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Assessing firefighters' tourniquet skill attainment and retention – A controlled simulation-based experiment

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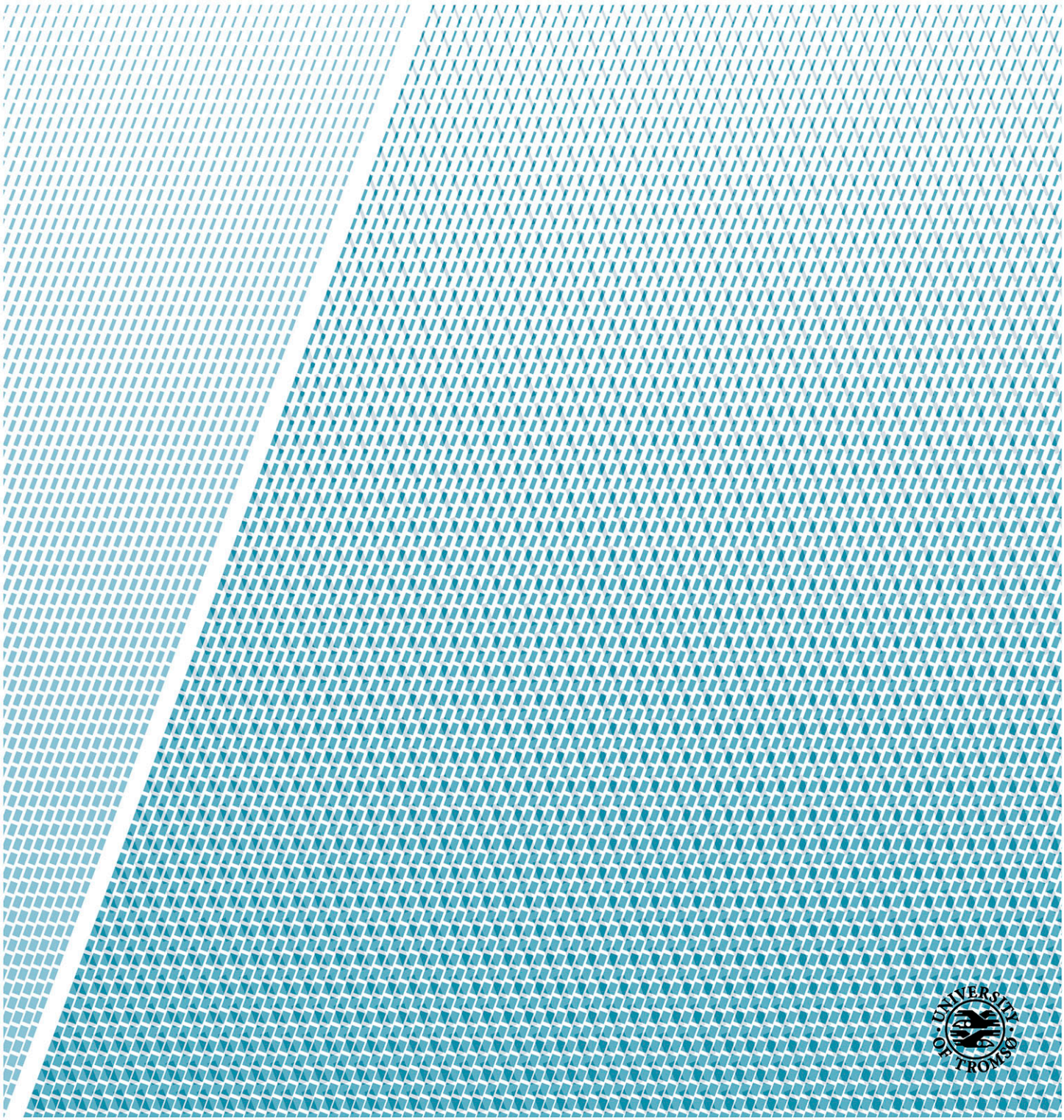

Preface

This master thesis was written as part of the subject MED-3950 at the University of Tromsø – The Arctic University of Norway. The authors share a great interest in prehospital and emergency medicine and want to ensure the implementation of best practice in this continuously changing and challenging field. Through The Norwegian National Advisory Unit on Trauma (NKT-traume), we contributed to the first Norwegian recommendation for civilian prehospital tourniquet use. This prompted a collaboration with the Fire- and Rescue Department in Oslo (OBRE) and Tromsø (TBRE), where the authors developed and provided a tourniquet course and the fire departments aided and facilitated the experimental simulation study. The purpose of this study was to train firefighters as first responders in the use of tourniquets and to assess their skill attainment and skill retention.

Dragset and Blix conducted the testing and provided the course at each fire department. Melau, Wilson and Lund-Kordahl had a supervisory role and assisted with statistical analysis and revision of the thesis. Lund-Kordahl and Melau were also quintessential in developing the tourniquet recommendation from NKT-traume, upon which the training course was modelled after.

We would like to extend our greatest gratitude to Oslo Fire- and Rescue Department and Tromsø Fire- and Rescue Department for their participation in this study. The Fire Chiefs welcomed us at every fire department and facilitated the testing, and every firefighter showed exceptional eagerness and skill. We would also like to thank the Skills and Simulation Centre (Ferdighets- og simuleringssenteret, FOSS) at the Faculty of Health Sciences for providing doppler ultrasound devices during the study period.

We applied for and received a research grant from Bergesenstiftelsen. The grant and NKT-traume financed our travel costs as well as essential equipment such as tourniquets. This study would not have been possible to conduct without their financial aid.

Tromsø, June 2019

Erik Dragset

Tromsø, June 2019

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Abbreviations and glossary

AIS – Abbreviated Injury Scaly. An anatomically-based, consensus-derived, global severity scoring system that classifies each injury by body region according to its relative importance on a 6 point ordinal scale

ANOVA – Analysis of variance

CBRN – Chemical, Biological, Radiological and Nuclear

CI – Confidence Interval

ED – Emergency Department

EMS – Emergency medical service

FA – First-aid

FOSS – Ferdighets- og simuleringssenteret. The Skills and Simulation Centre

HC – Hemorrhage control

ISS – Injury Severity Score. An anatomical scoring system that provides an overall score for patients with multiple injuries.

NKT-traume – National Kompetansetjeneste for Traumatologi. The Norwegian National Advisory Unit on Trauma

OBRE – Oslo Brann- og Redningsetat. Oslo Fire- and Rescue Department

OR – Odds ratio

PLIVO – Pågående livstruende vold. Ongoing lethal violence – any event with an active threat, such as shootings, stabbings, explosions, vehicles as weapons and other means of violence

REK – Regional etisk komité. Regional Committee for Medical and Health Research Ethics

TBRE – Tromsø Brann- og Redningsetat. Tromsø Fire- and Rescue Department

UiT – Universitet I Tromsø – Norges arktiske universitet. University of Tromsø – The Arctic University of Norway.

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Abstract

Background: The aim of this study was to train and assess firefighters' skill attainment in the use of tourniquets, and to assess their skill retention after three months. The purpose is to show whether firefighters can successfully apply a tourniquet after a short course based on the new national recommendation for civilian prehospital tourniquet use.

Material and methods: This was a prospective experimental study. The study population was firefighters in Oslo and Tromsø, and the inclusion criterion was any on-duty firefighter. The first phase consisted of baseline pre-course testing, a short tourniquet course based on the new national tourniquet recommendation, followed by immediate retesting. The second phase consisted of retesting of skill retention after 3 months. Primary outcome was absent distal pulse (confirmed with doppler ultrasound), correct placement (i.e. 5-10cm proximal to wound) and application time.

Results: There were 109 participants pre-course (T1), 105 immediately after the course (T2) and 62 participants at the three-months re-test (T3). The firefighters achieved a significantly greater proportion of successful tourniquet applications immediately after the course (91.4%, 96 of 105) as well as three months later (87.1%, 54 of 62) compared to 50.5% (55 of 109) pre-course ($p=0.009$). Mean application time was 59.6s (55.1-64.2) in T1, 34.9s (33.3-36.6) in T2 and 37.7s (33.9-41.4) in T3. The firefighters were significantly slower pre-course compared to both T2 (mean difference 24.7s, $p<0.000$) and T3 (mean difference 22.0s, $p<0.000$), but not between T2 and T3 (mean difference 2.7s, $p=0.983$).

Conclusion: Firefighters are able to successfully apply a tourniquet after a 45-minute course based on the new recommendation for civilian prehospital tourniquet use. Skill retention after three months was satisfactory for both successful application and application time. We strongly recommend that tourniquets should be a part of firefighters' hemorrhage control kit, but they should not be implemented without proper training. We recommend that tourniquet use is standardized in all prehospital medical providers across the country, including both the fire service and emergency medical service (EMS).

1.0 Introduction

Tourniquets are simple, portable and cheap instruments for controlling exsanguinating extremity hemorrhage. The effectiveness and safety of tourniquets has been a controversial subject for an extended duration, thus limiting both its battlefield and civilian prehospital use (1,2). Extremity hemorrhage constituted 9% of potentially preventable battlefield deaths in the Vietnam war (3). This discovery presented a potentially great survival benefit using hemorrhage control devices such as tourniquets.

1.1 Tourniquet safety and effectiveness in the battlefield setting

The increased use of tourniquets during the Israeli, Iraqi and Afghan war yielded much needed data for studying tourniquet effectiveness and safety. A 4-year retrospective study on tourniquet use in the Israeli Defense Force documented a 78% effectiveness in 110 tourniquets in 91 patients. After application of an additional second or third tourniquet, they achieved effective bleeding control in 97.3% of the 110 tourniquets. They reported a complication rate of 5.5%, with no amputations attributed to tourniquet use. Remarkably, no deaths were attributed to uncontrolled limb hemorrhage during the 4-year period (4).

Beekley et al compared tourniquet (n=67) vs no-tourniquet (n=98) in patients sustaining traumatic extremity amputations and/or extremity vascular injuries in a 1-year retrospective study from an Iraqi combat hospital. They documented that prehospital tourniquet application compared to no-tourniquet was associated with improved hemorrhage control, both overall (83.3% vs 60.7%) ($p=0.033$) and particularly in the severely injured (Injury Severity Score, ISS>15) (85% vs 17%) ($p<0.0001$). Overall tourniquet hemorrhage control effectiveness was 85%, and they estimated that four of seven hemorrhagic deaths were potentially preventable with functional prehospital tourniquet placement. No complications were attributed to tourniquet use (5).

