Performance of Norwegian civilian EMTs and army medics in penetrating trauma: a controlled simulation-based assessment

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Background: Penetrating trauma kills rapidly. Thorough and efficient examination and aggressive hemorrhage control is important to save lives. The aim of this study was to assess the skills of civilian Emergency Medical Technicians (EMTs) in bleeding examination and control compared to Army Medics. Our hypothesis was that civilian pre-hospital systems perform at a lower level compared to an expert group, and did not have sufficient focus on education and training in examination and treatment of penetrating injuries.

Material and methods: We included 60 volunteer Certified EMTs and Army Medics. First, the participants examined a wounded patient. Second, the participants were presented a patient with a penetrating injury on a pork side fixated to the thigh with an artificial arterial bleeding.

Results: The EMTs took significantly shorter time examining, median 1 min 5 s vs. 3 min 58 s ($P < 0.001$). 5/30 (17%) of EMTs and 28/30 (93%) of army medics did an approved gauze wound packing of the penetrating injury ($P < 0.001$). EMTs took (median) 18 s and army medics 8 s to hemostasis regardless of approved packing or not ($P < 0.001$). Time spent on the packing was (median) 1 min 50 s vs. 5 min 47 s respectively ($P < 0.001$). Increasing time spent on the procedure showed significantly better chance of a successful procedure.

Conclusion: The EMTs had lower accuracy in examination but used significantly shorter time than the Army Medics. The treatment part of the study showed poor EMT performance compared to the Army Medics. This study indicates that more wound packing training needs to be incorporated into initial and ongoing civilian EMT training.

Editorial Comment
Are today's civilian ambulance personnel as first reponders adequately trained to optimally limit exsanguination risk for penetrating trauma victims? In this simulation study, ambulance personnel response with hemostatic maneuvers and first wound dressing for this scenario was compared to a highly prepared reference group (battlefield medics). The findings suggest that more education and training for civilian ambulance personnel could improve performance in this setting.

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Terrorist attacks and other mass casualty incidents have become a real threat even in previous peaceful settings.[1] In Iraq and Afghanistan bleeding was responsible for more than 90% of deaths in soldiers with potentially survivable injuries.[2] A study of civilian public mass shootings in the US found that chest injuries were the most common death in potentially salvable victims, but these were events without explosives.[3] An attack using bombs and/or firearms can be expected to cause both head/torso and exsanguinating extremity injuries.[4] One may expect many victims in a shooting spree, and especially in school shootings swift recognition and proper treatment can save many quality-adjusted years of life. In 2015 the Norwegian Directorate for Civil Protection released a new national procedure for cooperation between emergency and law enforcement services during ongoing deadly violence.[5] Every ambulance service in Norway implemented this procedure through compulsory exercises in co-operation with the local police and fire department. However, many services only trained on organization and evacuation, not the actual treatment of patients. It seems to be expected that emergency medical technicians (EMTs) are adequately trained in examination and treatment of patients with penetrating injuries.

One of the authors (SWB) was trained both as an EMT and a medic in the Norwegian Armed Forces. All the authors have a background in the Norwegian Armed Forces and civilian pre-hospital environment. Based on this experience it was suspected that the Army's 3-week medic course makes soldiers better prepared to treat patients with penetrating injuries as opposed to the years of education and training an EMT goes through, despite this being part of the curriculum.[6] If the soldiers are indeed better skilled it should be relatively easy to implement the short course into the EMT education.

Although terror attacks are rare in Norway, stabbings and shootings are not uncommon. As we have seen, terror does happen and will probably happen again in the future.[7] The aim of the present study was thus to assess the skills in examination and pre-hospital/immediate treatment of penetrating injuries by EMTs compared to Army Medics. Our hypothesis was that civilian pre-hospital systems would perform less effectively compared to an expert reference group (army medics), and that the civilian pre-hospital systems do not have sufficiently focus on education and training in examination and treatment of penetrating injuries to perform at the highest level.

Material and methods

This was a prospective experimental study.

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 (2016/2075-3 REK Nord).

