doi: http://dx.doi.org/10.11606/issn.1679-9836.v100i1p15-19 Rev Med (São Paulo). 2021 Jan-Feb;100(1):15-9.

Bleeding control training by compressing the zones of care: a low cost synthetic simulatior

Treinamento para controle de sangramento por compressão direta: um simulador de baixo custo

Emanuelly Thays Muniz Figueiredo Silva[1], Francisco George de Lima Regis[1], Danielle Maria Camelo Cid[1], Luiza Vitória Fontenelle Costa[1], Isabelle Rodrigues Schramm[1], Daniel Souza Lima[1]

Silva ETMF, Regis FGL, Cid DMC, Costa LVF, Schramm IS, Lima DS. Bleeding control training by compressing the zones of care: A low cost synthetic simulatior / Treinamento para controle de sangramento por compressão direta: um simulador de baixo custo / . Rev Med (São Paulo). 2021 Jan-Feb;100(1):15-9.

ABSTRACT: *Background:* Trauma presents a serious public health issue in Brazil and the world, considering that uncontrolled hemorrhage injuries are main cause of preventable death in both civilians and military personnel. In this context, effective measures of bleeding control are incredibly relevant, making it a necessity to improve education through quality training. This can be achieved with efficient teaching and learning strategies, such as low cost synthetic simulation models. *Objective:* To present a low-cost model for training of bleeding control through direct compression technique and its evaluation results. *Method:* A synthetic model was made with materials that are easy to acquire and low cost, such as upholstery foam, EVA plate, pneumatic pump, saline container, water, school paint, saline infusion set, latex tourniquet tube and a commercial mannequin arm. During assembly, an active bleeding simulation system was created. The model was assessed by health professionals through a questionnaire, using the Likert scale, during the Stop The Bleed course from the Trauma Committee of the American College of Surgeons *Results*: During handling and usage of this low-cost simulation model, it was observed that the proper application of the direct compression technique proved to be efficient for simulating the interruption of simulated bleeding via jets and presented a low development cost. *Conclusion*: The model had an excellent evaluation by the health professionals that were participating in the course, and it was considered viable for educational purposes and of low production cost.

Keywords: Simulation training; Teaching materials; Bleeding; Low cost technologies.

RESUMO: *Contexto:* O trauma representa um grave problema de saúde pública no Brasil e no mundo, sendo as lesões hemorrágicas não controlada a principal causa de morte previsível tanto no ambiente militar, quanto no cenário civil. Nesse contexto, medidas efetivas de controle de sangramento tem notória relevância, tornando-se necessário o fortalecimento educacional através de treinamentos de qualidade, utilizando estratégias eficientes de ensino e aprendizagem, como os modelos sintéticos de simulação de baixo custo. *Objetivo:* Apresentar um modelo de baixo custo para treinamento de controle de sangramento com uso de compressão direta e seus resultados de avaliação. *Método:* Confeccionado um modelo sintético para aplicação da técnica de compressão direta, utilizando-se materiais de fácil aquisição e de baixo custo, como espuma de estofado, placa de E.V.A, bomba pneumática, recipiente de soro fisiológico, água, tinta escolar, equipos de soro, tubo de látex para garrote e um braço de manequim comercial. Durante a montagem, foi criado um sistema de simulação de sangramento ativo. O modelo foi então utilizado e avaliado por meio da escala *Likert* durante o curso *Stop The Bleed* do Comitê de Trauma do Colégio Americano de Cirurgiões por profissionais da área da saúde. *Resultados:* No manuseio e uso deste modelo de treinamento, foi observado que a aplicação adequada da técnica de compressão direta demonstrou ser eficiente para simulação da interrupção do sangramento simulado em jato e apresentou um baixo custo de desenvolvimento. *Conclusão:* O modelo teve excelente avaliação por aqueles que o utilizaram, considerado viável para fins educacionais e de baixo custo.

Palavras-chave: Treinamento por simulação; Materiais de ensino; Hemorragia; Tecnologias de baixo custo.