A prospective observational study by Kragh and colleagues conducted in 2006 demonstrated that the tourniquet's capacity to save lives far outweighed its risks (6,7). Tourniquets were strongly associated with increased survival rate, and the sooner they were applied, the

better the patients did. The survival rate of 222 patients with tourniquet application before onset of shock was 90%, compared to 10% (1/10) when tourniquets were applied after the onset of shock ($p < 0.0001$). When applying tourniquets prehospitally, mortality was halved compared to application in the emergency department (ED) (11% vs 24%) ($p = 0.05$).

Of the 309 limbs, the first tourniquet was effective (partially or completely) in 53% of cases (164 of 309), whereas side-by-side use of a second or more tourniquets next to the first was effective in an additional 34% (106 of 309) with an overall effectiveness rate of 87% (270 of 309). 97% of applied tourniquets were either medically or tactically indicated. The survival rate was 0% (0/5) where tourniquet was indicated, but not applied. These 5 were subsequently compared to 13 similarly injured patients who received tourniquet by matching for ISS and Abbreviated Injury Scale (AIS). Tourniquet use was associated with better survival rates, 77% vs 0% ($p < 0.007$).

Complications occured infrequently as only four patients (1.7%) sustained transient nerve palsy at the level of the tourniquet and five patients (2.2%) sustained soft tissue damage directly under the tourniquet. Amputation and fasciotomies were associated with tourniquet duration, however, the tourniquets were considered lifesaving in all six patients with amputations. All nine fasciotomies performed after ≥2 hours of tourniquet duration were done prophylactically without evidence of compartment syndrome. No limbs were solely lost from tourniquet use, and they estimated 31 saved lives at the cost of one knee (limb shortening) using prehospital tourniquets.

The promising results from 2006 prompted a continuation study for another 6 months to verify the outcomes (8). The total 12-month prospective observational study included 499 patients with a total of 862 tourniquets applied on 651 limbs. They reported major lifesaving benefit and minor morbidity risk consistent with the prior reports. Survival was once again strongly associated with prehospital application (89% vs. 78% in ED) ($p < 0.01$) and application before the onset of shock (90% vs 18% after shock) ($p < 0.001$). 97.5% of applied tourniquets were either medically or tactically indicated. 10 patients had indication for tourniquet but did not receive them, all ten died from exsanguinating extremity

hemorrhage. The complication rate for nerve palsies at the level of the tourniquet and limb shortening was 1.5% and 0.4%, respectively. These findings correspond well with the results from 2006 which increases the generalizability and reinforces continuous use of tourniquet.

After the full implementation of tourniquet use in the US army, the mortality rate from exsanguinating peripheral-extremity hemorrhage was reduced from 23.3 to 3.5 deaths per year, a 85% decrease in mortality (9).

1.1.1Transferability to a civilian population

The promising results from battlefield tourniquet application are not necessarily transferable to a prehospital civilian setting. Studies investigating battlefield tourniquet use suffer from survivor-bias and confounding. Casualties who died before arriving at the hospital were not a part of the database in either study, which excludes a large group of patients with a potential benefit from tourniquet use. Additionally, survival rate increase because tourniquet are applied both on casualties sustaining injuries that would benefit from tourniquets (i.e. indicated), and on casualties sustaining minor injuries that would not benefit from tourniquet use (i.e. not indicated) (10). The proportions of non-indicated tourniquet application in the aforementioned studies were 47% (4), 18% (5), 2.7% (6) and 2.5% (8). Confounding exists because of lacking matching of demographical, physiological and clinical variables such as multiple limb injuries (11).

There is also a significant difference between the characteristics of the military and civilian population. Military casualties are younger, predominantly male, wear body-armor, present with more severe injuries and suffer predominantly from penetrating or blast injuries (12). Civilian casualties consist of both elderly, children and females, and they sustain significantly more blunt trauma such as motor vehicle accident, and non-traumatic hemorrhage such as dialysis fistula rupture (13–15). Further, important situational/tactical indications for tourniquet application such as care under fire and mass casualty events occur at a much lower rate than in a military setting. Even in settings such as mass-shootings, the rate of exsanguinating extremity hemorrhage and traumatic amputations are lower in a civilian prehospital population (16).

Complications of tourniquet use could arise from ischemia-related metabolic effects and/or direct compression beneath the tourniquet. The exact type and rate of complications is not completely disclosed, but could include limb shortening, injury to nerve, muscle and vasculature, reperfusion injury, compartment syndrome and venous thromboembolic events (17). It is noteworthy that Lakstein and Beekley only mention nerve palsy and limb shortening as potential complications, which could partially account for the low complication rate (4,5). The retrospective design of the studies also limits their ability to identify such complications. These issues emphasize that separate investigations are needed to establish tourniquet effectiveness and safety in the civilian prehospital setting.

1.2 Tourniquet safety and effectiveness in the civilian prehospital setting

Relying heavily on the aforementioned military studies, several associations have recommended implementation of prehospital tourniquet use in the civilian setting as a first resort rather than last resort, including The American College of Surgeons Committee on Trauma (18,19), the Hartford Consensus (20,21), the American Heart Association and American Red Cross (22) and the European Resuscitation Council (23). This has led to a substantial increase in civilian prehospital tourniquet use over the past decade, particularly in the US. Subsequently, the body of studies on the topic has grown considerably.

Schroll et al found that prehospital tourniquets were effective at controlling hemorrhage in the field in 88.8% of 197 patients. They reported complications in 32.4% of the patients, however, they were not necessarily due to tourniquet use (12).

Inaba et al retrospectively examined 87 patients with an extremity injury requiring tourniquet application and reported a total of 28 complications including 15 amputations. After review, only one case of compartment syndrome and one amputation could partially have been contributed to by the use of tourniquet. However, the tourniquet was deemed lifesaving in all fifteen patients with amputations (24).

A 5-year singlecentered retrospective study by Scerbo et al reported that tourniquets were applied appropriately in 105 civilians with no complications attributed to tourniquet use (25). A continuation of this study compared application of a tourniquet prehospitally vs in the trauma center. After controlling for year, mechanism of injury, and the presentation of shock (systolic blood pressure ≤90 mm Hg or heart rate ≥120 beats per minute or base deficit ≤4), patients who had an indication for tourniquet application had a 4.5-fold increased risk of death from hemorrhagic shock if tourniquet application was delayed until after arrival at the trauma center (OR 4.5, 95% CI 1.23–16.4) (p = 0.02) (14).

Ode et al retrospectively compared 24 instances of tourniquet application to 32 patients who were treated with conservative hemorrhage control measures (direct pressure/trauma dressings). They reported no tourniquet-related complications despite documenting a high rate of unindicated tourniquet application (20.8%), and concluded that liberal prehospital tourniquet use poses a much lower risk for adverse effects than the risk of fatal exsanguination (26). Also, by documenting 22 patients who sustained extremity injuries which warranted tourniquet application in the course of 14 months, they concluded that uncontrolled extremity hemorrhage is common enough in the civilian population to warrant standardized prehospital tourniquet implementation (26).

A retrospective study by Zietlow et al documented 98.7% (76/77) successful hemorrhage control using prehospital tourniquets in a total of 73 patients. They also reported a large proportion – 22% – of tourniquet being applied by non-medical personnel such as firefighters, law enforcement officers and bystanders before arrival of emergency medical services (EMS). Of those, 98.7% of commercial tourniquets were successful, while the three improvised tourniquets (belts) were unsuccessful (15).

A retrospective multi-institutional study by Leonard et al demonstrated that prehospital use of tourniquets in a diverse civilian population was both safe and effective. In 61 applications of tourniquets, hemorrhage control was achieved in 98.4% and all-cause morbidity was 18%. Morbidity could have been related to the original injury as all major morbidities were seen in patients with severe injuries. They did not find an association between increased risk of

amputation following tourniquet application with being elderly, obese or in patients with known comorbidities (13).

The aforementioned studies, among others, were evaluated in recent extensive reviews by Beaucreux et al and Kauvar et al, respectively. They concluded that the overall evidence on civilian prehospital tourniquet use is weak as a result of the low quality (GRADE) of the identified studies, being mostly observational retrospective studies with small effectives (16,27). Overall reported effectiveness is high across studies, averaging 90% and ranging from 78-100%. However, the criteria for measuring efficacy rates differ between the authors, making them difficult to compare. Overall reported complication rate is low, however, most studies were unable to identify whether the observed morbidity was attributed to tourniquet use or the injury itself. The all-cause mortality reported is low but cause-specific mortality is not reported. Different criteria are used when assessing whether tourniquet application was appropriate (ie indicated) or not appropriate. Also, insufficient information regarding the situational setting for tourniquet application is reported, which makes it impossible to determine if a tactical indication for the tourniquet use existed.

The lack of standardized criteria and variables for analyzing outcomes across the studies, as well as their retrospective design, serve as potential sources for information- and selection bias. Although the overall quality of the studies is evaluated as weak, the quantity of studies documenting effective and safe tourniquet use is substantial. Further, until recently no study has been able to firmly establish a definitive survival benefit from the use of tourniquet in a civilian prehospital setting.

Teixeira et al recently published a 6-year multicentered retrospective study comparing prehospital tourniquet application in civilians sustaining peripheral vascular injuries with a similarly matched no-tourniquet control group (28). 1026 patients sustaining peripheral vascular injuries were admitted to eleven level 1 trauma centers during the 6-year period, and 181 (17.6%) received a prehospital tourniquet. Prehospital tourniquet application was independently associated with a 6-fold mortality reduction in patients with peripheral vascular injuries (adjusted OR 5.86) ($p = 0.0015$). Prehospital tourniquet application was not

associated a with significant increase in the risk of delayed amputation, however, it was associated with a significant increase in the rate of thromboembolic complications (adjusted OR 0.44) (p = 0.039). Although a lifesaving benefit from civilian prehospital tourniquet application has been suggested in earlier studies, Teixeira et al achieved to validate an independent association between tourniquet use and survival in the civilian setting.