Emergency Medical Technicians in Norway are primarily trained through two different routes of education. The newer generation passes 2 years of theoretical training after public school, and then a 2-year apprenticeship period ending with a final examination. The former generation participated in local courses and on-the-job training before implementation of a standardized curriculum for EMT training. During a transition period EMTs with sufficient experience could sit for the final examination in the new curriculum.

Battlefield medicine is organized in tiers in the Norwegian Armed Forces. Military medics gets a 103-h course with optional added modules for evacuation and Role 1 medical support.[8] They are at the third level of Norwegian battlefield medicine. The soldiers tested in this study are all conscripts and primarily or secondarily serve as medics at level 3. Battlefield medicine is focused on preventing extremity exsanguination. The medics have a short and focused course that makes them a good control group both in terms of optimal treatment and transferability to civilian EMTs.

We estimated the necessary sample size to 30 participants in each group, which at a two-sided 5% significance level would provide at least 90% power to detect a relevant difference in packing skill performance of at least 20% between groups.

Potential participants received a document informing them of the nature of the project, that they would participate in two skill-relevant cases, without disclosing that it would be either

trauma or penetrating injuries. The EMTs were primarily recruited because they were on duty the day testing was done at their station. Testing the soldiers was arranged with the Medical Battalion and the Norwegian Armed Forces Medical Services, but every soldier was individually asked (without the presence of an officer) to ascertain participation out of free will. At the day of testing the participants were told that the cases would focus on pre-hospital examination and treatment of penetrating injuries.

The first case was designed to test how the participants examined patients with penetrating injuries. The model (in most cases a woman) wore underwear and a disposable paper full-body suit cut into a jacket and a pair of pants. The patient was unconscious, unresponsive to pain and breathing normally. Five named injuries were marked with a dab of thick artificial blood (enough both to stain gloves during a blood sweep or spot during exposure). All the injuries are close to major arteries and are therefore potentially deadly if not found and treated (see Fig. 1).

- Injury A was placed at the spinous process of C7
- Injury B was placed in the left armpit
- Injury C was placed on the abdomen, about 5 cm left of umbilicus.
- Injury D was placed 1 cm below the right clavicula, 3 cm lateral to the manubrium.
- Injury E was placed medial on the left thigh, 6 cm below the groin.

The participants were given disposable gloves and following instructions:

> In this task you are to examine a patient with injuries from gunshots and shrapnel. Examine the patient as you normally would, but do not start any treatment. Clearly report any injuries you find, and continue the examination. Injuries are marked by blood. Measured criteria are precision and speed. The patient is wearing disposable clothes that you may remove or tear. Examine on the outside of the underwear as if it was not there. Time starts when you enter the room and stops when you state that you are finished.

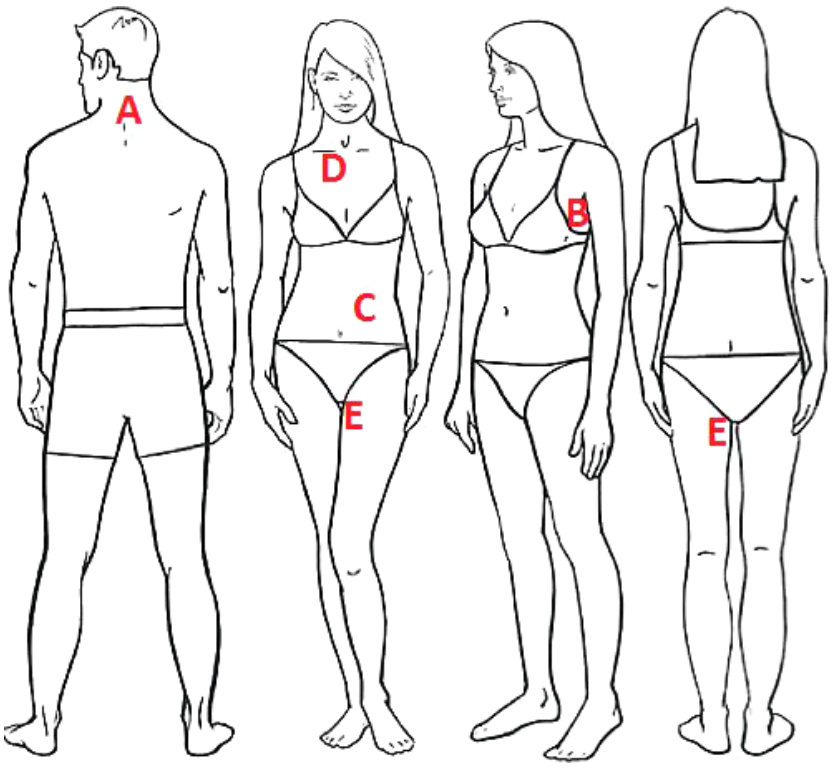

Fig. 1. The figure illustrates the five injuries in the first case. [Colour figure can be viewed at wileyonlinelibrary.com]

