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ORIGINAL ARTICLE

Introduction and assessment of an inanimate model for basic surgical skills training of veterinary students

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Abstract

Introduction: In recent decades, simulation-based training has become an important component of learning and the practice of surgery. Surgical training is shifting from traditional methods to a more standard realistic approach, using simulation to improve some aspects of training. However, high costs can be a limiting factor. One solution to reduce the cost is using low-cost inanimate bench models. Studies have shown that surgical skills learned by trainees from bench models have resulted in better performance on surgical patients in the operating room. In this study, the introduction of a bench model was evaluated for teaching basic surgical skills to veterinary students in a simulated environment. **Materials and methods:** Thirty veterinary students were randomly divided into two groups of 15 trainees: group A (control group) were trained in basic surgical skills on live animals (clinical cases) without any training on bench models; group B (test group) received 30 minutes of training on bench models and then training on live animals. Recorded performances of both groups were evaluated using two checklists: the Global Rating Scale and the Skin Suturing Scale. **Results:** The performance scores (combined scores from both checklists) for group B on live animals, after their training on educational bench models, were higher (P = 0.001) than those of group A, who did not have the bench model training. **Discussion:** On the basis of this research, learning and training of basic surgical skills is possible by practicing on bench models, and significant progress was demonstrated in the clinical performance of trainees who practiced on bench models.

Keywords: *surgical simulation; surgical training; basic surgical skills; veterinary medical education; simulation in veterinary medicine; inanimate models*

Introduction

The need for simulation in veterinary education

In recent decades, the education of health professionals has seen a significant increase in the application of simulation for teaching and evaluation. This has mainly been in the area of human medicine (physicians, dentists, midwives, nurses, physical therapists, paramedics, etc.).[1] However, in veterinary medicine, this technology has only been exploited and developed more recently. Its importance in the veterinary context relates to issues of animal welfare and competency-based education.

There are many factors that have resulted in the increasing use of simulation in medical education. The first is the technological progress in medical diagnosis, treatment and procedures. For example, thoracoscopic and laparoscopic techniques, which are commonly applied in human medicine, necessitate the development of skills that differ from traditional approaches, and require novel methods for teaching and learning.[2] These techniques are now becoming more popular in the veterinary field.[2]

Second, changes in health care policies have resulted in the decreased availability of patients (as educational cases) and teaching time; shortage of clinical consultations available for educational purposes and accelerated hospital discharges.[3,4] Veterinary schools are dealing with similar issues according to this philosophy of teaching hospitals whereby they accept only ‘good teaching cases’ that provide a student-centred educational experience but a limited number and variety of patients.[1]

Third is the matter of ethics and patient safety in veterinary medicine ('Primum non nocere: First, do no harm') and the emphasis on animal welfare. Nowadays, using animals as educational resources is under debate, especially for clinical training involving tasks that might be harmful to animal's health (e.g. rectal examination and endotracheal intubation). Many of the approaches used previously for the teaching and learning of veterinary clinical skills are now unavailable.[1]

These issues (changes in health care policy, ethical concerns and patient safety) all tend to decrease veterinary students' opportunities to practice professional and clinical skills,[1] and the typical veterinary curriculum offers only very limited opportunities for students to gain experience with real patients.[5] In comparison with the educational opportunities in human medicine, whereby almost all medical school graduates follow a residency/fellowship training in different specialties (at least three more years of clinical experience), 70% of veterinary graduates with the DVM or equivalent degrees go directly into clinical practice, often in an apprenticeship or junior partnership arrangement.[1]

Using the phrase 'expert graduates from veterinary schools'[6] does not seem reasonable. According to the studies done in the veterinary schools of University of California (Davis)[7,8] and University of Ontario,[9] the usual 12–18 months of clinical training is not enough time to gain the wide range of skills (some involving invasive treatments) that are expected of practicing veterinarians.[1]

With so many challenges tending to limit the use of veterinary patients as educational resources, and the shortage of clinical training time, how can veterinary students practice the skills sufficiently to gain minimum acceptable standards of competency and proficiency? According to the published evidence from the human medical education literature, simulation technology offers one solution to this problem.

