowed to enroll as long as they were not excluded by other criteria.

Study Protocol

A participant was randomized, using an online block randomization generator in a 3:1 ratio, into the JiT instruction group or the no-instruction control arm. The participant then moved into a partitioned test area in a USU lobby.

An observer read aloud a scenario describing an explosion at a public event. The observer then asked a participant to apply a Combat Application Tourniquet (C-A-T; Composite Resources, Rock Hill, SC) to the lower limb of a static lower-body mannequin (waist-down) on a table in front of the participant. A piece of tape on the mannequin's leg marked the location of the simulated wound. The lower-body mannequins did not bleed during the study. The observer started timing the participant after reading the scenario aloud and handing the participant the tourniquet.

Those in the test group were given a 4 × 6-inch JiT instruction card consisting of eight steps and six photographs at the same time they were handed the C-A-T. The timer started as soon as the instructions and tourniquet were handed to a participant. Participants in the study group had access to the instruction card the entire time they attempted tourniquet placement. The participant applied the tourniquet until he or she indicated completion, or until the timer reached 7 minutes, at which time the observer stopped the procedure. Following tourniquet application, the participant left the study area and completed a postactivity questionnaire that asked his or her comfort and willingness to use tourniquets again. The entire study process took less than 15 minutes.

The observer recorded whether or not the participant applied the tourniquet appropriately and recorded the time to successful placement. If the participant did not successfully apply the tourniquet, no time was recorded. The appropriateness of the placement was determined by correct anatomical location, adequate tightness, and properly securing the windlass and straps. Adequate tightness was determined by a combination of the tourniquet indenting the mannequin's skin, and an observer being unable to slide his or her index finger between the tourniquet and mannequin. If the participant did not apply the tourniquet appropriately, the observer documented the reason(s) for failure. No feedback was given to participants.

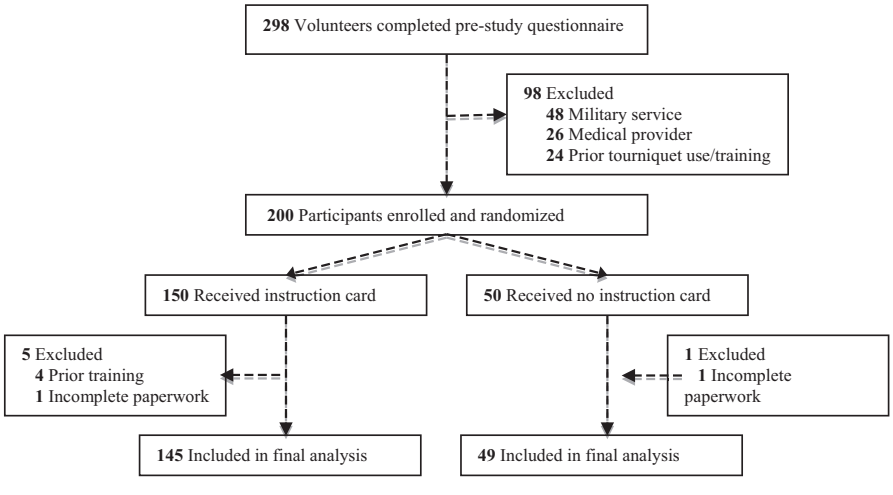

Figure 1. Participant enrollment and exclusions.

Twenty-one observers were used in this study. All observers had received military medical tourniquet training and were instructors for the university's combat casualty care courses. One observer assessed each participant, and each participant was assessed individually. Study authors trained all observers about the study protocol. The C-A-T was chosen due to the U.S. military's substantial experience with it on the battlefield, and evidence that supports its effectiveness in the prehospital environment.[9]

Outcomes

The study's primary outcome is the proportion of successfully applied tourniquets by participants receiving JiT instructions compared to participants not receiving instructions. Secondary outcomes included the median time for successful tourniquet placement, reasons for failed tourniquet application, and participants' self-reported willingness and comfort using tourniquets in real-life settings.