1.3 Tourniquet and firefighters – Ongoing lethal violence

Terrorist attacks and other mass casualty incidents have become a real threat even in previous peaceful settings (29). In Iraq and Afghanistan bleeding was responsible for more than 90% of deaths in soldiers with potentially survivable injuries (9). A study of civilian public mass shootings in the US found that chest injuries were the most common cause of death in potentially salvable victims, but these were events without explosives or stabbings (30). An attack using bombs, firearms or edged weapons can be expected to cause both injuries to the head and torso, and exsanguinating extremity injuries (31). One may expect many victims in a deliberate act of violence, and especially in school attacks swift recognition and proper treatment can save many quality-adjusted years of life.

As a consequence of the 2011 «22nd of July» terror event at the executive government quarter and Utøya, the Norwegian Directorate for Civil Protection released a national procedure for cooperation between emergency and law enforcement services during active shooter events (32). This was termed PLIVO, an abbreviation meaning «ongoing lethal violence», which includes any event with an active threat, such as shootings, stabbings, explosions, vehicles as weapons and other means of violence. This was implemented through cooperative field exercises with law enforcement, emergency medical services and fire departments. In both exercises and real events, the number of firefighters is usually several times the number of emergency medical personnel. Statistics from the Norwegian Directorate for Civil Protection also revealed that firefighters were first on site in 54.8% of instances where all three emergency services were activated (33). Their primary objective is to deal with fires and/or chemical-, biological-, radiological- and nuclear threats, but their secondary objective is to assist emergency medical services in evacuation and treatment.

During ongoing lethal violence, the focus should be airways- and hemorrhage control, rapid evacuation and transport to a hospital (34). In a situation with many patients or an active threat, tourniquets are recommended to control extremity hemorrhage (18–23). Motor vehicle accidents resulting in mangled extremities and/or amputations represents another example where tourniquet application would be beneficial. Application of a tourniquet is a technical skill which does not require a lot of medical knowledge. We believe that with training and exercise, firefighters are qualified to apply tourniquets. This is consistent with the new recommendation for civilian prehospital tourniquet use released by The Norwegian National Advisory Unit on Trauma in 2019 (35). As of today, firefighters represent an unutilized resource in civilian prehospital hemorrhage control.

1.4 Purpose

The aim of this study is to train and assess firefighters' skill attainment in the use of tourniquets, and to assess their skill retention after three months. As described in detail above, tourniquets are effective and safe instruments for controlling exsanguinating extremity hemorrhage, and a potential for tourniquet use by firefighters has been identified. The purpose of this study is to show whether firefighters can successfully apply a tourniquet after a short tourniquet course based on the new national recommendation for prehospital tourniquet use.

2.0 Materials and methods

This was a prospective experimental study of firefighter´s tourniquet skill attainment and skill retention. The data sampling occured in two phases. The first phase was divided into three parts; baseline pre-course testing of tourniquet application, a tourniquet course followed by immediate retesting of tourniquet application. This took place in November 2018 and January 2019 for OBRE and TBRE, respectively. The second phase consisted of retesting after three months. The project was submitted to the Regional Committee for Medical and Health Research Ethics, and was considered not to include elements regulated by the Norwegian law of health research (2018/2066-2 REK Nord).

2.1 Testing

The test is designed to assess if the participants are able to correctly apply a tourniquet. A model will have a simple moulage on the right thigh to simulate a bleeding injury, the model will in most cases be the participant that had just finished the test. The model will be instructed to breathe normally, and act unconscious and unresponsive to pain. The participant will be given the following instructions:

"*In this scenario you will find a patient with a massive arterial bleeding on the right thigh. You are to place a tourniquet as you would in a real scenario. You are only to focus on tourniquet application. Do not examine the patient or perform any other procedures. The scene is safe for you and the patient. There is no need for you to triage the patient or to report to anyone. The tourniquet is located next to the patient. Time starts when you enter the room and stops when you state that you are finished*"

To eliminate confounders such as differences in time spent on examining the patient, we excluded everything but the tourniquet application from the test. Each participator was asked to volunteer as moulages for their colleague during the subsequent test. If a participator did not volunteer, one of the authors acted as the moulage.

2.1.1 Data

Primary outcome was absent distal pulse, correct placement (i.e. 5-10cm proximal to wound) and application time (in seconds). Absent distal pulse was verified using doppler

ultrasound on the posterior tibial artery. The posterior tibial artery was identified and marked before each test rounds to reduce the risk of operator error. Descriptive data included age, gender and previous training/experience with tourniquets. Also, the current round of tourniquet application was noted (see section 2.1.2 below). The data was collected using a standardized form (Appendix 1).

2.1.2 Tourniquets

We used the Combat Application Tourniquet (CAT) GEN7 by C•A•T Resources, Rock Hill, South Carolina. The CAT is designed for one-time use only, however, our budget did not allow us to purchase the number of tourniquets needed to achieve this. After testing a number of tourniquets several times with doppler ultrasound, we determined that they still achieved complete arterial occlusion after twelve applications. To maintain our budget, we therefore settled to use each tourniquet up to 10 consecutive times. We noted the current round of application for the tourniquet ("tourniquet-round") during each test to see if worse results were associated with increasing number of tourniquet applications.

2.2 Tourniquet course

The participants recieved a 45-minute long theoretical and practical course in correct tourniquet application based on the new recommendation on civilian prehospital tourniquet use by the National Advisory unit on trauma (35) (Appendix 2). The course focused on correct tourniquet indications and technique, and outlined some key concepts on duration, potential complications and pain management. The firefighters then practiced on each other under supervision.

2.3 Second phase - Retesting

The second phase took place exactly 12 weeks after the first phase for both OBRE and TBRE. This phase consisted of one round of testing on all available participants to assess their tourniquet skill retention after 3 months. Each participant was asked these questions prior to testing:

- Have you trained on tourniquet application in the last three months? (no, 1, 2, 3, >3 times). If yes, how long was it since your last tourniquet application?

- Have you applied a tourniquet on a patient in the last three months? (no, 1, 2, 3, >3 times). If yes, how long was it since you applied a tourniquet on a patient?

2.4 Inclusion and exclusion criteria

Our contact at the fire departments provided a schedule where we visited several units at different brigades and fire stations over the course of a week. The inclusion criterion for this study was simply any firefighter on duty at the time of our visit at their respective fire station. Participation was voluntary and anonymously. Every firefighter signed a consent form and recieved oral and written information on how to withdraw from the study.

At the time of our study, some fire units were already implementing a tourniquet course as part of their hemorrhage control training. Because we wanted to test the firefighters' skill attainment/retention solely based on our course, these units were excluded from our study. We did not exclude firefighters with prior tourniquet experience from The Norwegian Armed Forces because we considered the duration between their military experience and testing to be substantial enough. This could potentially serve as an interesting comparator. As the firefighters were on duty there was a risk of them being dispatched during the testing and/or course.

2.5 Statistical analysis

Categorical data are reported as proportions and tested for significance using χ^2 test of independence. Continuous data, i.e. application time, is reported as means with 95% confidence intervals, and analyzed using a repeated measure ANOVA. A multivariate regression was performed to analyze multiple independent variables. A p-value of less than <0.05 was considered statistically significant for all the analyses. The IBM SPSS Statistics 24 software was used to analyze the data.

We conducted a power calculation based on available literature on skill retention and have estimated a necessary sample size of at least 87 participants, which at a two-sided 5% significance level would provide at least 90% power to detect a relevant difference between before and after training.

3.0 Results

3.1 Study population

The study population consisted of 109 participants in the first test round, pre-course (Table 1). All were male with a mean age of 40.25 years (25-59). Of these, 69 firefighters (63.3%) had no previous experience with a tourniquet, 36 firefighters (33%) had used a tourniquet >12 months ago, 2 firefighters (1.8%) had used a tourniquet in the past 6-12 months, and 2 firefighters (1.8%) had used a tourniquet in the past 6 months. All earlier tourniquet experience was related to service in the Norwegian Armed Forces.

The second test round, immediately after the course, consisted of 105 participants. The remaining 4 were lost because they were dispatched on an emergency mission. The three-months re-test consisted of 62 participants. Changes in unit schedules made follow-up difficult which caused the loss of additional 43 participants.

3.2 Successful tourniquet applications

A successful tourniquet application was defined as achieving both absent distal pulse as well as placing the tourniquet correctly (i.e. 5-10cm proximal to the wound), as these are the factors that determine whether the hemorrhage is controlled or not. The proportion of successful application was 50.5% (55 of 109) pre-course, 91.4% (96 of 105) immediately after, and 87.1% (54 of 62) at the three-months re-test (Table 2). The firefighters achieved a significantly greater proportion of successful tourniquet applications after the course as well as three months later (Pearson chi-square p=0.009).

We ran a simple logistic regression where we adjusted for previous tourniquet experience to see if this affected the baseline skill level. There was not a significant difference between firefighters with or without prior tourniquet experience, OR = 0.916 (CI 0.2 – 2.9) (p=0.802), we could therefore treat them as equals with equivalent baseline skill level.

As each tourniquet was used up to ten times, an increasing number of consecutive applications («tourniquet-round») could possibly contribute to a worse success-ratio. Also,

the testing occured in two parallels where Dragset and Blix tested separate groups of firefighters. The group selection was random, but could introduce observer and confirmation bias due to operator difference in use of doppler ultrasound. We ran a multivariate logistic regression where successful application was adjusted for both tourniquet-round and observer, as well as application time, to test for these potential confounders. Neither tourniquet-round (OR 0.998, CI 0.876-1.137) (p=0.979) or observer (OR=1.223, CI 0.594-2.520) (p=0.584) was associated with significant differences in successful application. However, application time was statistically significant, OR 0.981 (CI 0.966-0.997) (p=0.016) (Table 3). Meaning, faster tourniquet application was associated with a slightly greater odds of achieving a successful application, but the difference was miniscule.