Specific simulations in veterinary medical education

Currently there are not enough devices in terms of animal simulators that are designed specifically for application in veterinary medicine education.[1] However, in recent decades, studies have reported the development and application of veterinary-specific simulators for teaching the tasks and skills of veterinary curricula at different veterinary schools throughout the world, such as the haptic canine, feline, bovine and equine models.[10–32]

A group from the University of Glasgow described virtual reality animal simulators for teaching horse ovary palpation[33] and bovine rectal palpation.[34,35] After integrating the latter system into the veterinary curriculum, veterinary students considered it useful for learning the technique.[35,36] Also other similar studies from the same group demonstrated significantly improved performance of skills and tasks in veterinary students.[35,37]

Development of simulation devices such as these is one solution to the shortcomings identified in veterinary training in technical, especially invasive, procedural skills.[7] There are other reports of using 'virtual veterinary clinics' to offer alternatives to improve technical skills in veterinary training.[9,38,39]

Low cost simulation models for veterinary surgical skills

Previous articles have documented the benefits of simulation for surgical training[40–47,49] and drawn attention to ethical concerns surrounding the teaching of surgical skills during the treatment of human patients.[48] Despite the advantages of using simulation, some aspects such as high cost[50] (especially in developing countries),[51–54] lack of time, shortage of experts (traditional instructors),[55,56] the ethical/legal problems regarding training on live animals, difficulty accessing cadavers and live laboratory animals, and the expense of virtual reality simulators have been seen as limiting factors for implementation.

One solution to reduce the expense is the use of low-cost bench models, such as the one described in this study. Previously, oranges have been used for teaching skills in plastic surgery and debridement of necrotic ulcers, and tomatoes and melons for the training of micrographic biopsy and surgery.[57–61] There are other studies on using eggplant, lemon and orange for training basic surgical skills.[52,55,62]

The banana model has minimal requirements for storage, can be easily disposed of, and is also versatile, reproducible, portable, simple, easy to acquire, affordable and allows the assessment of training with feedback for correcting the suturing techniques. Some advantages of using fruits instead of other models are that they can be acquired in local supermarkets, and reused if stored in proper cooling conditions. However, the most obvious limitation of such models is that they can be used only for one surgical technique rather than an entire operation. Seasonal availability of items (in some countries) may also have an influence on training.

Also, the banana model resembles the skin and students trained on it will learn to respect the different layers of skin (epidermis, dermis, subcutaneous tissue and muscle).[52,53] We chose three types of sutures (single interrupted, simple continuous and horizontal mattress) because the possibility of training in two- and three-dimensional sutures is one of the benefits of using this bench model in comparison with other low-fidelity and low-cost synthetic simulators.[63]

A wide range of models have been introduced in recent years, however, they all have advantages and disadvantages, and none of them offer a perfect solution. These models differ greatly with respect to their degree of fidelity or 'realism' to live patients.[47,64] As has been described previously,[64] they can be divided into organic or inorganic simulators. Organic simulators, including fresh cadaver and live animal models, are considered to be of high fidelity. Unfortunately, studies have demonstrated that they are limited in terms of high costs, potential for transmission of infectious disease, availability and possible ethical concerns.[47,64–66] On the other hand, lower-fidelity inorganic bench models often sacrifice realism for the convenience of lower costs, portability and the possibility for repetitive administration.[47,64–66]

The main focus of this study was to propose an inanimate bench model and its benefits, discussing the importance of using inanimate bench models for simulation and exploring their effectiveness in teaching and training.

Materials and methods

Thirty veterinary students were divided randomly and blindly into two groups of 15 trainees: group A, the control group (no use of the bench model), and group B, the test group (with bench models). All of the trainees were 5th year veterinary students and none had previous experience of performing a surgical operation. They were chosen regardless of age, sex, ability or academic achievement. The data were collected and reviewed under two checklists (tests): the Skin Suturing Scale[67] (Appendix 1) and the Global Rating Scale[68] (Appendix 2). These checklists were chosen for use in this study after assessment by members of the surgery department.

