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Practice makes perfect: The impact of Stop the Bleed training on hemorrhage control knowledge, wound packing, and tourniquet application in the workplace

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ABSTRACT

Introduction: The national Stop the Bleed (STB) campaign was implemented in 2015 to provide hemorrhage control education to non-medical providers to reduce the number of deaths due to uncontrolled hemorrhage. Hands on training limits the availability of this program, and its importance is not known amongst lay providers. This study aimed to evaluate the efficacy of STB training for laypersons on knowledge and skill-based abilities in the workplace setting. We hypothesized such hands on and in-person training would improve performance.

Methods: Non-medical potential first responders (PFR; $N = 298$) participated in STB training comprised of a lecture and hands-on component. PFRs completed a bleeding control knowledge-based pre-and post-assessment. Following the lecture, participants were divided into experimental and control groups during which hands-on practice was manipulated to determine the impact of guided practice on wound packing and tourniquet application. Wound packing and tourniquet application assessments were performed and scores compared between the experimental and control groups.

Results: PFRs scored higher on the bleeding control bleeding control knowledge-based post-test ($M = 4.63$, $SD = 1.32$) than on the pre-test ($M = 3.21$, $SD = 1.14$). Employees in the experimental group ($M = 2.93$, $SD = .26$) also scored significantly higher than the control group ($M = 1.97$, $SD = .77$) that attempted wound packing without any hands-on training. PFRs in the experimental group scored significantly higher ($M = 7.41$, $SD = .91$) than PFRs in the control group ($M = 5.99$, $SD = 1.81$) for tourniquet application.

Conclusion: Knowledge related to hemorrhage control increased following the STB course. Participants who engaged in hands-on practice for tourniquet and wound packing were more proficient than those who only saw the lecture. We confirm that in person, hands on training is key to the success of lay STB training.

Introduction

Background

Trauma remains the leading cause of death in individuals aged 1–44 in the United States [1]. Hemorrhage involving the extremities is the most frequent cause of preventable death from injury, which may occur as a result of intentional or unintentional trauma [2]. According the Federal Bureau of Investigation (FBI), 250 active shooter incidents occurred between 2000 and 2017 and resulted in the death of 799 individuals and injured 1418 others [3]. Shootings accounted for 394 cases of the 500 workplace homicides in 2016 [4]. Given life threatening hemorrhage accounts for 40% of mortality occurring within the first 24 h of injury, hemorrhage control training for laypersons in the workplace setting may be warranted to prevent future fatalities [2,4].

Despite this substantial nationwide death toll and prevalence of workplace homicides, the shooting at the Sandy Hook elementary school in Newtown, Connecticut during which 20 children and 6 adults lost their lives served as the impetus for a national call to

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action for education related to bleeding control training. This effort involved a number of police, fire, emergency medical services (EMS), and federal agencies that were tasked with creating a protocolized national policy to enhance survivability from active shooter incidents and mass casualty events [5]. Their recommendation, known as the Hartford Consensus, aims to provide hemorrhage control education to the civilian population. The Hartford Consensus was born of the recognition that civilians may be the only immediate responders and that uninjured bystanders and minimally injured victims are often tasked with providing the initial response for victims requiring urgent hemorrhage control regardless of etiology [6]. In cases such as the October 2017 shooting murders of 58 concert goers at the Route 91 Harvest festival in Las Vegas, at least half an hour elapsed prior to first patient contact by emergency medical services. This further emphasizes the delay that may exist from time of injury to the arrival of first responders and the need for earlier medical intervention [7].

In October 2015, the White House enacted the national Stop the Bleed (STB) campaign to provide additional hemorrhage control education to non-medical providers in hopes to address these unnecessary deaths due to uncontrolled hemorrhage. The campaign empowers individuals to attend training involving basic hemorrhage control techniques using approved tourniquets and wound packing skills and material. In addition, it encourages making hemorrhage control supplies readily available to the public [8].