3.3 Application time

Mean application time in the three rounds was 59.6s (55.1-64.2), 34.9s (33.3-36.6) and 37.7s (33.9-41.4), respectively (Table 4). A repeated measure ANOVA showed a significant difference between the groups. Mauchly's test of sphericity indicated that the assumption of sphericity was violated (p<0.001), therefore a Greenhouse-Geisser correction was used (p<0.001). Post-hoc tests using the Bonferroni correction revealed that the firefighters were significantly slower pre-course compared to both the second (mean difference 24.7s) (p<0.000) and third round (mean difference 22.0s) (p<0.000), but not between the second and third round (mean difference 2.7s) (p=0.983) (Table 5). The firefighters reduced their mean application time by 41.4% after the course, and the time usage did not increase significantly after three months.

3.4 Training before the three-months re-test

The rate of participants who reported tourniquet training or real-life use between the second and three-months re-test were extremely low 3/62 (4.7%). Based on the low rate, it was considered as a weak confounder and not included in the final analysis.

4.0 Discussion

The firefighters achieved 91.4% successful applications and reduced their time use by 41.4% after the course. Skill retention was satisfactory after three months by achieving 87.1% successful applications, without significantly increasing the time usage. This validates the quality of the course based on the new recommendation on civilian prehospital tourniquet use. Also, the rate of 50.5% successful tourniquet applications pre-course confirms that a course is necessary to be able to apply a tourniquet correctly. We believe that a short 45-minute tourniquet course including indications, technique, possible complications and practical training is both necessary and highly cost-beneficial.

Firefighters are remarkably dexterous and proficient in their profession, but they have limited medical and anatomical knowledge. This was reflected in pre-course application were some firefighters applied the tourniquet directly over the wound. Subsequently, the excellent results immediately- and three months after the course demonstrates that tourniquets are simple devices which can be mastered by people with limited medical qualifications. We therefore believe that prehospital emergency medical personnel should have no problem applying a successful tourniquet after the same course. We do not know whether EMS-personnel would succeed without a tourniquet course, but we would not recommend implementing new equipment without training, regardless of expertise.

The use of tourniquets must like any other skill be trained to achieve proficiency. The firefighters achieved satisfactory skill level after three months, but we did not have the opportunity to continue the study to identify the interval where skill retention becomes insufficient. As those with prior tourniquet experience preceding more than twelve months before the study did not achieve better pre-course success-ratio, this interval presumably lies between 3-12 months. Norwegian firefighters re-certify their first aid and cardiopulmonary resuscitation (CPR) qualifications every twelve months. We don’t believe that tourniquet application requires re-certification more frequent than CPR as we view CPR as more essential and challenging than tourniquet application. We suggest tourniquet re-certification every twelve months as part of firefighters’ hemorrhage control training.

4.1 Other studies

To the best of our knowledge there exists no similar prospective study evaluating firefighters', or similarly capable, tourniquet skill attainment and skill retention. A 2019 study by McCarthy et al compared self-reported prior first-aid (FA) and hemorrhage control (HC) training to no prior training in laypersons' ability to apply a tourniquet (36). A correct tourniquet application was defined as sufficient distance above the injury (>2inches proximal), adequate tightness and application time less than seven minutes. The proportion of successful application for those who reported no prior training, FA training only, and FA+HC training was 14.4% (16 of 111), 25.2% (35 of 139), and 35.8% (24 of 67), respectively. The comparatively greater pre-course success-ratio amongst the firefighters in our study (50.5%) indicate that they are dexterous and quick learners.

Martinez et al evaluated the effect of a tourniquet refresher training session in French soldiers (37). 52 soldiers were tested pre-course and subsequently randomized in a refresher group (R+) and a no-refresher group (R-). The authors developed a composite performance score including effectiveness, application time, «tourniquet pre-positioning» and «tourniquet preparation» to assess tourniquet performance. The groups were tested again two months later. A refresher session was not associated with improved performance score after two months, as the score improved by 61.5% in the R(+) group and by 37.5% in the R(−) group (P=0.09). This could partially be contributed by the fact that median time between the last tourniquet training and pre-course assessment was 10.8 months (interquartile range 4.3-13.3) for the R(+) group, and 2.3 months (interquartile range 2.3-2.3) ($p<0.0001$). However, soldiers whose most-recent training occurred more than six months prior to the first assessment were more likely to improve their performance score between the two assessments (P=0.04). The authors concluded that a tourniquet refresher session is especially effective six months after previous training. This reinforce our proposal that tourniquet application should be trained and re-certified at least every twelve months.

4.2 Relevance

Twenty-five people were murdered in 2018 in Norway, 13 of which were killed by firearms or stab-weapons (38). In the same year, 108 people were killed in motor vehicle accidents

(39). The estimated number of murders in the US in 2017 was 17 284 (40), and 37 461 people were killed in motor vehicle accidents in 2016 (41). These numbers illustrate that the rate of incidents with potentially exsanguinating extremity hemorrhage is very low in Norway. Also, the number of emergency providers generally exceeds the number of patients, which permits the use of traditional hemorrhage control such as direct pressure and wound packing. This might not be the case for rural Norway, where firefighters, especially, could arrive on-scene several minutes before emergency medical services and law enforcement. Regardless of emergency services' mobility, one can never foresee a pending mass casualty event with multitudes of exsanguinating extremity hemorrhage where tourniquets could be lifesaving. To prepare for such an unforeseeable event, we strongly recommend that firefighters and emergency medical services implement tourniquets in their hemorrhage control protocol.

4.3 Strengths and weaknesses

Oslo Fire- and Rescue Department was selected because it is the largest fire department in the country, and Tromsø Fire- and Rescue Department was selected because of close vicinity to UiT – The Arctic University of Norway. Every on-duty firefighter was invited to participate, and none declined. Every participant was male, but as only 2.3% of firefighters in Norway are female, we believe that the study population is representative for Norwegian firefighters (42).

The initial population size of 109 participants was positive. The loss to follow-up was 3.7% immediately after the course and 43.1% at the three-months re-test (Table 1). The follow-up rate was lower than desirable at three-months, but the loss was out of our control and random by changes in the unit schedules.

The execution of the testing has some limits. Firstly, confirmation- and observer bias cannot be ruled out as we conducted our own testing. Secondly, we would have preferred to use the tourniquets only one time each, as recommended by the producers. We did not have the budget to accomplish this, however, an increased number of "tourniquet-rounds" was not associated with lower odds-ratio of achieving a successful tourniquet application (Table 3).

Thirdly, the moulage/model during the testing was the firefighter that had just finished the test. They were instructed to act unconscious and unresponsive to pain, but tourniquets will elicit considerable pain when applied correctly. The fear of hurting their colleague was partly a cause of unsuccessful applications amongst the firefighters. This was observed in all three test rounds, but predominantly in the pre-course testing. An inert model could eliminate this source of error, but would not prepare the firefighters for a real-life response. The patient's likely intense pain as a response to tourniquet application was discussed in the course. Lastly, to evaluate the full benefit and quality of the course, we should have tested their knowledge and skill concerning indications for tourniquet use. Tourniquets are recommended in exsanguinating extremity hemorrhage which cannot be controlled by direct pressure and wound packing. Tourniquet use in hemorrhage where direct pressure and wound packing is sufficient increases the risk of possible complications without increasing survival benefit. We did not have the time or resources to conduct a theoretical or practical test to evaluate indications for tourniquet use.

5.0 Conclusion

Firefighters are able to successfully apply a tourniquet after a 45-minute course based on the new recommendation for civilian prehospital tourniquet use. The firefighters achieved 91.4% successful applications and reduced their time use by 41.4% after the course. Skill retention was satisfactory after three months by achieving 87.1% successful applications, without significantly increasing the time usage.

We strongly recommend that tourniquets should be a part of firefighters' hemorrhage control kit, but they should not be implemented without proper training. We recommend that tourniquet use is standardized in all prehospital medical providers across the country, including both the fire service and emergency medical service. Further studies should investigate the potential survival benefit after implementation of tourniquets in prehospital emergency care.

6.0 References

(1) Navein J, Coupland R, Dunn R. The tourniquet controversy. J Trauma 2003;54:219–20. doi:10.1097/01.TA.0000047202.16935.E9.

(2) Husum H, Gilbert M, Wisborg T, Pillgram-Larsen J. Prehospital tourniquets: there should be no controversy. J Trauma 2004;56:214–5. doi:10.1097/01.TA.0000104494.62175.2F.

(3) Bellamy RF. The causes of death in conventional land warfare: implications for combat casualty care research. Mil Med 1984;149:55–62.

(4) Lakstein D, Blumenfeld A, Sokolov T, Lin G, Bssorai R, Lynn M, et al. Tourniquets for hemorrhage control on the battlefield: a 4-year accumulated experience. J Trauma 2003;54:221–5. doi:10.1097/01.TA.0000047227.33395.49.

(5) Beekley AC, Sebesta JA, Blackbourne LH, Herbert GS, Kauvar DS, Baer DG, et al. Prehospital Tourniquet Use in Operation Iraqi Freedom: Effect on Hemorrhage Control and Outcomes. J Trauma Inj Infect Crit Care 2008;64:S28–37. doi:10.1097/TA.0b013e318160937e.

(6) Kragh JF, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, et al. Practical Use of Emergency Tourniquets to Stop Bleeding in Major Limb Trauma. J Trauma Inj Infect Crit Care 2008;64:S38–50. doi:10.1097/TA.0b013e31816086b1.

(7) Kragh JF, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, et al. Survival with emergency tourniquet use to stop bleeding in major limb trauma. Ann Surg 2009;249:1–7. doi:10.1097/SLA.0b013e31818842ba.

(8) Kragh JF, Littrel ML, Jones JA, Walters TJ, Baer DG, Wade CE, et al. Battle casualty survival with emergency tourniquet use to stop limb bleeding. J Emerg Med 2011;41:590–7. doi:10.1016/j.jemermed.2009.07.022.

(9) Eastridge BJ, Mabry RL, Seguin P, Cantrell J, Tops T, Uribe P, et al. Death on the battlefield (2001-2011): Implications for the future of combat casualty care. J Trauma Acute Care Surg 2012;73:431–7. doi:10.1097/TA.0b013e3182755dcc.

(10) Kragh JF, Nam JJ, Berry KA, Mase VJ, Aden JK, Walters TJ, et al. Transfusion for shock in US military war casualties with and without tourniquet use. Ann Emerg Med 2015;65:290–6. doi:10.1016/j.annemergmed.2014.10.021.

