DOI: 10.1590/0100-6991e-20192324 Original Article

Low-cost synthetic tourniquet training model.

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

Daniel Souza Lima, ACBC-CE[1,2]; Yuri Augusto da Silva Almeida[2]; Danielle Maria Camelo Cid[2]; Lucas Candeira Cardoso[2]; Camila Söldon Braga[2]; Francisco George de Lima Regis[3]

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 adults[1-3]. Uncontrolled hemorrhage after trauma is the main cause of preventable death in both military and civil settings[4-6].

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 trauma[7]. Military experiences in Iraq and Afghanistan wars have shown benefits and safety with the early use of the tourniquet in combatants with hemorrhagic extremity injuries[5,8,9]. 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 victims[10] 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 XABCDE (where "X" corresponds to the immediate control of external hemorrhage[11,12]) 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 accessible[13,14]. 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.

1 - Doctor Jose Frota Institute, Emergency and Trauma Department, Fortaleza, CE, Brazil. 2 - Fortaleza University, Medicine School, Fortaleza, CE, Brazil. 3 - Fortaleza University, Recife Center for Advanced Studies and Systems, Postgraduate Program on Design, Fortaleza, CE, Brazil.

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 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).

Figure 2. *Tourniquet device applied to the model, stopping simulated bleeding.*

Twenty participants were involved in the application and evaluation of the model, being eight (40%) doctors, three (15%) nurses, and nine (45%) medical students. Of these, 50% were male and the average age was of 25 years. Analysing data from the applied questionnaires, it was found that 17 (85%) participants answered that they totally agreed on the existence of a good anatomical relationship of the training model and also on the good quality of the used material. Regarding the perception that the model allowed the practical skill learning of tourniquet use to control bleeding, 19 participants (95%) totally agreed. 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[14-17]. 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[5], 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.

Table 1. *Result of the perception questionnaire based on Likert scale.*

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.

The involvement of young medical undergraduates, participants of a league of trauma and encouraged by their advisor, demonstrated through this study the potential of creation, creativity, organization, teamwork, and contribution to the improvement of trauma patient care through the construction of a feasible educational tool.

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.

R E S U M O

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, equipos de soro, tubo de látex 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.*

REFERENCES

1. Murray J, Cerqueira D, Kahn T. Crime and violence in Brazil: systematic review of time trends, prevalence rates and risk factors. Aggress Violent Behav. 2013;18(5):471-83.
2. Pfeifer R, Teuben M, Andruszkow H, Barkatali BM, Pape HC. Mortality patterns in patients with multiple trauma: a systematic review of autopsy studies. PLoS One. 2016;11(2):e0148844.
3. Lima D. O impacto das emergências traumáticas e não traumáticas no Brasil. In: Lima DS, editor. Emergência médica: suporte imediato à vida. Fortaleza: Unichristus; 2018. p. 49-60.
4. Holcomb JB, del Junco DJ, Fox EE, Wade CE, Cohen MJ, Schreiber MA, Alarcon LH, Bai Y, Brasel KJ, Bulger EM, Cotton BA, Matijevic N, Muskat P, Myers JG, Phelan HA, White CE, Zhang J, Rahbar MH; PROMMTT Study Group. The prospective, observational, multicenter, major trauma transfusion (PROMMTT) study: comparative effectiveness of a time-varying treatment with competing risks. JAMA Surgery. 2013;148(2):127-36.
5. Drew B, Bennett BL, Littlejohn L. Application of current hemorrhage control techniques for backcountry care: part one, tourniquets and hemorrhage control adjuncts. Wilderness Environ Med. 2015;26(2):236-45.
6. Pikoulis E, Salem KM, Avgerinos ED, Pikouli A, Angelou A, Pikoulis, A et al. Damage control for vascular trauma from the prehospital to the operating room setting. Front Surg. 2017;4:73.
7. Jacobs LM Jr.; Joint Committee to Create a National Policy to Enhance Survivability from Intentional Mass-Casualty and Active Shooter Events. The Hartford Consensus III: implementation of bleeding control--if you see something do something. Bull Am Coll Surg. 2015;100(7):20-6
8. Kauvar DS, Dubick MA, Walters TJ, Kragh JF Jr. Systematic review of prehospital tourniquet use in civilian limb trauma. J Trauma Acute Care Surg. 2018;84(5):819-25.
9. 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. 2008;64(2 Suppl):S28-S37.

10. Fedor PJ, Burns B, Lauria M, Richmond C. Major trauma outside a trauma center. Emerg Med Clin North Am. 2018;36(1):203-18.
11. Advanced Trauma Life Support Students Manual. 10th ed. Chicago, IL: American College of Surgeons; 2018.
12. National Association of Medical Technicians. Prehospital Trauma Life Support. Burlington, MA: Jones & Berlett Learning; 2018.
13. Amoretti R. A educação médica diante das necessidades sociais em saúde. Rev Bras Educ Med. 2005;29(2):136-46.
14. Cunha C, Frota Júnior J, Ferreira J, Troiani Neto G, Félix D, Menezes F. Montagem e aplicação de modelo de baixo custo de dissecção venosa. Rev Med (São Paulo). 2017;96(4):220-4.
15. Motta E, Baracat E. Treinamento de habilidades cirúrgicas para estudantes de medicina - papel da simulação. Rev Med (São Paulo). 2018;97(1):18-23.
16. Rocha IRO, Oliveira MHB, Bengtson KL, Alves AMN, Brito MVH. Modelo artesanal para treinamento de acesso vascular periférico. J Vasc Bras. 2017;16(3):195-8.
17. Bauer F, Rommel N, Kreutzer K, Weitz J, Wagenpfeil S, Gulati A, et al. A novel approach to teaching surgical skills to medical students using an ex vivo animal training model. J Surg Educ. 2014;71(4):459-65.

Received in: 08/07/2019
Accepted for publication: 10/06/2019
Conflict of interest: none.
Source of funding: none.

Mailing address:
Daniel Souza Lima
E-mail: souzadl@hotmail.com
almeidayuri@outlook.com