How to do it: Teaching surgical skills to medical undergraduates

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Abstract

Medical students must be capable of performing clinical and surgical procedures in outpatient care and initial emergency care in all stages of the biological cycle. Here, we describe the surgical skills schedule with different animal models fulfilled at the Municipal University of São Caetano do Sul (USCS) Medical School, São Caetano do Sul, SP, Brazil, during the surgical abilities module.

We retrospectively reviewed the surgical abilities module schedule provided at the USCS Medical School from 2015 until 2020; in this paper, we describe the use of different animal models. The activities were developed for two semesters during medical school and included an ox tongue, cylindrical Styrofoam, chicken leg and neck, live rabbits, and pigs.

Practical surgical teaching starts with sutures using the ox tongue, after which students are taught to perform tenorrhaphy using cylindrical Styrofoam and chicken legs, followed by vascular anastomosis using the chicken trachea and esophagus. Rabbits are appropriate for training a variety of procedures such as cystostomy, gastrotomy, and appendectomy. Pigs allow for the simulation of several types of procedures such as chest drainage.

Surgical training for medical undergraduates was demonstrated with an evolutionary intent, starting with simple sutures and ending up with basic emergency room surgical procedures.

1. Introduction

National and international guidelines define some mandatory procedures that must be taught to medical students such as suture techniques, thoraccentesis, paracentesis, and pleural drainage. Students must be capable of performing clinical and surgical procedures in outpatient care and initial emergency care in all stages of the biological cycle [1–4].

Surgical teaching around the world has been redesigned due to regulatory standards that restrict the use of animals. The replacement of dogs by pigs and dummies, among other simulation equipment, has greatly increased the costs of surgical technique training. Its direct consequence was the emergence of countless inanimate bench models for pig legs, chicken legs, and synthetic skin pads. Some advantages and disadvantages of different models have been summarized by Reznick et al. [3, 5–8].

Despite the teaching surgical panorama described above, animal models still play an important role in surgical simulation, as they seem to enable the development of better and more reliable technical skills, as well as the decision-making process, in a safer environment and with less pressure when compared to the actual scenario [9].

The aim of this paper is to describe the surgical skills schedule with different animal models fulfilled at the Municipal University of São Caetano do Sul (USCS) Medical School, São Caetano do Sul, SP, Brazil, during the surgical abilities module.

2. Material and methods

We retrospectively reviewed the surgical abilities module schedule implemented in the USCS Medical School from 2015 to 2020 and describe the use of different animal models to fulfill the objective of promoting the development of surgical skills in medical undergraduates.
3. Results

The activities were developed for two semesters, the sixth and seventh, during medical school. There were 15 activities in each semester, with 1 h and 30 min per week, totaling 45 h dedicated to practical surgical training. Our surgical team of professors included three plastic surgeons, one veterinary technician, and one laboratory technician.

Surgical training starts with theoretical guidance and video demonstrations of each procedure to be taught. At this time, the following topics were discussed: procedure indications, different possibilities of sutures and threads, and anesthesia. After the explanation, the students went to the lab to start the practice.

All the suture videos are available online at: https://www.youtube.com/channel/UC4WC5m9OBN7kdYuew077Zlw.

The first semester of training (see Table 1) was entitled “Basic Surgical Skills (BSSK)” as the students were supposed to learn basic surgical movements, posture, and how to manage surgical instruments, starting with a simple suture up to their first surgery on live animals. During BSS, students were seated at hexagonal tables with their individual materials: wooden plate, straight scissors, Mayo-Hegar needle holder, rat tooth forceps, appropriate suture thread, and the animal material to be used (Table 1). During all surgical activities, the teachers supervised the students. Typically, 10 students are assisted by each teacher.

The second semester of training (see Table 2) was entitled “Advanced Surgical Skills (ASS)” (Table 2), as the students were supposed to review previous topics and evolve their surgical skills, becoming able to perform small surgical procedures on live animals. When practicing ASS, the students were seated at surgical tables (Picture 1), with the animals submitted to general anesthesia, in groups of four students per animal. During all surgical activities, teachers were available to supervise the students in the same proportion as previously mentioned. Animal use followed all Brazilian and international regulations [10].