(11) Kragh JF, Dubick MA. Bleeding Control With Limb Tourniquet Use in the Wilderness

Setting: Review of Science. Wilderness Environ Med 2017;28:S25–32. doi:10.1016/j.wem.2016.11.006.

(12) Schroll R, Smith A, McSwain NE, Myers J, Rocchi K, Inaba K, et al. A multi-institutional analysis of prehospital tourniquet use. J Trauma Acute Care Surg 2015;79:10–4. doi:10.1097/TA.0000000000000689.

(13) Leonard J, Zietlow J, Morris D, Berns K, Eyer S, Martinson K, et al. A multi-institutional study of hemostatic gauze and tourniquets in rural civilian trauma. J Trauma Acute Care Surg 2016;81:441–4. doi:10.1097/TA.0000000000001115.

(14) Scerbo MH, Holcomb JB, Taub E, Gates K, Love JD, Wade CE, et al. The trauma center is too late: Major limb trauma without a pre-hospital tourniquet has increased death from hemorrhagic shock. J Trauma Acute Care Surg 2017;83:1165–72. doi:10.1097/TA.0000000000001666.

(15) Zietlow JM, Zietlow SP, Morris DS, Berns KS, Jenkins DH. Prehospital Use of Hemostatic Bandages and Tourniquets: Translation From Military Experience to Implementation in Civilian Trauma Care. J Spec Oper Med 2015;15:48–53.

(16) Kauvar DS, Dubick MA, Walters TJ, Kragh JF. Systematic review of prehospital tourniquet use in civilian limb trauma. J Trauma Acute Care Surg 2018;84:819–25. doi:10.1097/TA.0000000000001826.

(17) Fitzgibbons PG, Di Giovanni C, Hares S, Akelman E. Safe tourniquet use: A review of the evidence. J Am Acad Orthop Surg 2012;20:310–9. doi:10.5435/JAAOS-20-05-310.

(18) Bulger EM, Snyder D, Schoelles K, Gotschall C, Lang E, Sanddal ND, et al. An Evidence-based Prehospital Guideline for External Hemorrhage Control: American College of Surgeons Committee on Trauma. Prehospital Emerg Care 2014;18:163–73. doi:10.3109/10903127.2014.896962.

(19) ATLS Subcommittee; American College of Surgeons' Committee on Trauma, Working IA. Advanced trauma life support (ATLS®): the ninth edition. J Trauma Acute Care Surg 2013;74:1363–6. doi:10.1097/TA.0b013e31828b82f5.

(20) Pons P, Jerome J, Mcmullen J, Manson J, Robinson J, Chapleau W. The Hartford Consensus on active shooters: Implementing the continuum of prehospital trauma response. J Emerg Med 2015;49:878–85. doi:10.1016/j.jemermed.2015.09.013.

(21) Jacobs LM, Mcswain NE, Rotondo MF, Wade D, Fabbri W, Eastman AL, et al. Improving

survival from active shooter events : The Hartford Consensus 2013;74:1399–400. doi:10.1097/TA.0b013e318296b237.

(22) Singletary EM, Charlton NP, Epstein JL, Ferguson JD, Jensen JL, Macpherson AI, et al. Part 15 : First Aid 2015 American Heart Association and American Red Cross Guidelines Update for First Aid. Circulation 2015;132:574–89. doi:10.1161/CIR.0000000000000269.

(23) Zideman DA, Buck EDJ De, Singletary EM, Cassan P, Chalkias AF, Evans TR, et al. European Resuscitation Council Guidelines for Resuscitation 2015 Section 9. First aid. Resuscitation 2015;132:278–87. doi:10.1016/j.resuscitation.2015.07.031.

(24) Inaba K, Siboni S, Resnick S, Zhu J, Wong MD, Haltmeier T, et al. Tourniquet use for civilian extremity trauma. J Trauma Acute Care Surg 2015;79:232–7. doi:10.1097/TA.0000000000000747.

(25) Scerbo MH, Mumm JP, Gates K, Love JD, Wade CE, Holcomb JB, et al. Safety and Appropriateness of Tourniquets in 105 Civilians. Prehosp Emerg Care 2016;20:712–22. doi:10.1080/10903127.2016.1182606.

(26) Ode G, Studnek J, Seymour R, Bosse MJ, Hsu JR. Emergency tourniquets for civilians: Can military lessons in extremity hemorrhage be translated? J Trauma Acute Care Surg 2015;79:586–91. doi:10.1097/TA.0000000000000815.

(27) Beaucreux C, Vivien BB, Miles E, Ausset S, Pasquier P, C. B, et al. Application of tourniquet in civilian trauma: Systematic review of the literature. Anaesthesia, Crit Care Pain Med 2018;S2352-5568. doi:10.1016/J.ACCPM.2017.11.017.

(28) Teixeira PGR, Brown CVR, Emigh B, Long M, Foreman M, Eastridge B, et al. Civilian Prehospital Tourniquet Use Is Associated with Improved Survival in Patients with Peripheral Vascular Injury. J Am Coll Surg 2018;226:769–776.e1. doi:10.1016/j.jamcollsurg.2018.01.047.

(29) Hirsch M, Carli P, Nizard R, Riou B, Baroudjian B, Baubet T, et al. The medical response to multisite terrorist attacks in Paris. Lancet 2015;386:2535–8. doi:10.1016/S0140-6736(15)01063-6.

(30) Smith ER, Shapiro G, Sarani B. The profile of wounding in civilian public mass shooting fatalities. J Trauma Acute Care Surg 2016;81:86–92. doi:10.1097/TA.0000000000001031.

(31) Turner CDA, Lockey DJ, Rehn M. Pre-hospital management of mass casualty civilian shootings: A systematic literature review. Crit Care 2016;20:362. doi:10.1186/s13054-016-1543-7.

(32) The Norwegian Directorate for Civil Protection. National procedure - The cooperation of emergency services during ongoing lethal violence [Norwegian] [Internet]. Oslo 2015 [cited 12/30/2018]. Available at: https://www.dsb.no/lover/brannvern-brannvesen-%0Dnodnett/artikler/nasjonal-prosedyre-for-nodetatenes-samvirke-ved-pagaende-%0Dlivstruende-vold-plivo/(.

(33) Inderhaug E. Brannvesenet er oftere først på stedet [Norwegian] [Internet]. Politiforum.no 2018. [cited 12/30/2018]. Available at: https://www.politiforum.no/artikler/brannvesenet-er-oftere-forst-pa-stedet/454297.

(34) Zafar SN, Haider AH, Stevens KA, Ray-Mazumder N, Kisat MT, Schneider EB, et al. Increased mortality associated with EMS transport of gunshot wound victims when compared to private vehicle transport. Injury 2014;45:1320–6. doi:10.1016/j.injury.2014.05.032.

(35) Nasjonal Kompetansetjeneste for Traumatologi. Anbefaling vedrørende bruk av turniké [Norwegian] [Internet] 2019. [cited 01/01/2019]. Available at: http://traumatologi.no/wp-content/uploads/2019/01/Anbefaling-vedr.-bruk-av-turniké-fra-NKT.pdf.

(36) McCarty JC, Caterson EJ, Chaudhary MA, Herrera-Escobar JP, Hashmi ZG, Goldberg SA, et al. Can they stop the bleed?Evaluation of tourniquet application by individuals with varying levels of prior self-reported training. Injury 2019;50:10–5. doi:10.1016/j.injury.2018.09.041.

(37) Martinez T, Duron S, Schaal JV, Baudoin Y, Barbier O, Daban JL, et al. Tourniquet Training Program Assessed by a New Performance Score. Prehosp Disaster Med 2018;33:519–25. doi:10.1017/S1049023X18000845.

(38) The National Criminal Investigation Service - KRIPOS. Nasjonal drapsoversikt 2018 [Norwegian] [Internet] 2018. [cited 05/30/2019]. Available at: https://www.politiet.no/globalassets/04-aktuelt-tall-og-fakta/drap/drapsoversikt-2018.pdf.

(39) Statistisk sentralbyrå. Drepte og hardt skadde i trafikken [Norwegian] [Internet] 2019.

[cited 05/30/2019]. Available at: https://www.ssb.no/vtu/.

(40) U.S Department of justice. Federal Bureau of Investigation - Criminal Justice Information Services Division. Crime in the United States [Internet] 2017. [cited 05/30/2019]. Available at: https://ucr.fbi.gov/crime-in-the-u.s/2017/crime-in-the-u.s.-2017/topic-pages/tables/table-1.

(41) U.S. Department of Transportation. National Highway Traffic Safety Administration. Quick Facts 2016 [Internet] 2017:1–6. [cited 05/30/2019]. Available at: https://crashstats.nhtsa.dot.gov/#/PublicationList/38.

(42) Geard K. Nettverkstøtte i mannsyrke - Lill--Marit er en av få kvinnelige brannkonstabler: – Dette er en fin jobb for damer [Norwegian] [Internet]. Fagbladet 2018:1–15. [cited 05/30/2019]. Available at: https://fagbladet.no/nyheter/lillmarit-er-en-av-fa-kvinnelige-brannkonstabler--dette-er-en-fin-jobb-for-damer-6.91.531778.857b71ccda.

7.0 Tables

Table 1

Baseline demographics		N (percentage)
Population	Pre-course	109 (100%)
	Immediately after course	105 (96.3%)
	Three-months re-test	62 (56.9%)
Age	Mean	40.25
	Minimum	25
	Maximum	59
Gender	Male	109 (100%)
	Female	0 (0%)
Previous tourniquet experience	None	69 (63.3%)
	>12 months ago	36 (33%)
	6-12 months ago	2 (1.8%)
	<6 months ago	2 (1.8%)

Baseline demographics for the study population.

Table 2

Successful tourniquet application			
	Pre-course (T1)	Immediately after course (T2)	Three-months re-test (T3)
Successful tourniquet application	55 (50.5%)	96 (91.4%)	54 (87.1%)
Not successful	54 (49.5%)	9 (5.6%)	8 (12.9%)
Total	109	105	62

Proportions of successful tourniquet application in the three testrounds.