Study objectives

To date, little study has been done to evaluate the efficacy of the various components of the STB program. In person hands-on training limits the availability and audience of such programs and the importance of this aspect in particular with regard to preparing civilians to address life threatening hemorrhage is unknown. Unlike many other medical training programs, STB skills are fairly basic. The curriculum needed for mastery is differs from that of a program like advanced cardiac life support (ACLS) which follows relatively complex treatment algorithms and requires basic anatomic and medical knowledge, thus requiring in person training. This study aimed to measure the impact of the STB hands-on educational program on cognitive and psychomotor abilities related to wound packing and tourniquet application in a group of non-medical employees. Addressing this knowledge gap is critical to the future and dissemination of the STB program.

Methods

Study setting and participants

The Pennsylvania Department of Transportation (Penn DOT) hosted five STB courses at Philadelphia area locations as a part of a larger workshop for the Occupational Safety and Health Administration's (OSHA) Workplace Violence Awareness Month. All employees attending the workshop had the opportunity to participate in the evaluation. The STB training sessions were hosted in warehouses for the potential first responders (PFR) at five different Penn DOT locations. Training and data collection occurred over the period of one month from April 2018 to May 2018 during which 314 non-medical PFRs took part. Institutional Review Board approval was obtained for this study.

Study protocol

Each PFR was given a bleeding control (BCON) knowledge assessment prior (Table 1) to the start of the STB program to determine baseline knowledge of bleeding control. Once all pre-tests were collected, a member of the study team presented a 30-min lecture in the warehouses at five separate Penn DOT locations on bleeding control basics created by the American College of Surgeons (ACS) Committee on Trauma (COT). During the course of the lecture, the basics principles of hemorrhage control were covered. These principles included establishing the safety of the immediate responder as the number one priority as well as a review of the ABC's of bleeding control. The importance of early activation of the 911 systems and EMS response to the location of the incident was highlighted to minimize the time to definitive care for casualties. Various examples of life threatening bleeding were then reviewed through descriptors and the use of images and video. Upon completion of this review, bleeding control algorithms discussing appropriate use of hemorrhage control tourniquets and wound packing techniques based on the location of the injury were reviewed.

Table 1
Pre- and post-knowledge based assessment questions to evaluate understanding of the ABC's of immediate response to bleeding, steps to properly pack a wound and apply a tourniquet, and signs of life threatening bleeding.

Knowledge-based Questions
True/False False) The first thing you should do when you see an injured person is rush to help them. False) When utilizing a tourniquet to stop bleeding, the tourniquet should be placed below the site of bleeding. True) All methods used to stop bleeding have one thing in common- compressing a bleeding blood vessel to stop bleeding.
Rank-Order Please place the following actions in order to control bleeding in an extremity without access to a tourniquet. 1) Alert Emergency Medical Responders 2) Find the source of bleeding 3) Pack the wound with gauze or a clean cloth 4) Apply steady direct pressure
Please place the following actions in order to control bleeding in an extremity with access to a tourniquet. 1) Wrap the tourniquet around the bleeding extremity 2–3 inches above the bleeding site 2) Pull the free end of the tourniquet to make it as tight as possible and secure the free end 3) Twist or wind the windlass until bleeding stops 4) Secure the windlass to keep the tourniquet tight 5) Secure the tail of the tourniquet through the clips 6) Put the time strap over the secured tail 7) Note the time the tourniquet was applied
Check All That Apply Which of the following are signs of life-threatening bleeding? • Blood that is spurting out of the wound • Blood that won't stop coming out of the wound • Blood that is pooling on the ground • Clothing that is soaked with blood • Bandages that are soaked with blood • Loss of all or part of an arm or leg • Bleeding in a victim who is now confused or unconscious