The first checklist, a detailed skin suturing scale, consisted of 19 tasks to be assessed. The second checklist, the Global Rating Scale, adopted in this study, is part of the Objective Structured Assessment of Technical Skills, which is considered as the gold standard for the objective evaluation of teaching surgical skills.[68]

Group A (control group) attended two surgery classes and their performance on live animals (dogs referred for surgery at our veterinary educational hospital; students were supervised by veterinary surgery department members) was assessed in both sessions (Fig. 1). On another day, group B (test group) also attended two surgery classes (same format as for group A) but each member of the group was given 30 minutes of bench model training before the start of each surgery class (Fig. 2). Their performance was assessed on the bench models and on live animals (as for group A, under supervision, on dogs referred for surgery at our veterinary educational hospital) (Fig. 3).

Thirty minutes of training was provided on the cutting and suturing techniques. The bench models were incised with a scalpel to facilitate teaching the proper way to grip the instrument, its position on the skin, cutting the skin, the depth of the incision (which is important to promote good healing). Then, according to the requested pattern for each line, sutures were made to close the edges of the incised area (single interrupted, simple continuous and horizontal mattress). After their training on the bench models, the members of group B worked on live animals in surgery classes.

The confidence level for all tests was placed at 95% and α was considered 0.05. Descriptive data were expressed as means $\pm$ standard error (mean $\pm$ SEM).

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All animals were under anaesthesia during the surgery.

Results

Given that the results were qualitative and ranking based, non-parametric statistical tests were used. The Mann-Whitney U test was used to compare the two groups that were independent from each other; the Wilcoxon signed rank test was used to compare the performance in group B on the bench model and with live animals.

First checklist: Skin Suturing Scale

As there were 19 tasks, the total score for each student was divided by 19 to give a final score. Group A's performance was compared first with group B's performance on bench models and then with group B's performance on live animals.

Group B achieved higher scores on bench models than group A achieved (live animals) (P = 0.045). Also group B achieved higher scores on live animals than group A ($P <$ 0.001). In group B, there was a statistically significant difference in the performance of students on bench models compared with live animals ($P <$ 0.001) with higher scores achieved on the live animals (Table 1) (Fig. 4).

Second checklist: Global Rating Scale

There were eight tasks, each with a score of 1 to 5 (1 being the minimum and 5 the maximum). The total score for each