1. Universidade de Fortaleza, Ceará. Orcid: Silva ETMF - https://orcid.org/0000-0001-6204-6299; Regis FGL - https://orcid.org/0000-0001-8337-6377; Cid DMC - https://orcid.org/0000-0003-4333-9680; Costa LVF - https://orcid.org/0000-0003-2856-6586; Schramm IS - https://orcid.org/0000-0003-1273-2121; Lima DS - https://orcid.org/0000-0003-1779-6984. Emails: emanuellymuniz@edu.unifor.br, fgeorge05@gmail.com, daniellecid@hotmail.com, luizafontenellemed@gmail.com, isabelleschramm@gmail.com, souzadl@hotmail.com.

Endereço para correspondência: Rua: Prof. Francisco Gonçalves, 1271, Apto 1303, Cocó, Fortaleza, Ceará, Brasil. CEP: 60192-170

INTRODUCTION

Trauma remains a serious public health problem in Brazil and worldwide. In some Brazilian states, it stands out as the second leading death cause for the general population, claiming lives mainly of young adults[1-3]. Uncontrolled bleeding after trauma is the main cause of preventable death in both the military and civilian settings[4-5].

The bleeding control importance was even established for the public, through the proposal of mass training of the Hartford III consensus, in the United States, establishing an immediate response, offered by the lay citizen on the spot, as vital[6]. Direct manual pressure or compressive dressing, applied directly to the hemorrhagic lesion, are the initial techniques used to control bleeding[7]. They are particularly useful in junctional areas (groin, armpit and neck), where the tourniquet cannot be applied[8]. These areas represent a challenge, as technically maintaining effective compression of these areas is technically difficult and contain large vascular structures which cannot be controlled proximally with simple prehospital interventions[9].

The care strategy with an initial priority to control exsanguinating external injuries is crucial, so much so that the current editions of the Advanced Trauma Life Support® - ATLS® (10th edition) and Prehospital Trauma Life Support® - PHTLS® (9th edition) programs have already comment on the importance of early bleeding control through direct compression, compressive dressing and tourniquet. Especially the PHTLS that institutes for civil pre-hospital care the XABCDE, where the "X" corresponds to the immediate control of extreme hemorrhage[7,10].

Considering the new guidelines for initial trauma care, it is necessary to strengthen education through quality training, using efficient teaching and learning strategies. One of the necessary tools is the use of anatomical models for training the direct compression of hemorrhages. In developing countries, such as Brazil, it is desirable that educational facilities are affordable[12]. The aim of this study is to present a low-cost model for training the direct compression technique to control bleeding and to evaluate its effectiveness for teaching.

METHODS

The model was developed by the authors of this work, members of the Trauma, Emergency and Intensive Care League of the University of Fortaleza. The main materials used were an upper limb of a commercial mannequin, functioning as an anatomical support; a plastic container for containing simulated blood; a linear meter of latex tube, serving as blood vessels; a manual pneumatic pump with a maximum pressure of 2.5 pound per square inch (psi), acting as a blood propellant; a serum set to control blood flow volume and pressure; 50 square centimeters (cm^2) by 3 cm in height, of upholstered foam, which deforms naturally in 10% of its thickness and according to the manufacturer's specifications it loses 10-20% of its thickness in 1 year, and must be replaced. The foam was used to simulate musculature and subcutaneous fat; a 60X40 cm ethylene vinyl acetate (EVA) sheet, simulating the model's skin; 250 ml of red school paint and water to simulate blood.

In order to prepare the model, two rectangular cuts were made in the commercial arm model, in the proximal and distal regions of the upper limb, respectively, with a distance of 30 cm between them. These will function as a simulation of injuries suffered in the upper limb of a patient, being, in the proximal region, a more superficial injury and, in the distal region, a deeper injury. Two holes were made, the proximal with a circumferential shape of 1 cm in diameter and the distal of a square shape with 3 cm^2 in order to function as a support place for fixing the tubes of the equipment, which simulate the injured vessels. The first pair was made on the posterior face of the limb in a more proximal region, at the same height as the superficial cut, and the second, on the posterior face of the member, in a more distal region, at the same height as the deep cut. To simulate the blood, washable, water-based red dye was mixed with the serum that runs in the teams' tubes. The teams were connected to a container with serum and a propellant pump that, when pressed at maximum capacity, generates 2.5 psi equivalent to 129.29 millimeter of mercury [mmHg], spurting the liquid content, simulating the high arterial blood flow. The arm and forearm muscles were made from the red flocked foam cover, so that the final structure obtained a firm consistency. To cover the mannequin and simulate the skin, an EVA sheet was used (Figure 1).