### Table 1

| Week | Material/Animal | Activity                        | Group Dinamic    |
|------|-----------------|--------------------------------|------------------|
| 1    | Ox tongue       | Simple suture                  | Individual activity |
| 2    | Ox tongue       | Donati suture                  | Individual activity |
| 3    | Ox tongue       | Simple continuous suture       | Individual activity |
| 4    | Ox tongue       | Anchored continuous suture     | Individual activity |
| 5    | Ox tongue       | Inverted simple suture         | Individual activity |
| 6    | Ox tongue       | Intradermic continuous suture  | Individual activity |
| 7    | Ox tongue       | X suture                       | Individual activity |
| 8    | Ox tongue       | Skin graft and V–Y Flap        | Individual activity |
| 9    | Ox tongue       | Suture revision                | Individual activity |
| 10   | Surgical        | Hand antisepsis, Surgical      | Individual activity |
|      | instruments     | vestment and Operating table   | assembly         |
| 11   | Chicken foot    | Kessler tenorraphy suture      | Individual activity |
| 12   | Chicken neck    | Simple suture vascular         | Individual activity |
|      | styrofoam       | anastomosis                    |                  |
| 13   | Chicken neck    | Continuous suture vascular     | Individual activity |
|      | styrofoam       | anastomosis                    |                  |
| 14   | Rabbits         | Exploratory Laparotomy         | Group activity (4 students per animal) |
|      | 14              | Gastrostomy                    |                  |
|      | 15              | Intradermic continuous suture  | Individual activity |

### Table 2

| Week | Material/Animal | Activity                        | Group Dinamic    |
|------|-----------------|--------------------------------|------------------|
| 1    | Ox tongue       | Sutures Review                  | Individual activity |
| 2    | Chicken neck    | Anastomosis Review              | Individual activity |
| 3    | Chicken foot    | Tenorrhaphy review              | Individual activity |
| 4    | Rabbits         | Appendectomy                    | Group activity (4 students per animal) |
| 5    | Rabbits         | Cystostomy                      | Group activity (4 students per animal) |
| 6    | Rabbits         | Cystostomy                      | Group activity (4 students per animal) |
| 7    | Rabbits         | Cystostomy                      | Group activity (4 students per animal) |
| 8    | Rabbits         | Gastrostomy                     | Group activity (4 students per animal) |
| 9    | Rabbits         | Gastrostomy                     | Group activity (4 students per animal) |
| 10   | Rabbits         | Colostomy                       | Group activity (4 students per animal) |
| 11   | Rabbits         | Colostomy                       | Group activity (4 students per animal) |
| 12   | Pigs            | ATLS practical lesson           | Group activity (4 students per animal) |
| 13   | Pigs            | ATLS practical lesson           | Group activity (4 students per animal) |
| 14   | Pigs            | ATLS practical lesson           | Group activity (4 students per animal) |
| 15   | Pigs            | ATLS practical lesson           | Group activity (4 students per animal) |

4. Discussion

In the literature, practical surgical teaching starts with sutures, which, from our perspective as well, seems reasonable. We believe that students need to learn how to handle surgical material and sutures before progressing to the actual surgical procedures [11].

Many different materials have been used to help students practice sutures. There is no material considered perfect for all sutures because of differences from the human skin. We chose ox tongue because it is easily accessible at a low cost in Brazil. Moreover, its superficial layer appropriately simulates aspects of the human skin, and its deep layer (muscle) mimics the human subcutaneous. In several studies, ox tongue was found to be the material that best met the requirements to simulate human skin and, as it is biodegradable, it can be discarded in the same way as other organic materials [11-15].

The natural progression after learning how to suture, from our perspective, is to perform tenorrhaphy and vascular anastomosis. In this way, the students understand concepts that will be used during animal surgeries and medical practice. Kessler tenorrhaphy training was performed first with cylindrical Styrofoam and then with a chicken foot. Vascular anastomosis was performed using a chicken neck, given its resemblance to human tissues and the possibility of performing both simple and continuous sutures for the anastomosis. The chicken trachea simulates arterial anastomosis, and the esophagus mimics venous anastomosis [16].

There are many advantages of using rabbits as models for surgical treatment, such as easy handling, affordable cost, low morbidity, no tendency toward hypoglycemia, no requirement for pre-operative fasting for the execution of abdominal surgical procedures, easy anatomy identification, and several similarities to the human anatomy, especially
in relation to the digestive tract. Therefore, this model is considered appropriate for training procedures such as cystostomy, gastrostomy, appendectomy, and artery and vein dissection [17–19].

The main disadvantage of the rabbit model is related to endotracheal intubation, which is complicated due to the small size of the rabbit and its oral cavity shape. Considering this, we chose to include cricothyroidotomy and tracheostomy as part of the surgical training of the definitive airway. These were performed by students, always under direct supervision [19,20].