Table 3

Multiple logistic regression

		B	S.E.	df	Sig.	OR	95% CI
Successful tourniquet application	Tourniquet-round	-0,002	0,066	1	0,979	0,998	0,876 – 1,137
	Application time	-0,019	0,008	1	0,016	0,981	0,966 – 0,997
	Observer	0,202	0,369	1	0,584	1,223	0,594 – 2,520

Multiple logistic regression of successful tourniquet application adjusted for tourniquet-round, application time and observer.

Table 4

Application time

	N	Mean ± SD (seconds)	95% CI for Mean Lower Bound	95% CI for Mean Upper Bound
Pre-course	109	59,64 ± 23.7	55,14	64,15
Immediately after	105	34,94 ± 8.5	33,30	36,59
Three-months re-test	62	37,66 ± 14.8	33,90	41,43
Total	276	45,31 ± 20.8	42,84	47,77

Mean time of tourniquet application in the three rounds.

Table 5

Post hoc analysis Bonferroni correction

Dependent Variable: Application time

Test (A)	Comparator (B)	Mean Difference (A-B)	Std. Error	Sig.	95% CI
Pre-course (T1)	T2	24,699*	2,366	,000	19,00 – 30,40
	T3	21,981*	2,753	,000	15,35 – 28,61
Immediately after course (T2)	T1	-24,699*	2,366	,000	-30,40 – -19,00
	T3	-2,718	2,772	,983	-9,39 – 3,96
Three-months re-test (T3)	T1	-21,981*	2,753	,000	-28,61 – -15,35
	T2	2,718	2,772	,983	-3,96 – 9,39

*The mean difference is significant at the 0.05 level.

Bonferroni post hoc multiple pairwise comparison of time of tourniquet application between the three rounds.

9.0 Appendices

Appendix 1: Form during testing - “Observatørskjema” [Norwegian]

Appendix 2: Nasjonal Kompetansetjeneste For Traumatologi. Anbefaling vedrørende bruk av turniké [Norwegian] 2019. [cited 01/01/2019]. Available at: http://traumatologi.no/wp-content/uploads/2019/01/Anbefaling-vedr.-bruk-av-turniké-fra-NKT.pdf.

Appendix 3: GRADE 1

Appendix 4: GRADE 2

Appendix 5: GRADE 3

Appendix 6: GRADE 4

Appendix 7: GRADE 5

Appendix 1

UiT
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Blix, S.W., Dragset, E. 2018

Assessing firefighters tourniquet skill attainment and skill retention – A controlled simulation based experiment

Markør-briefing:
I dette scenarioet har du en kraftig blødning på høyre lår. Du er bevisstløs og reagerer ikke på smerte, men du puster normalt. Hvis smertene er uutholdelige kan du naturligvis varsle om dette.

Testscenario:

- I dette scenarioet finner du en pasient med kraftig blødning på høyre lår. Du skal plassere en turniké slik du ville gjort i et ekte scenario.
- Du skal kun fokusere på bruk av turniké. Du skal ikke undersøke eller gjennomføre andre tiltak hos pasienten. Test-omgivelsene er trygg for deg og pasienten, du trenger ikke triagere eller rapportere noen funn.
- Tiden starter idet du går inn i rommet, og stopper når du oppgir at du er ferdig.
- Turnikéen ligger ved pasientens høyre lår.

Gjennomføring:

Kandidat:	Kandidatnummer: Alder: Kjønn: M ☐ F ☐	
Turniké runde:	Nr:	
Tidligere trening/opplæring i turniké (tid siden trening/opplæring)	Ingen <1-3mnd 4-6mnd 6-12mnd >12mnd	☐ ☐ ☐ ☐ ☐
Plassering:	Korrekt Feilplassering	☐ ☐
Tidsstropp (tidspunkt for påføring av turniké):	Påført Ikke påført	☐ ☐
Tid (sek):		
Puls v/doppler:	Ingen puls Puls	☐ ☐
Observatør:	Sigurd Erik	☐ ☐
Avbrutt test?		

UNIVERSITETET I TROMSØ

Appendix 2:

Anbefaling vedrørende bruk av turniké

Innledning/bakgrunn:

- Nasjonal Kompetansetjeneste for Traumatologi (NKT-Traume) har sammen med en gruppe eksperter fra både prehospitale tjenester, sykehus, politi og Forsvaret utarbeidet denne anbefaling for bruk av turniké i Norge. Den representerer ekspertgruppens vurdering høsten 2018, basert på systematisk gjennomgang av tilgjengelig litteratur, for å kunne definere «best-practice» retningslinjer utfra kunnskapsgrunnlaget, slik det foreligger i dag.
- Det er utarbeidet et undervisningsopplegg i blødningskontroll, der turniké er et av hjelpemidlene. Opplegget er egnet for instruksjon/undervisning lokalt, og kan lastes ned med instruktørveiledning fra NKT's hjemmeside www.traumatologi.no fra vinteren 2019. Når det er klart blir det annonsert på hjemmesiden.

Målgruppe:

- Ambulansepersonell og annet helsepersonell
- Brannmannskaper
- Politi
- Annet personell med opplæring i bruk
- Turniké skal *kun* brukes av personell som har fått opplæring.

Indikasjoner:

- Livstruende ekstremitetsblødninger som ikke lar seg kontrollere med direkte trykk eller pakking av sår, f.eks.:
    - Amputasjoner
    - Flere livstruende blødningskilder
    - Skader som ikke tilgjengelig for blødningskontroll, f.eks. hos fastklemt pasient.
- Situasjoner med flere pasienter med livstruende ekstremitetsblødninger hvor mangel på personell og/eller utstyr ikke tillater tradisjonell blødningskontroll med direkte trykk eller pakking av sår.
- Situasjoner der trusselbildet ikke tillater tradisjonell blødningskontroll med direkte trykk eller pakking av sår, f.eks. ved PLIVO-situasjoner.

Teknikk:

- Plassering:
    - Ideelt plasseres turnikéen direkte på hud for å unngå at den sklir. Dette skal ikke gå på bekostning av lengre tidsbruk, plasser derfor turnikéen over/på klær om nødvendig for rask plassering.
    - Turnikéen plasseres 5-10 cm over skaden. Vær obs på at den kan skli ned under forflytning.

    - Ved tvil om hvor skaden sitter eller ved mistanke om flere skader kan man sette turnikéen øverst i lyske eller i armhule.
    - Turniké kan settes på underarm og legg, men ikke ovenpå et ledd.
- Stramming:
    - Stroppen strammes helt inn. Sørg for at pinnen er lett tilgjengelig/vender mot deg.
    - Dra pinnen til deg, vri til blødningen stanser, deretter en halv runde til (180 grader). Forankre pinnen og noter tidspunkt.
    - Vær obs på at sivblødning fra knokler/benmarg ikke vil stoppes av turniké.
- Manglende blødningskontroll:
    - Effekten av turniké avgjøres av om blødningen stanser eller ikke. Hvis turnikéen ikke stanser blødningen gjøres følgende
        - Sjekk at turnikéen er stram nok
        - Hvis blødningen fortsatt ikke stanser, påføres enda en turniké like over den første turnikéen. Hvis den første er satt i armhule eller lyske, påføres den andre like under.
- Oppfølging:
    - Turniké er svært smertefullt, spesielt over tid. Pasienten må informeres og holdes under oppsyn, også for at de ikke selv løsner turnikéen. Avlever pasienten til helsepersonell raskest mulig og gi informasjon om når turniké ble påsatt.
    - Pasienten smertelindres om mulig, men dette bør ikke forsinke evakuering og transport.
- Improvisert turniké:
    - Improvisert turniké gir sjelden høyt nok trykk til å stanse blødningen og skal derfor ikke brukes. I verste fall kan improviserte turnikéer klemme av venene, men ikke arteriene, og dermed forverre blødningen.

Fjerning av turniké:

- Turniké skal *kun* fjernes av helsepersonell eller annet personell med særlig trening og kompetanse.
- Så snart omstendighetene tillater det, skal behovet for turniké revurderes. Fjerning av turniké avhenger av flere faktorer; pasientens status, estimert tid til nærmeste sykehus, tilgjengelige ressurser og eventuelle andre skader som behøver tiltak. Denne vurderingen skal kun tas av kompetent personell.
- Hvis blødningen kan kontrolleres på andre måter, kan turnikéen forsøkes fjernet. Før turnikéen fjernes skal det sikres blødningskontroll med direkte trykk og pakking av sår.
- Sett en ny turniké over den første, uten å stramme den. Fjern deretter den første turnikéen forsiktig, men la den sitte løst slik at den raskt kan strammes ved manglende blødningskontroll.
- Hvis ukontrollert blødning gjenoppstår, skal den første turnikéen strammes og sitte på til pasienten er ankommet operasjonsstuen. Hvis den første turnikéen svikter, stram den den nye turnikéen.
- Ved kort evakuering til sykehus eller mistanke om flere skader, bør fjerning av turniké ikke forsinke transport.

Risiko/komplikasjoner:

- Turniké gir opphørt blodforsyning til vevet nedenfor nivået den er plassert med risiko for skader på muskler, nerver og blodkar. Det er lite kunnskap om når skaden blir varig, men det ser ut til at risikoen øker etter mer enn 90 minutter. Risikoen for bivirkninger må vurderes opp mot risikoen for blødning ved manglende bruk av turniké.

Trening

- Ved trening skal turnikéen alltid strammes hardt på markøren. Hverken den som øver eller markøren skal løsne turnikéen, dette bør gjøres av instruktør etter kort tid. Dette for å unngå innlæring av feil handlingsmønster.
- Det finnes ingen retningslinjer på hvor ofte man kan få påsatt turniké, men gruppen anbefaler maksimalt én stram/skarp turniké per kroppsdel per døgn.