Following the lecture, PFRs were divided into groups with an instructor in a 10:1 ratio to learn more about wound packing and tourniquet application. Prior to arrival Penn DOT locations were randomized into experimental or control conditions. The experimental group received hands-on wound packing and tourniquet guided practice in small groups led by program volunteers comprised of medical and non-medical professionals. Following demonstration from the instructor, the experimental group was able to practice wound packing on a Hemorrhage Control Trainer (Z-Medica/QuikClot, Wallingford, CT; see Fig. 1) and self- and buddy-rescue application with a Combat Application Tourniquet (CAT; C-A-T Resources, Inc. Rock Hill, SC; see Fig. 2). Once the experimental group felt comfortable with their ability to pack a wound and apply a tourniquet, each instructor had the employees demonstrate wound packing and tourniquet application and noted which steps were performed correctly on the wound packing and tourniquet application psychomotor assessment. The control group only obtained knowledge about bleeding control, wound packing, and tourniquet application from the STB lecture prior to their attempt at applying a tourniquet or packing a wound. The control group differed from the experimental group by not having received hands- on guided practice or demonstration prior to the wound packing and tourniquet application psychomotor assessments. Following the conclusion of the skill-based assessment, the control group participated in the same hands-on practice as the experimental group to ensure all employees received sufficient training.

Fig. 1. Combat Application Tourniquets (CAT) used during the skill-based assessments.

Fig. 2. Hemorrhage Control Trainer used during the skill-based assessments.

At the conclusion of the wound packing and tourniquet application assessments, PFRs returned to their seats and completed the same written assessment they were given at the beginning of the course. Once all post-tests were collected, answers were reviewed and final questions were addressed. The program overall took approximately one hour to complete.

Measures

The BCON knowledge-based assessment consisted of six-item (three true/false, two rank-order, and one check all that apply) and was given to employees before and after the STB training (Table 1). The questions were created collaboratively by members of the study team from two level I trauma centers to address the following goals of the program: knowledge of the ABC's of immediate response to bleeding, steps to properly pack a wound and apply a tourniquet, and knowledge of the signs of life threatening bleeding. Knowledge-based evaluations were scored on a binary scale for correct or incorrect responses.

The wound packing and tourniquet application skill-based assessments were developed based on the step-by-step instructions provided in the STB presentation and Save a Life Booklet [9]. A three-item checklist was developed to evaluate wound packing and an eight-item checklist was developed to evaluate tourniquet application (Table 2). The wound packing and tourniquet application skill-based assessments of participants were completed in real time by volunteer instructors of the STB program who were not blinded to the participant study groups. Both skill-based evaluations were graded on a binary scale for completion or omission of steps required to Stop the Bleed presentation.

Statistical analysis

Analyses were performed using SPSS 24.0 (IBM Corp. Armonk, NY) to determine the impact of the STB training program on laypersons (N = 298) bleeding control knowledge, ability to pack a wound, and ability to apply a tourniquet. Responses from PFRs who

Table 2
Pre- and post-assessment checklists to evaluate hands-on wound packing and tourniquet application skills.

Assessment Actions
Wound Packing Psychomotor Assessment
• Pack (stuff) the wound with bleeding control gauze (preferred), plain gauze, or clean cloth.
• Apply steady pressure while packing the bleeding wound with both hands directly.
• Continue to hold pressure after packing complete.
Tourniquet Application Psychomotor Assessment
• Wrap the tourniquet around the bleeding arm or leg.
• Ensure tourniquet is about 2–3 inches above the bleeding site.
• Pull the free end of the tourniquet to make it as tight as possible and secure the free end.
• Twist or wind the windlass until bleeding stops.
• Secure the windlass to keep the tourniquet tight.
• Secure the tail of the tourniquet through the clips.
• Put the time strap over the secured tail.
• Note the time the tourniquet was applied.

did not follow directions on the cognitive pre- and post-test ($n = 16$) were removed from analysis. For example, if a question on the cognitive pre-test asked the PFR to list the order in which tasks should be performed to intervene with life-threatening bleeding as indicated by numerals, but instead they interpreted the question as a check all that apply and utilized check marks to answer the question, their cognitive test was excluded for not properly following directions indicated on the assessment. To compare baseline knowledge about bleeding control to knowledge following the STB training. To determine the impact of hands-on wound packing and tourniquet demonstration on PFR's ability to properly pack a wound and apply a tourniquet, psychomotor test scores were compared between the control and experimental groups using independent samples *t*-tests. Descriptive statistics such as means and standard deviations were also calculated and reported.