Pigs are the main animal species used for surgical training and are usually used as an alternative to dogs. The advantages of their use as a human tissue simulation model are the abdominal cavity with a basic muscular and fascial anatomy that is common to all mammals, and its abdomen may be compared in size to that of human adults. In this way, it is possible to simulate several types of procedures such as bowel resection with manual anastomosis, splenectomy, partial hepatectomy, and chest drainage. According to our schedule, students have the opportunity to perform chest drainage, orotracheal intubation, peritoneal lavage, and exploratory laparotomy. Few studies have reported the use of pigs for undergraduate medical training [21–24].

Training with animal models has some benefits beyond the technical improvements. Some studies show that the surgical training performed in this way allows students to experience working together and develop the capacity to interact and work in synchrony with other students, helping them to work as a team. Other benefits noted are the improvement of students’ confidence in their abilities and capacities as well as increased self-assessment. Thus, even with the high cost and other obstacles in the development of the animal model practice, the educational experience seems to make it all worth it, as this model can help to qualify future doctors for large centers as well as smaller cities where they would need to perform low-complexity surgical procedures [23–25].

5. Conclusion

Surgical training of medical undergraduates was demonstrated with an evolutionary intent, starting with simple sutures and ending up with basic emergency room surgical procedures.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jamsu.2022.104617.

References

[1] K.S.M. Purim, J. Skinovsky, J.W. Fernandes, Basic skills for outpatient surgery in medical graduation, Rev. Col. Bras, Cir 42 (5) (2015) 341–344, https://doi.org/10.1590/0100-699120150050103.
[2] E.F. Mendonça, Diretrizes Curriculares Nacionais do curso de graduação em medicina, 2014. http://portal.mec.gov.br/index.php?option=com_docman&view=downloads&alias=15874-ren003.14&category_slug=junho-2014-pdf&itemid=30192. Accessed 23 March 2021. Ministério da EDUCAÇÃO ECONSELHO Nacional de EDUCAÇÃO CAMARA de EDUCAÇÃO SUPERIOR.
[3] R. Denadai, R. Saad-Hosse, A.P. Todelo, L. Kirylko, L.R. Souto, Low-fidelity bench models for basic surgical skills training during undergraduate medical education, Rev. Col. Bras, Cir 41 (2) (2014) 137–145, https://doi.org/10.1590/0100-6991201400200012.
[4] M.B. Zanolli, Diretrizes Nacionais do curso de graduação em medicina – Capítulo IV – “Internato Médico” - Diretrizes Nacionais da ABEM para o internato no curso de graduação em medicina, de acordo com as diretrizes curriculares nacionais. Associação Brasileira de Ensino Médico, Rio de Janeiro (ABEM), 2014.
[5] R.K. Reznick, H. Macrae, Teaching surgical skills – changes in the wind, N. Engl. J. Med. 355 (25) (2006) 2664–2669, https://doi.org/10.1056/NEJMra054785.
[6] M.V.H. Carvalho, S.F. Modena, R. Anania de Paula, E. Marchi, O ensino de introdução à cirurgia nos Estados Unidos da América (EUA): informações obtidas em sítios eletrônicos, Perspect. Med. 20 (2) (2009) 45–50.
[7] R. Denadai, R. Saad-Hosse, M. Oishiwa, E.M. Bastos, Training on synthetic ethylene-vinyl acetate bench model allows novice medical students to acquire suture skills, Acta Cir. Brasiliana 27 (3) (2012) 271–278, https://doi.org/10.1590/s0102-86502012000300012.

Picture 1. Surgical lab for animal practice – Using pigs for ATLS practical lesson: Chest drainage and Peritoneal lavage.
E. Vanyolos, I. Furka, I. Miko, A. Viszla, N. Nemeth, K. Petro, How does practice improve the skills of medical students during consecutive training courses?, Acta Cir. Bras, 32 (6) (2017) 491–502, https://doi.org/10.1590/s0102-86502017006000010.

C.Y.Y. Loh, A.Y.L. Wang, V.T.Y. Tiong, T. Athanassopoulos, M. Loh, P. Lim, H. K. Kao, Animal models in plastic and reconstructive surgery simulation – a review, J. Surg. Res. 221 (2018) 232–245, https://doi.org/10.1016/j.jss.2017.08.052.

M.A. Raupp, Diretriz brasileira para o cuidado e a utilização de animais para fins científicos e didáticos (DBCA), 2013. https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/31061653/do1-2013-09-25-resolucao-normativa-n-12-de-20-de-setembro-de-2013-31061649 . Accessed 23 March 2021. (Ministério da Ciência, Tecnologia e Inovação/Conselho Nacional de Controle de Experimentação Animal – CONCEA).