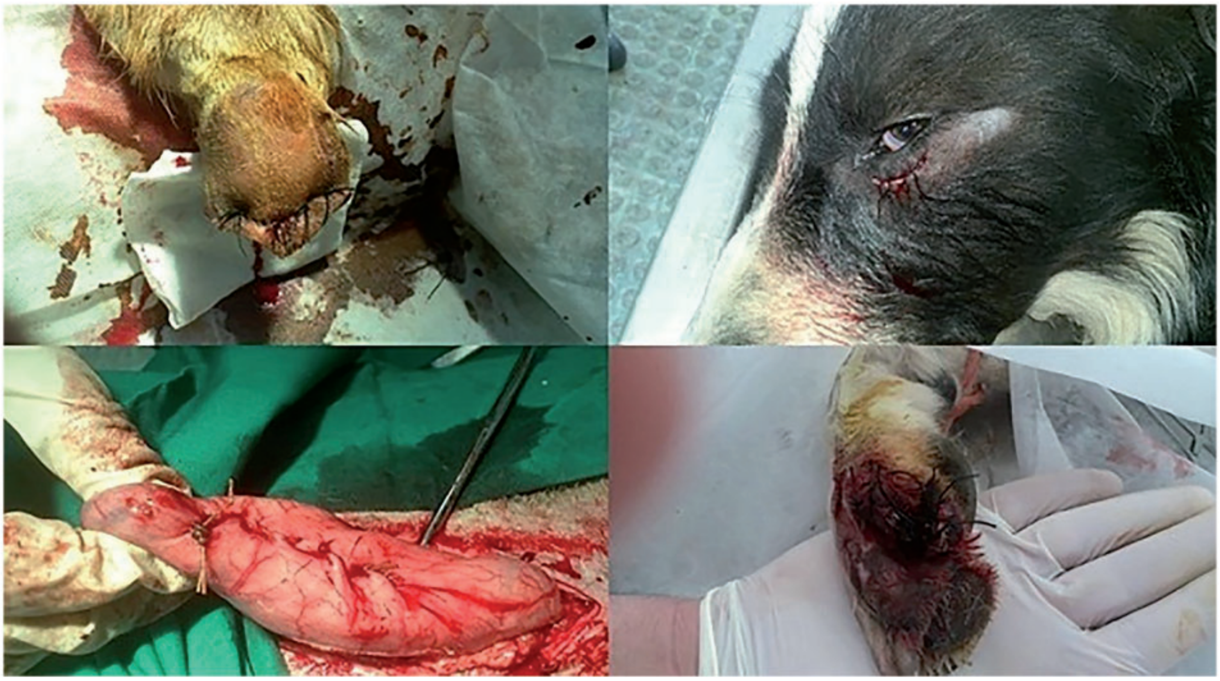

Figure 1. The performance of group A (control group) on live cases.

Figure 2. The training of group B (test group) on bench models.

student was divided by 40 for their final score. As measured by the second checklist, there was no statistically significant difference between group A's performance (live animals) and group B's performance on bench models ($P = 0.367$). Group B achieved higher scores for their performance on live animals than group A, and this was statistically significant ($P = 0.001$). In group B, there was a statistically significant difference between the performance of students on the bench model and live animals ($P = 0.001$), with the scores being higher on live animals (Table 2) (Fig. 4).

Final assessment

In the final analysis and comparing the two groups based on the mean of each student's scores on both checklists, it was found that there was no statistically significant difference between group A's performance and group B's performance

Figure 3. Comparing the performance of each trainee (using numbers for each trainee) in group B on both bench and live models.

on bench models (P = 0.116), but that group B achieved higher scores on the live animals compared with group A ($P < 0.001$). In group B, there was a statistically significant difference in the performance of students on bench models compared with live animals (P = 0.001) (Table 3) (Fig. 5).

Table 1. Skin Suturing Scale

Group	Training type	Mean ± standard deviation
A	On live animals	10.67 ± 1.11
B	On bench models	11.47 ± 0.92
B	On live animals	13.93 ± 1.03

Discussion

The main focus of this study was to determine whether training on an inanimate low-fidelity bench model can be recommended or used as a teaching tool for veterinary undergraduates. To the best of the authors' information, this study is one of its kind that objectively assesses the learning of basic surgical skills by veterinary students by comparing a low-fidelity model with a high-fidelity model.

In a similar study in Brazil by Denadai et al.[69] but in medical students, regardless of the model fidelity, medical students who practiced on bench models performed better than the control group.

In various studies on surgical simulator-based training, there is evidence that the surgical skills developed on inanimate bench models can result in performance improvements on corpses, animal models, and in the operating room;[47,70–72] and that for novice students in surgical practice, the shift of skills to the clinical situation is acceptable when gained from cheap low-fidelity models compared with when it is derived from expensive high-fidelity models or virtual reality simulators.[68,73]

Nevertheless, there were limitations to this study that must be addressed. First, the retention of acquired skills was not measured. Therefore, further research and models would be necessary to assess whether students taught in this way are able to retain and improve on the learned skills.[50,56]

Second, our study evaluated only some basic surgical skills (e.g. suturing), which would not meet all the training needs of veterinary students. Our results cannot be generalized to other technical surgical skills.[56]

Third, as the students in our study were taught a limited number of basic surgical skills, and our sample size was small, our findings cannot be generalized to other skills