Results

Knowledge assessment

The number of correct responses on the BCON knowledge pre-test ($n = 286$) were compared to the number of correct responses on the cognitive post-test ($n = 257$). PFRs scored higher on the cognitive post-test ($M = 4.63$, $SD = 1.32$) than on the cognitive pre-test ($M = 3.21$, $SD = 1.14$; see Table 3). On the BCON knowledge pre-test, PFRs were able to recognize five signs of life threatening bleeding, which increased to the identification of six signs of life threatening bleeding on the post-test. PFRs in the experimental and control groups did not perform differently on the BCON knowledge pre-test, suggesting the groups were equivalent in baseline knowledge about bleeding control.

Skill-based assessments

Wound packing

Scores on the wound packing assessment for the experimental ($n = 94$) and control groups ($n = 69$) were compared. PFRs in the experimental group who packed a wound following hands-on demonstration scored significantly higher ($M = 2.93$, $SD = .26$) than PFRs in the control group ($M = 1.97$, $SD = .77$) that attempted wound packing without any hands-on training (Table 3); $t\ (161) = 11.21$, $p \leq 0.0001$.

Tourniquet application

Scores on the tourniquet application assessment for the experimental ($n = 70$) and control groups ($n = 72$) were compared. PFRs in the experimental group who applied a tourniquet following hands-on demonstration scored significantly higher ($M = 7.41$, $SD = .91$) than those in the control group ($M = 5.99$, $SD = 1.81$) that attempted tourniquet application without any hands-on training (Table 3); $t\ (140) = 5.91$, $p \leq 0.0001$.

Discussion

From the events of the 21st century thus far, one may deduce that mass casualty events will continue to be a major source of morbidity and mortality both in America and abroad. While the use of tourniquets in the civilian population was initially met with skepticism, they are now regarded as a critical life-saving tool [10,11]. The Boston Marathon Bombing of 2013 demonstrated that despite a reluctant acceptance of tourniquets as an effective and important adjunct to hemorrhage control, both lay providers and professional responders failed to apply them correctly [10]. Educating both the lay public and professional first responders on effective and appropriate hemorrhage control, as demonstrated in the battlefield, may translate to saving lives on American streets [12].

The best form of education for any given topic is always a source of debate. While many subjects may be well suited to learning through lecture, it intuitively follows that skills should be both taught and practiced. Effective hemorrhage control is certainly no exception and our study demonstrates the need for hands-on training to promote proper hemorrhage control practices.

Though his group did not study the best means of teaching hemorrhage control, Ross et al. showed that a brief educational intervention increased participants' self-efficacy and willingness to utilize a tourniquet in an emergency [13]. Members of the public were more comfortable and more willing to intervene in an emergency following instruction on the proper use of a bleeding control tourniquet, which demonstrates the importance of conducting formal educational interventions for civilians with little to no medical training. However, a separate study performed by Ross et al. also confirmed what healthcare providers learned from the Boston Marathon Bombings of 2013 that rates of failure to properly place commercially available tourniquets is extremely high without appropriate and specific training [14]. Our study highlights the need for additional civilian training to ensure individuals are aware of best practices for hemorrhage control.

Given that many mass shootings occur in the workplace, hosting workshops in such settings is critical. To this end, Penn DOT's OSHA Workplace Violence Awareness well represented the target audience for STB. PFRs in both the experimental and control group showed an increase in performance on the BCON knowledge assessment and the identification of signs of life threatening bleeding following training. There were no differences from pre-test cognitive scores between the control and experimental groups, establishing the groups were not significantly different at baseline, and that this difference in skill-based assessment performance of tourniquet application and wound packing is related to whether or not PFRs received hands-on training prior to testing.