Observations were total time spent and which injuries were found.

The second case was designed to assess how the participant treated a patient with a massive extremity hemorrhage. The injuries from the last case were washed off, or another model was used. The model was dressed in similar clothing and was unconscious, unresponsive, and breathing normally. A 5 cm thick side of pork ribs with skin measuring 25 × 13 cm was shot at point-blank range with a shotgun, and taped to the patient's right thigh. The entry wound measured 5 × 5 cm, and there was no exit wound. An I.V.-line in the wound connected to a system of syringes simulated an arterial bleeding with fake blood. The participants were again given disposable gloves and following instructions:

> In this task you are to examine and treat a patient like you would in a real scenario. The scene is safe for both you and the patient. You should only focus on examination and treatment of one patient. Do not triage, do not report to anyone, do not assess the situation beyond the one patient and do not think about evacuation. Do not focus too much on prevention of hypothermia as it is not the focus of this study (the model was actually cold before every scenario, and we did not want this to disturb other treatment). Time starts when you enter the room and stops when you state that you are finished.

Available equipment was eight 6 cm × 4 m gauze rolls and two 10 cm × 2.5 m elastic bandages. The participants were shown one of each to make sure they knew what they were, and were informed that the equipment was laying next to the patient. When they understood the task they received the following callout: 'It has been reports of gunshots, followed by an explosion'. The participants were shown a short video taken minutes after the bombing in Oslo in 2011 to set the scene.[9] Following observations were made:

- Was the bleeding stopped immediately (direct pressure, femoral artery pressure, or packing) or was Airways and/or Breathing checked first?
- How long time passed until the bleeding was primarily addressed?
- When did the participant start and finish packing and dressing the wound?
- Was the packing deemed to be of sufficient quality? (A successful wound packing procedure means filling all the crevices with gauze, packing with sufficient pressure and preferably in a circular pattern.)
- How much time did the participant spend?

After finishing the case the participant was asked three questions to map the educational level of the EMTs.

- Have you received practical training in the use of tourniquets?
- Have you received practical training in wound-packing?
- Do you have training in battlefield medicine from the Norwegian Armed Forces?

Data were collected in Windows Office Excel and analyzed in IBM SPSS version 24 (IBM Corp., Armonk, NY, USA). Mann–Whitney *U*-tests were used for non-parametric data, Chi square tests for categorical data and logistic regression for relationships between continuous variables and outcome.

Results

The data were collected in December 2016 and January 2017.

We recruited 32 EMTs and 30 army medics. Two of the EMTs received callouts after the first case, and were therefore not able to participate in the second case or answer the questions at the end.

EMTs had poorer recognition of bleeding during the first part of the study, as 23/32 (72%) EMTs and 30/30 (100%) army medics found four or five of the five bleeding spots on the patient ($P = 0.002$). The EMTs used significantly shorter time on trauma examination (median) 1 min 5 s vs. 3 min 58 s ($P < 0.001$). The army medics identified insignificantly more injuries, summarized in Table 1.

Increasing time spent on examination did not significantly increase the chance of finding the bleeding injuries when adjusted for profession OR 1.13 (95% CI: 0.981–1.45).

Approved gauze wound packing of the penetrating injury was achieved by 5/30 (17%) of EMTs and 28/30 (93%) of army medics

Table 1 Distribution of injuries found by EMTs and army medics.