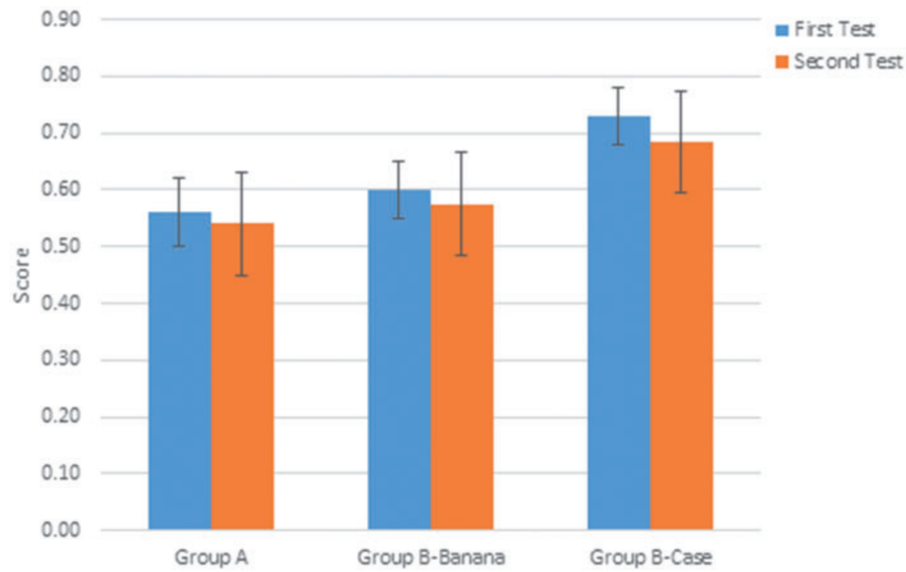

Figure 4. The performances of both groups in the two tests.

Table 2. Global Rating Scale

Group	Training type	Mean ± standard deviation
A	On live animals	21.73 ± 3.49
B	On bench models	23 ± 3.51
B	On live animals	27.40 ± 3.40

Table 3. Groups A and B: final performances based on both checklists

Group	Training type	Mean ± standard deviation
A	On live animals	0.55 ± 0.07
B	On bench models	0.59 ± 0.06
B	On live animals	0.71 ± 0.06

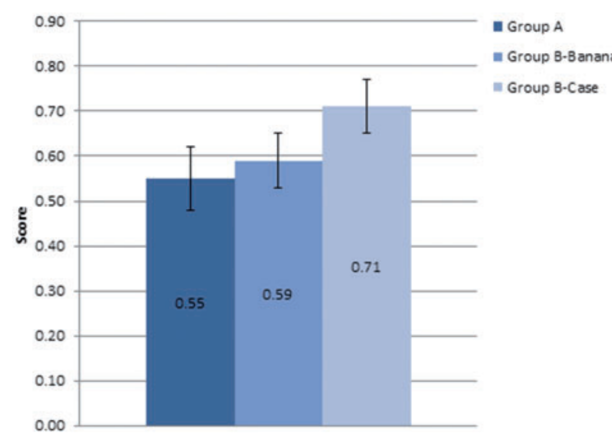

Figure 5. The final performance of all trainees.

(e.g. skin grafts) or to students who may differ in their level of mastery of the skills examined here.

Fourth, an extensive literature review[69] retrieved no relevant reports demonstrating the superiority of a high-fidelity model over a low-fidelity model (or the superiority of one low-fidelity model over another low-fidelity model). So far, there is no standard recommendation for an ideal model for training and gaining of skills.[74] In addition, studies[47,71,72] that compare high- and low-fidelity models demonstrated that surgical skills were gained when each model was compared with training without any simulation, but that there were no differences between these models themselves. As there is no evidence to support the choice of one particular simulation model, we chose to explore the use of a new model for our study. Other reports[50,54,56,70,75–80] used the performance of basic surgical skills and sutures on bench models for the exploration of other applicable features in training of surgery (e.g. ideal tutor, student ratio, and assessing the demand for a faculty tutor to instruct basic surgical skills); and therefore, objective comparisons were not made between high-fidelity and low-fidelity bench models.

The banana model can be used by trainees with little experience who have never performed basic surgical skills and by those who have had some experience with these skills but need to improve their performance. This model can be used for training in several sessions (days or weeks), which can be modified and developed in a way that complements the pre-existing curriculum and can be used in the background of the clinical and surgical courses.

The bench model and its suggested use as described in this study can provide training/learning for undergraduate students, complementing existing training, and, as students acquire the basic surgical skills, teaching of more complicated methods using the same model or using other simulators can be introduced.

Further studies are required to measure other aspects of the use of this model: the retention of skills over time and the acquisition of techniques by trainees at other levels of training (e.g. intern students and residents).