D. Franco, J. Medeiros, A. Grossi, T. Franco, Uso de língua bovina na prática de técnicas de sutura, Rev. Col. Bras. Cir 35 (6) (2008) 442–444, https://doi.org/10.1590/S0100-69912008000600015.

P.N. Khalil, M. Siebeck, W. Mutschler, K.G. Kanz, The use of chicken legs for teaching wound closure skills,, Eur. J. Med. Res. 14 (10) (2009) 459–460, https://doi.org/10.1186/2047-783x-14-10-459.

F.L. Cole, E.G. Ramirez, Beef tongue: a model for teaching complex wound closure to emergency nurse practitioner students, J. Emerg. Nurs. 28 (5) (2002) 467–468, https://doi.org/10.1067/men.2002.127762.

K.G. Tokuhara, D.W. Boldt, L.G. Yamamoto, Teaching suturing in a workshop setting: a comparison of several models, Hawaii Med. J. 63 (2004) 258–259.

J.M. Camelo-Nunes, J. Hiratsuka, M.M. Yoshida, C.A. Beltrani-Filho, L.S. Oliveira, A.C. Nagae, Ox tongue: an alternative model for surgical training, Plast. Reconstr. Surg. 116 (1) (2005) 352–354, https://doi.org/10.1097/01.prs.0000173550.42201.b5.

R.A.N. Achar, P.A.M. Lozano, B.N. Achar, G.V. Pereira Filho, E. Achar, Experimental model for learning in vascular surgery and microsurgery: esophagus and trachees of chicken, Acta Cir. Bras. Bras. 26 (2) (2011) 101–106, https://doi.org/10.1590/s0102-86502011000200005.

C.R. Molinas, M.M. Binda, K. Mailova, P.R. Koninckx, The rabbit necropsy model for training in laparoscopic surgery, Hum, Reprod 19 (1) (2004) 185–190, https://doi.org/10.1093/humrep/deh025.

C. Esposito, M. Escolino, I. Draghici, M. Cerullo, A. Farina, T. De Pascale, et al., Training models in pediatric minimally invasive surgery: rabbit model versus porcine model: a comparative study, J. Laparoendosc. Adv. Surg. Tech. 26 (1) (2016) 79–84, https://doi.org/10.1089/lap.2015.0229.

J.R. Alves, L.R. Lopes, T. Sasasaki, Perioperative care in an animal model for training in abdominal surgery: is it necessary a preoperative fasting?, Acta Cir. Brasiliana 26 (6) (2011) 541–548, https://doi.org/10.1590/s0102-86502011000600022.

M.D. Calansans-Maia, M.L. Monteiro, F.O. Ascoli, J.M. Granjeiro, The rabbit as an animal model for experimental surgery, Acta Cir. Bras. 24 (4) (2009) 325–328, https://doi.org/10.1590/s0102-86502009000400014.

M. Noda, M. Mizuma, S. Maeda, A. Sakurada, Y. Hoshikawa, C. Endo, et al., Presented at the 64th Annual Scientific Meeting of the Japanese Association for thoracic surgery: wet-lab training for thoracic surgery at the laboratory animal facilities, Gen. Thorac. Cardiovasc. Surg 60 (11) (2012) 756–759, https://doi.org/10.1007/s11748-012-0134-z.

S. Khan, C. Cipriano, J.M. Marks, S.J. Schomisch, Porcine abdominal wall simulator for laparotomy incision and closure, Surg. Innovat. 22 (4) (2015) 426–431, https://doi.org/10.1177/1553350614556266.

K.E. Roberts, R.L. Bell, A.J. Duffy, Evolution of surgical skills training, World J. Gastroenterol. 12 (20) (2006) 3219–3224, https://doi.org/10.3748/wjg.v12.i20.3219.

J. Drosdeck, E. Carraro, M. Arnold, K. Perry, A. Harzman, R. Nagel, et al., Porcine wet lab improves surgical skills in third year medical students, J. Surg. Res. 184 (1) (2013) 19–25, https://doi.org/10.1016/j.jss.2013.06.009.

V.A. Felzemburgh, H.A. Sampaio, G.F.D. Abreu Junior, J.H.O. Campos, Comparison between the traditional and the new training model using rabbits in the assessment, Acta Cir. Brasiliana 27 (6) (2012) 433–438, https://doi.org/10.1590/s0102-86502012000600013.