	EMTs	Medics	*P*-value
Injury A	18/32 (56%)	26/30 (87%)	0.08
Injury B	23/32 (72%)	29/30 (97%)	0.08
Injury C	31/32 (97%)	30/30 (100%)	0.33
Injury D	30/32 (94%)	30/30 (100%)	0.16
Injury E	24/32 (75%)	28/30 (93%)	0.04

($P < 0.001$). EMTs used (median) 18 s and army medics 8 s to hemostasis by either direct pressure, femoral artery compression, or wound packing ($P < 0.001$). Total median time spent on the packing was 1 min 50 s vs. 5 min 47 s respectively ($P < 0.001$). Increasing time spent on the procedure showed significantly better chance of an approved procedure OR 1.4 (95% CI: 1.1–1.7). Decreasing time to hemostasis was significantly associated with approved packing procedure OR 0.82 (95% CI: 0.78–0.91).

Practical training in the use of tourniquets was reported by 6/30 (20%) of EMTs and 30/30 (100%) of army medics ($P < 0.001$), while 13/30 (43%) of EMTs and 30/30 (100%) of army medics reported that they had practical training in wound-packing ($P < 0.001$). Training in battlefield medicine by the Norwegian Armed Forces' curriculum was reported by 3/30 (10%) of EMTs and 30/30 (100%) of army medics ($P < 0.001$).

Discussion

Although terror attacks are rare in Norway, they do happen.[7] The aim of this study was to examine the ability and preparedness of civilian EMTs in the aspect of preventing unnecessary deaths from extremity exsanguination. The EMTs were compared to conscript army medics.

Packing a penetrating injury is a life-saving and relatively simple procedure, if one is trained and practiced. The curriculum states that EMTs should be able to identify and treat life-threatening injuries,[10] and we consider this to include packing wounds in extremities.

Our observations showed that most of the EMTs examined adequately and in a timely fashion, and adapted their examination approach to best fit the setting. The army medics, on the other hand, all followed a strict procedure which lead to a comprehensive but slower examination. Although the medics were more thorough, increasing time did not significantly increase accuracy.

The EMTs used significantly longer time to hemostasis (bleeding initially stopped). This might be because the military algorithm is more focused on massive bleeding vs. airway obstructions. Decreasing time to hemostasis was significantly associated with an approved packing procedure.

Even though almost half of the EMTs reported that they were trained in packing, only 17% managed an approved packing procedure. The EMTs spend shorter time packing the wound, but this was because most did not to the procedure properly. Increasing the time spent packing significantly increased the amount of successful procedures. Only three of the 13 EMTs trained in packing received the training in the Norwegian Armed Forces, in which two succeeded. Four of the five EMTs who succeeded in wound packing were trained in the procedure. Either the training is inadequate, or too much time passes without practice, and the skills are lost. An American RCT showed that lack of training was the main barrier for not incorporating military medical techniques in civilian pre-hospital practice.[11] If a modified army course is implemented in the EMT curriculum, it seems that the skills can be maintained through training, despite infrequent use.[12] A recent review stated the importance of civilian and military emergency care units sharing experience and bilateral feedback.[13]

Limitations

As participation in this study was voluntary, a potential bias could be that many of the EMT participants were those who are interested in this field of emergency medicine. We sought to negate this by not informing participants of the nature of the cases before they turned up, and EMTs were mostly selected because they were on call on the day of testing.

Almost all training cases for army medics include penetrating injuries. They were not informed of the testing until the same day or the day before, so they would have no advantage over the EMTs.

Ideally we would have included a case to test the participants in the use of tourniquets, but it is difficult to attain valid data on practical use of the tourniquet on a model because of the pressure needed, which is a crucial part of proper tourniquet application.

This study did not examine skills in Norwegian civilian hospitals. As Norwegian doctors and nurses in general are exposed to penetrating injuries even less than EMTs, one might fear that skills would be even poorer than the study findings.

In summary, the EMTs had lower, but acceptable accuracy in examination, but used significantly shorter time than the Army Medics because they adapted to best handle the situation. The treatment part of the study showed poor EMT performance compared to the Army Medics. In conclusion, civilian EMTs do not appear to be adequately prepared for casualties involving penetrating extremity injuries, both in single and multiple casualty scenarios. Based on this study, wound packing training needs to be incorporated into initial and ongoing civilian EMT training. Although we tested Norwegian EMTs and Army Medics, we believe that the results are relevant for civilian emergency services around the world.

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