Appendix 3:

Referanse: Kragh JF, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, et al. Practical Use of Emergency Tourniquets to Stop Bleeding in Major Limb Trauma. J Trauma Inj Infect Crit Care [Internet]. 2008 Feb [cited 2018 Oct 23];64(Supplement):S38–50			Studydesign: Cohort Grade – quality: Moderate
Purpose	Materials and methods	**Results**	**Discussion**
The purpose of this study was to measure the use of tourniquets and complications attributable to their use. Conclusion The morbidity risk was low, and there was a positive risk benefit ratio in light of the survival benefit. No limbs were lost because of tourniquet use, and tourniquet duration was not associated with increased morbidity. Education for early military tourniquet use should continue. **Country** Iraq Year of data collection The study period was from March 19 to October 4, 2006.	**Population:** 232 patients on United States combat support hospital in Baghdad, Iraq with tourniquets applied in the field or in the emergency department/intensive care unit. **Outcome:** Effectiveness of tourniquets measured in visual control of bleeding and lack of peripheral pulse. Patients were also evaluated for limb outcome and morbidity. **Limitations** Limited population (primarily soldiers, a few women, elderly and children) and rapid evacuation to a quality healthcare system limit generalization. **Statistical methods** Descriptive statistics for tourniquet use and outcome. For comparison between subgroups of categorical data, significance was determined by X^2 or, when there were fewer than 5 categories, Fisher's exact test. Subgroup analyses for continuous data were done with Student's *t* test. All tests were two-tailed. Descriptive statistics were used to draw conclusions regarding the potential for improved doctrine, training or devices to impact the care given to combat casualties.	**Results** Tourniquet effectiveness varied from 92% to 66% (different tourniquet models). Lack of effect was too narrow tourniquets compared to the girth of the limb, incorrect use or tourniquet breakage. Improvised tourniquets were ineffective in 67% of cases. Of 10 clots (one deep vein thrombosis and nine thrombectomies), none were attributed to tourniquet use by the vascular surgeon. No pulmonary embolisms were detected in the patients. 10 patients got temporary nerve palsies, six at the level of the wound and four at the level of the tourniquet. The four palsies at the level of the tourniquet improved in the first hour to day after release, and only one had mild persistence at 6 days follow-up. 8 limbs had tourniquet time of more than 2 hours (commonly used threshold for prolonged use). Long tourniquet time was associated with amputation and fasciotomy, but no other morbidity. Incorrect tourniquet placement was associated with increased morbidity and mortality. Incorrect placement includes distal to the most proximal injury or directly over the wound instead of proximal to it.	**Sjekkliste:** • Is the purpose stated clearly - Yes • Are the groups recruited from the same population (selection bias)? - There was one major group with several subgroups • Were the the groups comparable (selection bias)? -Yes, the subgroups were comparable • Were they representative of their population? - Yes, all was soldiers • Was exposure and outcome measured similarly and reliably? (Validity. Classification bias) - Yes • Were the authors blinded? - No • Was the study prospective? - Yes • Was follow-up adequate? (Attrition bias/follow-up-bias)- Yes • Did they analyse loss-to follow-up? (Eval. attrition bias)- No • Was the duration long enough to evaluate positive/negative outcome?- Yes • Are important confounders discussed and adjusted for?-Yes • Are the results credible? - Yes • Are the results directly transferable to the general population? - The study population was mostly recruited from soldiers and there was rapid evacuation to a quality healthcare system. This limits generalization. • Other similar studies whichs strengthens/weakens the results? - This study compares favorably with similar studies • Implication of the results? - Tourniquet education and use should continue, and should be considered for civilian use. • **Strengths** • Prospective study, large population, significant results • **Limitations** • - Limited population (primarily soldiers, a few women, elderly and children) and rapid evacuation to a quality healthcare system limit generalization.

Appendix 4:

Reference: Scerbo MH, Mumm JP, Gates K, Love JD, Wade CE, Holcomb JB, et al. Safety and Appropriateness of Tourniquets in 105 Civilians. Prehosp Emerg Care [Internet]. NIH Public Access; 2016 [cited 2018 Oct 31];20(6):712–22			Study design: Cohort Grade – quality: Moderate
Purpose	**Material and method**	**Results**	**Check-list**
The purpose of this study was to examine the injuries resulting in major limb trauma sustained by civilians. They hypothesized that appropriately trained prehospital and in-hospital civilian personnel could safely and appropriately apply tourniquets in patients with major limb trauma from common mechanisms of injury sustained by civilians, including motor vehicle collisions, single stab wounds and gunshot wounds. **Conclusion** The study displays that in civilians sustaining major limb trauma, prehospital and in-hospital personnel are capable of applying tourniquets to the appropriate patient. After adjudication, there were no complications due to tourniquet use, even in pediatric and elderly patients, deeming them safe for use in civilians with major upper or lower limb trauma via blunt or penetrating mechanisms of any etiology. **Country** United States of America **Year of data collection** October 2008 to May 2013	**Population:** This was a single-center, retrospective cohort study of patients arriving Memorial Hermann Hospital with a trauma activation, identified using the institution's Trauma Registry of the American College of Surgeons database. All patients admitted between October 2008 and May 2013 with a tourniquet listed as a treatment were included in the study. Patients were excluded from the study if no documentation of tourniquet placement could be corroborated on review of prehospital and hospital medical records. All tourniquets were official-issued Combat Application Tourniquets (CAT, Composite Resources, Rock Hill, SC), a type of windlass tourniquet. **Outcomes** Patients were evaluated by indicated or non-indicated tourniquet placement. The primary outcome evaluated was the presence of a complication potentially due to the tourniquet, including amputation, acute renal failure, compartment syndrome, nerve palsy, or venous thromboembolism (VTE). Secondary outcomes included removal, replacement or addition of a tourniquet in the ED, operative procedures including amputation, revascularization, vascular ligation, exploration/fixation of the extremity and fasciotomy, mortality and resuscitation. **Statistical methods** Continuous data are presented as medians and interquartile range (IQR). Comparisons between groups are performed using the Wilcoxon rank-sum (Mann-Whitney U test). Categorical data are reported as proportions and, where appropriate, tested for significance using Chi-square or Fisher's exact tests. STATA Statistical software (version 13.1, College Station, TX) was used for the analysis.	Between October 2008 and May 2013, 107 patients arrived as a trauma activation and were identified by the Trauma Registry as having a tourniquet placed either prehospital, in the emergency department, or in both settings. After review of patient records, documentation of tourniquet placement could not be identified for two patients and they were excluded from the study, leaving 105 patients for analysis. The majority (82%) of patients did not have a complication potentially associated with the use of a tourniquet, including amputation, acute renal failure, compartment syndrome, nerve palsy, or VTE. Of the 105 patients with a tourniquet, 30 patients (29%) underwent amputations. The reasons for amputation included traumatic amputation (n = 14), a non-salvageable limb (n = 14), and completion of a partial amputation (n = 2). Tourniquets placed for the a priori indication of amputation were not considered a complication unless judged by the adjudicating panel. As such, there were no amputations due to indicated tourniquet placement, and there were no amputations in patients with non-indicated tourniquet placement. In the 94 patients that had an indicated tourniquet placement, 3 (3.2%) developed acute renal failure, 2 (2.1%) developed compartment syndrome, 5 (5.3%) had nerve palsies, and 8 (8.5%) had VTEs. The only potential complication that occurred in patients with a non-indicated tourniquet placement was a VTE (pulmonary embolism, n = 1).	**Check-list:** • Was the research question or objective in this paper clearly stated? • - Yes • Was the study population clearly specified and defined? • - Yes • Was the participation rate of eligible persons at least 50%? • - Yes • Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? • - Yes, but the time period was five years. The authors took steps to minimize differences in patient outcome because of change in treatment. • Was a sample size justification, power description, or variance and effect estimates provided? • - No • For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? • - Yes • Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? • - Yes • For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? • - No, the patients either had or did not have a tourniquet • Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? • - Yes • Was the exposure(s) assessed more than once over time? • - No • Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? • - Yes • Were the outcome assessors blinded to the exposure status of participants? • - No • Was loss to follow-up after baseline 20% or less? • - Yes • Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? • - No **What do the authors discuss as:** • **Strengths** • - The largest single-center study to date and patients in the extremities of age • **Limitations** • - Single-center and retrospective, tourniquet times could not be assessed. Short transport times. No control group.

Appendix 5:

Reference: Ode G, Studnek J, Seymour R, Bosse MJ, Hsu JR. Emergency tourniquets for civilians: Can military lessons in extremity hemorrhage be translated? J Trauma Acute Care Surg. 2015;79(4):586–91			Study design: Cohort Grade – quality: Moderate
Purpose	Material and method	Results	Check-list
The purpose of this study was twofold: (1) determine the effects of tourniquets on hemorrhage control and clinical outcomes when used in civilian emergency medical service (EMS) and (2) to evaluate patient outcomes following both appropriate and inappropriate civilian EMS use. **Conclusion** The majority of tourniquets were appropriately applied to civilians who had vascular injuries or required operative intervention for hemorrhage control. With appropriate indications, an emergency tourniquet is a valuable instrument for hemorrhage control in the civilian prehospital setting and has a low rate of associated complications. **Country** United States of America **Year of data collection** September 2012 to November 2013.	**Population** They retrospectively reviewed EMS and hospital records from patient care reports from their countywide public EMS agency. Patients were included in the study if there was documented prehospital placement of an emergency tourniquet or prehospital documentation of active uncontrolled extremity hemorrhage, penetrating extremity trauma, open fracture with active bleeding, or traumatic extremity amputation (excluding amputations of the foot or hand). Subjects who died before transport, who refused transport, or who did not have complete prehospital and hospital records were excluded. **Outcome** The primary outcome was mortality and morbidity associated with tourniquet use. **Statistical methods** Descriptive statistics were calculated to examine the characteristics of the sample. t tests were conducted for comparisons between the groups on continuous variables and $\chi 2$ tests for comparisons between the groups on unranked categorical variables and Fisher's exact test where appropriate. For all analyses, significance was set at the $p < 0.05$ level.	Between September 2012 and November 2013, 112 subjects received treatment by EMS for documented acute uncontrolled hemorrhage. Fifty-six patients met the criteria for inclusion in the study. tourniquets were applied on 24 of 56 subjects, and the remaining 32 subjects were treated conservatively. There were no tourniquet-related complications reported among any of the 24 patients who received a tourniquet. Tourniquet patients had significantly higher incidences of shock (50% vs. 12.5%, $p = 0.003$) and vascular injury (69.6% vs. 25.8%, $p = 0.002$). tourniquet patients also had higher rates of hospital admission (77.3% vs. 38.7%, $p = 0.005$), emergent hemorrhage control surgery (50% vs. 9.7%, $p = 0.004$), and emergent blood transfusion (37.5% vs. 12.5%, $p = 0.05$) and significantly higher volumes of fluid resuscitation (2.8 L vs. 1.6 L, $p = 0.04$). There was no difference between both groups with regard to any initial physiologic parameters (pH, lactate, hemoglobin level). Fifteen patients had appropriate tourniquet placement, and seven patients had either delayed or missed tourniquets. Patients with delayed or missed tourniquets had higher incidences of shock and emergent blood transfusions.	**Check-list:** • Was the research question or objective in this paper clearly stated? • - Yes • Was the study population clearly specified and defined? • - Yes • Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? • - Yes • For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? • - Yes • Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? • - Yes • Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? • - Yes • Were the outcome assessors blinded to the exposure status of participants? • - No • Was loss to follow-up after baseline 20% or less? • - Yes • Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? • - No **What do the authors discuss as:** • **Strengths** • **Limitations** • The authors discuss neither strengths or limitations