Data Analysis

Comparisons between the JiT group and no-instruction group were made using chi-square or Fisher's exact tests for proportions and Mann-Whitney U-test for comfort level and time to successful application. Paired pre/post comparisons were made using the Stuart-Maxwell test for willingness to use a tourniquet and the Wilcoxon signed ranks test for comfort level. The target sample size of 208 with a 3:1 ratio of JiT to no instruction would have 80% power to detect a significant difference if the proportion of correct applications is 40% vs. 20%. The achieved sample size of 194 has 78% power for the same comparison. Calculations are based on a chi-square test with a 5% two-sided significance level. Data were analyzed using SPSS version 22.

RESULTS

A total of 194 participants completed the study. A total of 145 participants received JiT instructions, and 44.14% of this group (n = 64) successfully applied the C-A-T. Ten of the 49 participants (20.41%) who did not receive instructions successfully applied the C-A-T. The JiT instructions more than doubled successful tourniquet application (risk ratio = 2.16; 95% confidence interval [CI] = 1.21 to 3.87; p = 0.003, chi-square test).

A comparison of the failures demonstrated that the no-instruction group had more failures due to anatomical placement when compared with the instruction group (41.0% vs. 23.5%; p = 0.047). The most common reason for failure was the tourniquet being applied too loosely (71% in both groups). Eighty-four percent of all participants (n = 163) responded that they would use a tourniquet in a real-life emergency, and the self-reported comfort level for using a tourniquet significantly improved for both groups after participation in the study (from 2 to 4 points on a 5-point Likert scale; see Tables 1 and 2 for complete secondary outcomes).

DISCUSSION

Intentional mass casualty events are an alarming occurrence in modern America, and nonmedical bystanders may prove essential in preventing injured victims from dying while awaiting medical care. This pilot study provides important baseline information about laypeople's ability and willingness to provide hemorrhage control.

Laypeople are able to apply tourniquets appropriately to static mannequins without any prior training, and JiT written instructions improve the proportion of appropriate applications from 20% to 44%. In a mass casualty situation, having nearly half of laypeople placing a tourniquet correctly could be beneficial, as trained medical personnel at the point of injury will be limited initially. Mortality rates increase significantly when tourniquets are placed after patients are in hemorrhagic shock, so rapid, point-of-injury tourniquet application by laypeople could be beneficial.[9] This study revealed that more than 70% of the failed tourniquet applications were due to the tourniquet being placed too loosely. While not ideal, these loose tourniquets may still benefit

Table 1
Comparison of Factors Observed During Tourniquet Application Process

Outcome	JiT Instruction Card (n = 145)	No JiT Instruction Card (n = 49)	Risk Ratio (95% CI)	p-value*
Successful application, n (%) 95% CI	64 (44.14) 36.3–52.3	10 (20.41) 11.3–33.8	2.16 (1.21–3.87)	0.003
Seconds to successfully apply tourniquet, median (IQR)	108 (83–144)	59 (47–70)		<0.001†
Reason for failure (% of failures)				
Total number of failures	81	39		
Incorrect position	19 (23.5)	16 (41.0)	0.57 (0.33–0.99)	0.047
Device too loose	58 (71.6)	28 (71.8)	0.99 (0.78–1.27)	0.983
Not all steps completed	48 (59.3)	23 (59.0)	1.01 (0.73–1.38)	0.976
Subject requested to stop early	5 (6.2)	4 (10.3)	0.60 (0.17–2.12)	0.449‡
Time (>7 minutes)	1 (1.2)	0		0.675‡
Multiple reasons (any combination)	40 (49.4)	25 (64.1)	0.77 (0.56–1.06)	0.13

JiT = just-in-time.
*Calculated using chi-square test unless otherwise indicated.
†Calculated using Mann-Whitney U-test.
‡Calculated using Fisher's exact test for small number of subjects.