Findings suggest that demonstration of tourniquet usage and wound packing in small groups coupled with hands-on guided practice significantly improves participants' ability to properly apply a tourniquet and pack a wound to control hemorrhage. Although one could argue that any training about hemorrhage control is beneficial, we feel that we have answered the question as to what training is "best" and that standardization of the STB program to include and emphasize the hands-on component would be beneficial. We recommend that institutions invest the time in scheduling courses with a hands-on component, as opposed to exclusively a lecture or online course.

PRFs in the current study were instructed to participate in the training as a part of a larger workshop hosted in various

Table 3
Comparison of non-medical potential first responders' pre- and post-training scores.

Measure	Maximum Score	Pre-test *M*(*SD*)	Post-test *M*(*SD*)
Knowledge Assessment	6	3.21(1.14)	4.63(1.32)
Life Threatening Bleeding	7	5.14(1.94)	6.14(1.64)
Hands-on Wound Packing	3	1.97(0.77)	2.93(0.26)*
Hands-on Tourniquet Application	8	5.99(1.81)	7.41(0.91)*

* $p \leq .0001$ by independent samples *t*-test.

warehouses across Philadelphia County, and participating facilities were not supplied with tourniquets or hemostatic gauze to as a part of their participation. While this study has demonstrated improvement in skill-based wound packing and tourniquet application, many workplaces do not have tourniquets and hemostatic gauze on-site. Therefore, translation in a real reduction in mortality may be limited without the proper tools. Healthcare providers interested in starting STB training programs in their community should seek grants to provide tourniquets and hemostatic gauze to institutions receiving training to increase participant investment and funds to mitigate the volunteers' costs of travel. Though difficult to perform, further large scale study would then be necessary to evaluate the impact of such large scale training and well equipped PFRs.

Limitations

Although this study was not able to capture data related to the demographics of the population, the sample was observed to be largely male. Further, employees had the same or similar occupations given that trainings in this evaluation were provided exclusively to Penn DOT employees. Not all employees opted to participate in the hands-on training or to complete the cognitive post-test, which resulted in attrition and may have also lead to selection bias in the wound packing and tourniquet application skill-based assessments. Another limitation is that there may have been limited personal investment in completing training and assessments. The warehouse settings were also not ideal for the acoustics of the lecture and allowed some PRFs to see what actions other individuals in their groups had taken when performing the psychomotor assessments.

The STB training program is run by volunteers that travel to trainings and provide education without any compensation. Given the variations in times and locations of the trainings, multiple volunteers evaluated the psychomotor components of our training. While all evaluations were not performed by the same individuals, all individuals were trained on the criteria that constituted successful tourniquet application and wound packing prior to the training. The variability in evaluators also extends the external validity of the results. Given the lack of formal inter-rater reliability testing, the potential for bias does exist. Further, although the volunteers were not blind to the study hypothesis, the detail of the wound packing and tourniquet psychomotor checklists left little room for subjective interpretation. Regardless of the limitations, this study is the first to evaluate the BCON knowledge and skill-based aspects of the STB program and the limitations do not outweigh the importance or integrity of findings.

Conclusion

Given the rising rates of active shooter events and workplace homicides in the United States, hemorrhage control for laypersons has become an area of interest for both policymakers and healthcare providers. Findings from this study suggest that the STB program increases knowledge about hemorrhage control. Non-medical PRFs who receive hands-on training with guided practice perform better on tourniquet application and wound packing assessments. Results suggest that institutions hosting and providing training should continue to perform demonstrations and hands-on trainings in small groups as a part of the STB program to ensure proper tourniquet application and wound packing actions are performed in hopes to prevent future deaths from life threatening hemorrhage.

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