Appendix 6:

Reference: Beaucreux C, Vivien BB, Miles E, Ausset S, Pasquier P, C. B, et al. Application of tourniquet in civilian trauma: Systematic review of the literature. Anaesthesia, Crit care pain Med [Internet]. 2018;S2352-5568.			Study design: Review Grade – quality: Good
Purpose	Material and methods	Results	Check-list
The aim of this systematic review was to analyze the evidence-based medical literature in order to precise the use of tourniquet in the management of extremity hemorrhages in civilian setting. **Conclusion** This systematic review revealed tourniquets to be an effective tool for the management of extremity hemorrhages in civilian trauma, associated with few complications. Larger studies and dedicated training courses are needed to improve the use of tourniquets in the civilian standards of care. **Country** France **Year of data collection** Published in 2018	They performed a systematic literature search on PubMed and the Cochrane Database of Systematic Reviews and Embase with no regard to publication date in the past, until the 31 December 2016. First, medical subject headings terms were combined with non-indexed relevant search. Second, a systematic search of the grey literature was conducted using the Opengrey database, over the same period. Moreover, the references from included papers were also checked for additional material not found on the original search. For the inclusion criteria, the manuscripts had to contain descriptions, discussions or experiences of tourniquet application in civilian settings. Articles had to be written in English or French, published before December 31st 2016. Case reports and narrative reviews were excluded. Abstract reading, and then full text reading of the uncertain papers, assessed their eligibility. Included articles had to be accepted by two reviewers. In case of divergent opinions on an article, the opinion of a third reviewer was requested. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses [PRISMA] guideline was followed. Data extraction focused on identifying common themes in the articles. Quality was appraised using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies, and the Grades of Recommendations, Assessment, Development and Evaluation acting group (GRADE) were used to assess the level of evidence.	The original search included 380 studies, of which 182 duplicates were excluded. Among the 198 studies identified, 84 were selected based on the title and 26 on the abstract. Finally, 24 articles were selected for inclusion in the analysis after full text reading. Studies designs included retrospective observational studies (n = 18), surveys (n = 5), and an analysis of online protocols (n = 1). According to the GRADE recommendations, level of evidence of the included studies was low or very low because of their observational design and their small effectives. Overall reported effectiveness is high across studies, averaging 90% and ranging from 78-100%. However, the criteria for measuring efficacy rates differ between the authors, making them difficult to compare. Overall reported complication rate is low, however, most studies were unable to identify whether the observed morbidity were attributed to tourniquet use or the injury itself. The all-cause mortality reported is low but cause-specific mortality is not reported. Different criteria are used when assessing whether tourniquet application was appropriate (ie indicated) or not appropriate. Also, miniscule information regarding the situational setting for tourniquet application is reported, which makes it impossible to determine if a tactical indication for the tourniquet use existed.	**Check-list:** • Is the review based on a focused question that is adequately formulated and described?- Yes • Were eligibility criteria for included and excluded studies predefined and specified?- Yes • Did the literature search strategy use a comprehensive, systematic approach?- Yes • Were titles, abstracts, and full-text articles dually and independently reviewed for inclusion and exclusion to minimize bias?- Yes • Was the quality of each included study rated independently by two or more reviewers using a standard method to appraise its internal validity?-Yes • Were the included studies listed along with important characteristics and results of each study? • - Yes • Was publication bias assessed?- No • Was heterogeneity assessed? (This question applies only to meta-analyses.)- No **What do the authors discuss as:** • **Strengths** • - Two reviewers independently selected and evaluated the quality of the articles. Above all, the study of the grey literature, combined with that of the usual databases, led to an exhaustive search of the current data. Finally, the methodology used for the analysis of the studies (STROBE scale) was robust and largely acknowledged. • **Limitations** • - This systematic review presents several limitations. First, it was based on the analysis of retrospective studies, with a low level of evidence. The STROBE scale used for the evaluation of the quality of the articles was not fully adapted to the analysis of all the selected articles. Nevertheless, it was applied correctly for most of them and implied validated criteria. Second, literature that was not available in French or English was excluded. However, the low number of studies involved (n = 2) could not compromise the quality of the analysis.

Appendix 7:

Reference: Teixeira PGR, Brown CVR, Emigh B, Long M, Foreman M, Eastridge B, et al. Civilian Prehospital Tourniquet Use Is Associated with Improved Survival in Patients with Peripheral Vascular Injury. J Am Coll Surg. 2018;226(5):769–776.e1.			Study design: Retrospective cohort Grade – quality: Good
Purpose	Material and method	Results	Discussion/check-list
The purpose of this study was to investigate the prehospital use of tourniquet for patients with extremity vascular injuries in the civilian setting. **Conclusion** Although still underused, civilian prehospital tourniquet application was independently associated with a 6-fold mortality reduction in patients with peripheral vascular injuries. More aggressive prehospital application of extremity tourniquets in civilian trauma patients with extremity hemorrhage and traumatic amputation is warranted. **Country** United States of America **Year of data collection** January 2011 through December 2016	**Population:** All patients sustaining peripheral vascular injuries admitted to all 11 urban Level I trauma centers in the state of Texas in the study period. The study population was divided into 2 groups based on the prehospital tourniquet use. **Main outcome:** The primary outcome of the study was in-hospital mortality. Secondary outcomes included delayed amputation and thromboembolic complications. **Statistical methods** Differences in baseline demographics and injury characteristics between the two groups were assessed using univariate analysis. Continuous variables were compared using 2-tailed unpaired Student's t-test or Mann-Whitney U test and dichotomous variables were compared using chi-square test or Fisher's exact test as applicable and $p < 0.05$ was considered significant. To investigate the association between tourniquet use and the primary end point of mortality, adjusting for differences in demographics as well as physiologic and injury-related parameters, a logistic regression analysis model was created including, as dependent variables, all factors found to be significantly different between the 2 study groups and all factors found to be associated with mortality at $p < 0.05$ on univariate analysis. Adjusted odds ratio with adjusted p value for this association was derived from the equation. A separate regression model was then created to investigate the association of tourniquet use and each of the dichotomous secondary outcomes of delayed amputation, thromboembolic complications, respiratory complications, cardiac complications, and infectious complications. Adjusted odds ratios with adjusted p values were reported for each secondary outcomes variable. The association of tourniquet use and the continuous outcomes of hospital length of stay, ICU length of stay, and ventilator days were investigated using general linear model.	**Results** During the 6-year study period, 1,026 patients with peripheral vascular injuries were admitted to the 11 participating Level I trauma centers. Prehospital tourniquet was used in 17.6% (n = 181) of the patients. Wide variation in prehospital tourniquet use was observed across study sites, ranging from 61.9% in the site with the highest use rate to 1.4% in the site with the lowest use rate. No significant change in tourniquet use rates was observed during the study period. The mean ± SD tourniquet time was 77.3 ± 63.3 minutes (IQR 39.0 to 92.3 minutes). The majority of the tourniquets were applied proximally in the injured extremity: arm (49.4%) and thigh (28.7%), with a minority of the tourniquets applied to the calf (14.9%) or forearm (6.9%). Overall mortality was 5.0%. Direct repair was the most common management strategy for the vascular injuries at 30.2%, followed by vascular ligation (29.0%) and interposition graft (16.5%). Primary amputation was performed in 5.5% of the cases and limb reimplantation was performed in a single patient in this series. The use of tourniquets was not associated with a significant increase in the risk of delayed amputation (1.1% vs 1.1%; adjusted OR 1.82; 95% CI 0.36 to 9.99; adjusted p = 0.473). Patients in the non-tourniquet group, however, had a significantly lower rate of thromboembolic complications, which remained significant after multivariable analysis (3.4% vs 7.2%; adjusted OR 0.44; 95% CI 0.21 to 0.95; p = 0.039). After multivariable analysis adjusting for confounders, no significant differences were identified in the rates of pulmonary, cardiac or systemic complications. Hospital length of stay, ICU length of stay, and ventilator days were also not significantly different between the study groups after multivariable analysis. Traumatic amputations occurred in 98 patients (9.6% of the study population). Among patients with a traumatic amputation, 35.7% received a tourniquet. In this subgroup of patients with a traumatic amputation, mortality was 2.9% for the patients who received a tourniquet compared with 7.9% for those without a tourniquet (p = 0.315).	**Check-list:** • Was the research question or objective in this paper clearly stated? - Yes • Was the study population clearly specified and defined? - Yes • Was the participation rate of eligible persons at least 50%? - Tourniquets were only used in 17.6% of patients, but all patients were eligible • Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? - Yes • Was a sample size justification, power description, or variance and effect estimates provided? - No • For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? - Yes • Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? - Yes • For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? • - No, the patients either had or did not have a tourniquet • Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? - Yes • Was the exposure(s) assessed more than once over time? - No • Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? - Yes • Were the outcome assessors blinded to the exposure status of participants? - No • Was loss to follow-up after baseline 20% or less?- Yes • Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? - Yes **Strengths** - The major strength of the current study compared with the 3 civilian studies mentioned is the presence of a non-tourniquet comparison group, which allowed us for the first time to demonstrate the independent association between tourniquet use and survival. **Limitations** - Retrospective design and lack of detailed information about the use of other prehospital hemostatic adjuncts.