Table 2
Participant Opinions and Qualitative Data

Survey Item	No. (%) of Participants (N = 194)* Preactivity	Postactivity	p-value
Opinion on the safety of tourniquets			
Safe	122 (62.9)		
Unsafe	5 (2.6)		
Unsure	67 (34.5)		
Would you use a tourniquet in real life?			
Yes	104 (53.6)	163 (84.0)	<0.001†
No	7 (3.6)	5 (2.6)	
Unsure	83 (42.8)	26 (13.4)	
Comfort level of having to use a tourniquet in real life, median (IQR)	2 (2–3)	4 (3–4)	<0.001‡
JiT instructed (n = 145)	3 (2–3)	4 (3–4)	<0.001‡§
No instructions (n = 49)	2 (1–3)	4 (2–4)	0.001‡§
Comfort level of applying the tourniquet in the study, median (IQR)			
JiT instructed (n = 145)	Not assessed	4 (3–4)	0.017‖
No instructions (n = 49)	Not assessed	2 (2–4)	

JiT = just-in-time.
*Unless otherwise indicated
†Calculated using the Stuart-Maxwell test across all groups.
‡Calculated using Wilcoxon signed ranks test.
§No statistically significant difference between JiT and no-instruction groups (Mann-Whitney test).
‖Calculated using Mann-Whitney U-test.

victims. Kragh et al.[9] described a trend in which partially ineffective tourniquets resulted in lower mortality rates when compared to unimpeded bleeding. A partially effective tourniquet is possibly better than no tourniquet at all.

While the overall proportion of successful tourniquet applications is not high in this pilot study, the JiT instructions had a clear impact. These initial instructions more than doubled the proportion of successful tourniquet application. This raises hope that better instructions will yield even better success. A number of possibilities exist for boosting the quality of instructions seen in this study. One possibility is the addition of audio and/or video JiT instructions included with the tourniquet or suitable for access on a smart phone device. Other possibilities include illustrated images, like those found on airline emergency cards, open access Web-based training modules, or a public information campaign about the importance of hemorrhage management and associated techniques.

This pilot study also identified a time frame in which laypeople will appropriately apply a tourniquet—between 1 and 2 minutes with or without instructions. The JiT instruction group took a median of 48 seconds longer to apply the tourniquet, possibly because they ensured that instructions were followed correctly. While time from injury to fatal exsanguination has not been definitively defined in humans, and may vary based on injuries, swine models have shown ranges from 10 to 23 minutes.[10] Any patient harm from this 48-second delay should be more than offset by doubling the proportion of appropriately applied tourniquets from the JiT instruction group.

Next, we quantified the common reasons for layperson tourniquet failure. This information could play a critical role in improving future JiT instructions and optimizing public response.

Finally, this study found that laypeople are very willing to use tourniquets in real-world settings (84% of all participants) and that brief exposure to tourniquets, as in this study, improves their comfort with using the device. This qualitative information could prove useful when designing low-cost, mass educational strategies for the public.

LIMITATIONS

The study concentrates on the ability and willingness of laypeople to utilize a C-A-T, but does not address whether laypeople are able to recognize indications for tourniquet use. The study utilized a static mannequin without the chaos and fear inherent in a real mass casualty setting. We did not assess inter-rater reliability of our observers in this study. The study population included mostly federal employees from one site—future study in different populations, with accompanying demographic data, is needed to validate these results. The 3:1 test to control ratio was selected to allow for the greatest assessment of the JiT instructions as written, but it does increase the susceptibility of the control group to the errors associated with a smaller sample size.

CONCLUSIONS

Just-in-time instructions double laypeople's likelihood of successful tourniquet placement to nearly half of attempted applications. The rapid application time of less than two minutes could allow bystanders to prevent deaths from exsanguinating extremity hemorrhage. Laypeople indicate a strong willingness to use tourniquets and a have higher level of comfort after a single, brief exposure. Further study should focus on improved instructions and tourniquet design, the effects of other brief educational interventions, and testing laypeople under increasingly stressful conditions.

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