Low-cost synthetic tourniquet training model.

Modelo sintético de baixo custo para treinamento do uso de torniquete.

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ABSTRACT

Objective: to present a low-cost model for bleeding control training with the use of a tourniquet and the results of the training evaluation. Method: low-cost and easy-to-purchase materials, such as upholstery foam, ethylene-vinyl acetate (EVA) sheet, plastic propulsion pump, saline container, water, school paint, serum equipment, rubber tubing for tourniquet, and a leg and an arm of a ghost mannequin, were used. In the model assembly, we created an active bleeding simulation system, which could only be controlled with the correct application of the tourniquet. The model was submitted to professional and academic evaluation. Results: the model was similar to human anatomy, proved to be practical in the bleeding control training with the use of a tourniquet, and had low cost. Conclusion: the model for bleeding control training had excellent acceptability, was considered viable for educational purposes of tourniquet use, and had low cost.

Keywords: Low Cost Technology. Tourniquets. Hemorrhage. Emergencies.

INTRODUCTION

Trauma remains a serious public health problem in Brazil and worldwide. In some Brazilian states, it stands out as the second leading cause of death, especially among young adults1-3. Uncontrolled hemorrhage after trauma is the main cause of preventable death in both military and civil settings4-6.

The importance of bleeding control has been made public through a mass training proposal implemented by Hartford III Consensus in the United States, which has established as vital the immediate citizen response in the control of external hemorrhage at the site of trauma7. Military experiences in Iraq and Afghanistan wars have shown benefits and safety with the early use of the tourniquet in combatants with hemorrhagic extremity injuries5,6,8. This fact has determined the adoption of Massive hemorrhage, Airway control, Respiratory support, Circulation, Hypothermia and Head injury (MARCH) algorithm in the initial care of traumatized victims9 in military environment.

In civil setting, the strategy of care with an initial priority in the control of the exsanguinating external injury has been inspired by this military approach. The current editions of Advanced Trauma Life Support®/ATLS® (10th edition) and Prehospital Trauma Life Support®/PHTLS® (9th edition) comment on the importance of early bleeding control and tourniquet use. In particular, PHTLS® has instituted XABCDÈ (where “X” corresponds to the immediate control of external hemorrhage11,12) for civil prehospital care.

Given these new guidelines of initial trauma care, it becomes necessary to strengthen education through quality trainings, using efficient teaching and learning strategies. One of these tools is the application of anatomical models for training the use of tourniquets. In developing countries such as Brazil, it is desirable that educational equipments be economically accessible13,14. Thus, the aim of this study is to present a low-cost model for bleeding control training with the use of a tourniquet and the results of the training evaluation.
METHODS

The model of this paper was elaborated by its authors, who are members of League of Trauma, Emergency, and Intensive Medicine/Fortaleza University. In order to construct the model, they invested an amount of R$49,60 (U$ 11.50), destined to the acquisition of the necessary materials. The main used materials were: a leg of a ghost mannequin (functioning as anatomical support), a plastic saline container (to hold simulated blood), one meter of rubber tubing (serving as blood vessels), a simple manual air pump (as a blood propellant), a serum equipment (to control blood flow volume and pressure), 50cm upholstery foam (to simulate musculature and subcutaneous fat), a 60X40cm ethylene-vinyl acetate (EVA) sheet (simulating the “skin” of the model), and 250ml of red school paint and water (simulating blood).

Initially, an opening was made in the anterior region of the plastic mannequin’s leg to simulate a penetrating wound with vascular lesion. Then, two proximal holes to the initial opening were performed, at a distance of 5cm and 7cm with a rubber tubing passing through the leg in the proximal opening (wound), externalizing through the hole which was 7cm distant from the initial opening and entering the plastic leg through the next hole. The end of the tubing was positioned in the opening that simulated the lesion. After these steps, the interior of the plastic leg was filled with upholstered foam and the exterior was coated with EVA to simulate the skin. In the final stage, the school paint was mixed with water to achieve near-blood consistency and then this mixture was stored in a plastic container with an inlet for the air pump and an outlet for the serum equipment, which was connected to the rubber tubing. Thus, by activating the pump, the simulated blood was ejected from the container, passed to the equipment, where its flow could be adjusted, entered the rubber tubing, and gushed at the site of the simulated injury.

To be effective, the tourniquet should be applied between 5cm and 7cm from the site of the simulated bleeding in gush, produced by air pump effect. The tourniquet used was the Combat Application Tourniquet® (CAT®). The assembled device ready for use can be seen in figure 1.