Figure 1. Training simulator

The model was then used and evaluated in the Stop The Bleed course of the Trauma Committee of the American College of Surgeons, offered to the monitors of the Emergency Discipline of the Medical Course of the Christus University Center. In addition, it was also evaluated by a team of specialists, composed of surgeons, orthopedists, emergency doctors and nurses from one of the main emergency and trauma hospitals in the North and Northeast, the *Dr. José Frota* Institute, located in the capital of Ceará. For evaluation, perception questionnaires were applied, which evaluated the following items: anatomical relationship, material quality, learning provided and reproduction for teaching, using the Likert scale (Table 1). The results were tabulated and analyzed using the Microsoft® Office Excel program. The study project was submitted to the Ethics Committee of the University of Fortaleza under number 15418719.2.0000.5052 and followed the Norms and Guidelines established by the Resolution No. 466, of December 12, 2012 of the National Health Council / MS.

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

Likert scale	Anatomical reporting	Quality	Learning	Teaching reproduction
Strongly disagree	0%	0%	0%	0%
Partially disagree	0%	0%	0%	0%
Indifferent	0%	0%	0%	0%
Partially agree	15%	15%	5%	0%
Strongly agree	85%	85%	95%	100%

RESULTS

In order to build the model for this study, an investment in the amount of R $ 40.60 was required to purchase the various materials needed. The model was used in the practical station of the Stop The Bleed course taught by an instructor qualified by the American College of Surgeons, in a university center in the city of xxxxx. In the handling and use of this training model by professionals, it was observed that the proper application of the direct compression technique, proved to be effective in stopping simulated jet bleeding. There were 20 participants involved in the application and evaluation of the model, such as 08 (40%) doctors, 03 (15%) nurses and 09 (45%) medical students. From these, 50% were male and the average age was 25.

DISCUSSION

Inanimate models are developed for technique practical training, contributing to the development of professional skills, essential during graduation. Simulation in models allows practice repetition, enabling learning. The models manufactured by large companies vary in complexity, usually being the most complex and reliable of high cost, than models manufactured in academic environments, previously it was also common to practice simulations in animals, which generated even higher costs[13,14,15]. The model described in this study is fast to reproduce, low cost and educationally satisfactory.

The results obtained from the questionnaires demonstrated an excellent evaluation in all items, highlighting the recognition of its applicability for the training of direct bleeding compression. The lowest indexes were in relation to the anatomical correlation and quality of the materials used. Indicating the possibility of improving the model in order to increase its reliability.

The number of participants in the evaluation and use of the model was only 20 people, however we emphasize that most of them were professionals who work directly in the care of trauma victims in a reference hospital. We consider this aspect as the main validation factor for this training model.

The involvement of young medical students, members of a trauma and emergency league, encouraged by the experienced advisor, demonstrated through this study the innovative potential that academic leagues can have in improving the care of traumatized patients through the construction of a cheap, efficient and practical educational tool.

Figure 2. Simulator during evaluation of professionals in a reference hospital

CONCLUSION

The simulator of this study had excellent acceptability by the professionals who tested it, it allows the training of the direct compression technique, being a low cost alternative for educational purposes.