Further development of simulations in veterinary education

As mentioned above, there are a number of published reports, mostly in recent years, on simulation technology being used in veterinary education, but given the importance of veterinary medicine and veterinarians today, there is room for more research.[81–83] In contrast, there are hundreds of articles on human medical education detailing how simulation is used for training and teaching.[84] The main reason for this significant difference could be financial issues. Obviously, veterinary medical education is a much smaller enterprise with less funding than its human medicine counterpart. For example, there are 126 US and 16 Canadian medical schools but there are only 28 US and 4 Canadian veterinary schools.[1]

Application of pre-existing simulation technologies could be one way to keep costs down. One study reported the use of a human simulator for veterinary students' training instead of developing such technology for animal models, which is very both time-consuming and costly.[85] Other studies have demonstrated the application of pre-existing simulators for training clinical tasks.[86–89]

Veterinary schools must weigh up the costs and benefits of using simulation as part of the training they offer. As happened in human medical education, with the growing focus on increasing patient safety, it is possible that increasing concerns about animal welfare, food safety and public health may drive support for simulation in veterinary education.

Conclusion

According to our study, gaining basic surgical skills is possible by training on bench models. Also, it has been shown that shifting the skills gained to the clinical setting is independent of fidelity.[69] Thus, low-fidelity models can provide more material and training opportunities without jeopardizing the results. The banana model is accessible, portable, reproducible, and of low cost, and it can be used to complement the existing methods of basic surgical skills training. Different studies have demonstrated the effectiveness of bench models for basic surgical skills training and wider use of such methods in veterinary education would be beneficial.

Conflict of interest

None declared.

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Appendix 1: The Skin Suturing Scale checklist (test 1)

Item	Done correctly	Done incorrectly
Selects appropriate suture, needle holder and forceps		
Needle loaded 1/2 to 2/3 from tip		
Bite distance from the skin edge 5 mm		
Angle at which bite taken 90°		
Single attempt while taking bites in the skin		
Movement occurs at wrist		
Forceps used to hold skin or subcutaneous tissues (minimum use)		
Whether takes bites from both skin edges in one go or separately		
Equal bites on both sides		
Whether needle touched with hand		
Number of knots taken		
Knot is square or not		
Knot is too tight or too loose		
Suture breaks or not		
Knot is on the incision line or on one side		
Distance of cutting the suture from the knot		
Suture board moves or not		
Skin edges are everted or inverted		
Inter-sutural distance 0.5 to 1 cm		

Total score ____________________

Appendix 2: The Global Rating Scale checklist (test 2)

Respect for tissue	**1** Frequently used unnecessary force on tissues or caused damage by inappropriate instrument use	**2**	**3** Careful handling of tissue, but occasional inadvertent damage	**4**	**5** Consistently handled tissues appropriately with minimal damage
Time in motion	**1** Many unnecessary moves	**2**	**3** Efficient time and motion, but some unnecessary moves	**4**	**5** Clear economy of movement and maximum efficiency
Instrument handling	**1** Repeatedly makes tentative or awkward moves with instruments	**2**	**3** Competent use of instruments, but occasionally awkward	**4**	**5** Fluid movements
Suture training	**1** Awkward and unsure with poor knot tying, and inability to maintain tension	**2**	**3** Competent suturing with good knot placement and appropriate tension	**4**	**5** Excellent suture control with correct suture placement and tension
Flow of operation	**1** Frequently stopped operating, seemed unsure of next move	**2**	**3** Demonstrated some forward planning and reasonable progression of procedure	**4**	**5** Obviously planned operation
Knowledge of procedure	**1** Inefficient knowledge of procedure, looked unsure and hesitant	**2**	**3** Knew all important steps of procedure	**4**	**5** Demonstrated familiarity of all steps of procedure
Final product	**1** Final product of unacceptable quality	**2**	**3** Final product of average quality	**4**	**5** Final product of superior quality
Overall performance	**1** Very poor	**2**	**3** Competent	**4**	**5** Very good

Total score ______________________

Overall on this task, should the candidate: Fail: _________ **Pass:** ____________