Figure 1. Open tourniquet device before application to model.

The model was then used and evaluated in the Bleeding Control course of the Trauma Committee of the American College of Surgeons, offered to medical students (monitors of Emergency Discipline) of Christus University Center, located in Fortaleza, Ceara.

In addition, it was also evaluated by a team of specialists, composed by physicians (surgeons, orthopedists, and emergency doctors) and nurses from one of the main emergency and trauma hospitals in the North and Northeast of Brazil: Doctor Jose Frota Institute, located in the capital of Ceara. For evaluation, we applied perception questionnaires about the developed training model, using Likert scale. Results were tabulated and analysed using Microsoft® Office Excel program. The research was submitted to the Ethics Council and approved under CAAE number 15418719.2.0000.5052.

RESULTS

During practical skill station of tourniquet use in the Bleeding Control course, as well as
in the handling and use of this training model by professionals of the emergency and trauma hospital, it was observed that proper application of the tourniquet proved to be effective for stopping simulated bleeding in gush (Figure 2).

The last query of the questionnaire inquired if the model could be used as a didactic tool for the teaching of bleeding control through tourniquet application. All participants totally agreed, according to table 1.

### DISCUSSION

Simulators are inanimate models developed for practical training of technical and/or motor skill, contributing to the development of professional competence, especially during undergraduation. One of the advantages of the simulation and training using models is that they allow the practice repetition, making it easier for the trainee to reach the desired level of expertise. In general, they are classified as low-, medium-, and high-fidelity models, these latter with high cost and greater complexity in handling. The model of this study was not difficult to be built, besides having a viable educational applicability proposal and low cost.

One of the steps for the correct use of the tourniquet recommends that the device be applied proximally to the hemorrhagic lesion, at a distance between 5cm and 7cm. The use of the tourniquet on the model will only be effective in controlling simulated bleeding if it is actually applied at this distance from the lesion. This was the objective of the positioning of the rubber tubing according to the method description.

The results obtained in the questionnaires demonstrated an excellent evaluation of all items, highlighting the recognition and applicability of the model for the training of tourniquet use.

![Figure 2. Tourniquet device applied to the model, stopping simulated bleeding.](image)

| Question                                           | TD* | PD** | IN*** | #PA   | #TA   |
|----------------------------------------------------|-----|------|-------|-------|-------|
| Does the model maintain good anatomical correlation? | 0%  | 5% (n=1) | 0% | 10% (n=2) | 85% (n=17) |
| Is the used material of good quality?              | 0%  | 0% | 5% (n=1) | 10% (n=2) | 85% (n=17) |
| Does the model allow bleeding control learning?    | 0%  | 0% | 0% | 5% (n=1) | 95% (n=19) |
| Can the model be used for the teaching of the procedure? | 0%  | 0% | 0% | 0% | 100% (n=20) |

* TD: totally disagree; ** PD: partially disagree; *** IN: indifferent; # PA: partially agree; # TA: totally agree.
The lowest indexes were related to the anatomical correlation and quality of the used materials, indicating the possibility of model improvement in order to increase its reliability.

Although the number of participants was only 20 individuals, most of them were professionals who worked directly in the care of trauma victims at a referral hospital. We considered this aspect as the main validation factor of this training model.

We concluded that the model of this study had excellent acceptability and allowed the training of tourniquet use, being a low-cost alternative for educational purposes.

RESUMO

Objetivo: apresentar um modelo de baixo custo para treinamento de controle de sangramento com o uso de torniquete e os resultados da avaliação do treinamento. Método: foram utilizados materiais de fácil aquisição e de baixo custo, como espuma de estofado, placa de etileno-acetato de vinila (EVA), bomba plástica de propulsão, recipiente de soro fisiológico, água, tinta escolar, equios de soro, tubo de latex para garrote e manequins comerciais de perna e de braço. Na montagem, foi criado um sistema de simulação de sangramento ativo que só podia ser controlado com aplicação correta do torniquete. O modelo foi submetido à avaliação de profissionais e acadêmicos. Resultados: o modelo teve semelhança com a anatomia humana, mostrou-se prático no treinamento da contenção de sangramento com uso de torniquete e teve baixo custo financeiro. Conclusão: o modelo para treinamento de controle de sangramento teve excelente aceitabilidade, foi considerado viável para fins educacionais do uso de torniquete e teve baixo custo.

Descritores: Tecnologia de Baixo Custo. Torniquetes. Hemorragia. Emergências.

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