Authors' participation: *Emanuelly Thays Muniz Figueiredo Silva* - Student responsible for the production of the model and organization of the article; *Danielle Maria Camelo Cid* - Student responsible for building the model and searching for a theoretical framework for the article; *Luiza Vitória Fontenelle Costa* - Student responsible for building the model; *Isabelle Rodrigues Schramm* - Student responsible for building the model; *Daniel Souza Lima* – Doctor responsible for the project theoretical orientation and the article writing supervision; *Francisco George de Lima Regis* - Engineer responsible for the project theoretical creation

REFERÊNCIAS

1. Murray J, de Castro CDR, Kahn T. Crime and violence in Brazil: systematic review of time trends, prevalence rates and risk factors. Aggression Violent Behav. 2013;18(5):471-83. doi: https://doi.org/10.1016/j.avb.2013.07.003.
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. doi: 10.1371/journal.pone.0148844
3. Lima DS. O impacto das emergências traumáticas e não traumáticas no Brasil. Fortaleza: Editora Unichristus; 2018.
4. Holcomb JB, Del Junco DJ, Fox EE, Wade CE, Cohen MJ, Schreiber MA, Cotton BA. The prospective, observational, multicenter, major trauma transfusion (PROMMTT) study: comparative effectiveness of a time-varying treatment with competing risks. JAMA Surg. 2013;148(2):127-36. doi: 10.1001/2013.jamasurg.387.
5. Pikoulis E, Salem KM, Avgerinos ED, Pikouli A, Angelou A, Pikoulis A, Karavokyros I. Damage control for vascular trauma from the prehospital to the operating room setting. Front Surg. 2017;4:73. doi: https://doi.org/10.3389/fsurg.2017.00073.
6. Lima S, Almeida YADS, Cid DMC, Cardoso LC, Braga CS, Regis FGDL. Modelo sintético de baixo custo para treinamento do uso de torniquete. Rev Col Bras Cir. 2019;46(6): e20192324. doi: 10.1590/0100-6991e-20192324
7. Prehospital Trauma Life Support Committee of the National Association of Emergency Medical Technicians in Cooperation with the Committee on Trauma of the American College of Surgeons. Prehospital Trauma Life Support (PHTLS). 9th ed. Burlington, MA: Jones & Bartlett Learning; 2018.

8. Boulton AJ, Lewis CT, Naumann DN, Midwinter MJ. Prehospital haemostatic dressings for trauma: a systematic review. Emerg Med J. 2018;35(7):449-57. doi: http://dx.doi.org/10.1136/emermed-2018-207523.

9. Holcomb JB. Transport time and preoperating room hemostatic interventions are important: improving outcomes after severe truncal injury. Crit Care Med. 2018;46(3):447-53. doi: https://doi.org/10.1097/CCM.0000000000002915.

10. American College of Surgeons Committee on Trauma. Advanced Trauma Life Support (ATLS) Student Course Manual. 10th ed. Chicago: American College of Surgeons; 2018.

11. Amoretti R. A educação médica diante das necessidades sociais em saúde. Rev Bras Educ Med. 2005;29(2):136-46. doi: http://dx.doi.org/10.1590/1981-5271v29.2-020.

12. Cunha CMQ, Júnior JAGF, Ferreira JD, Neto GT, Félix DF, Menezes FJC. Montagem e aplicação de modelo de baixo custo de dissecção venosa. Rev Med (São Paulo). 2017;96(4):220-4. doi: https://doi.org/10.11606/issn.1679-9836.v96i4p220-224.

13. Motta EV, Baracat EC. Treinamento de habilidades cirúrgicas para estudantes de medicina–papel da simulação. Rev Med (São Paulo). 2018;97(1):18-23. doi: https://doi.org/10.11606/issn.1679-9836.v97i1p18-23.

14. Rocha IRDO, Oliveira MHBD, Bengtson KL, Alves AMN, Brito MVH. Modelo artesanal para treinamento de acesso vascular periférico. J Vasc Bras. 2017;16(3):195-8. doi: http://dx.doi.org/10.1590/1677-5449.010216.

15. Bauer F, Rommel N, Kreutzer K, Weitz J, Wagenpfeil S, Gulati A, Kesting MR. 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. doi: https://doi.org/10.1016/j.jsurg.2014.01.017.

Received: 2020, May 31
Accepted: 2021, February 19