DIOGO DE FREITAS VALEIRO GARCIA

Uso dos modelos SurgeMan®, TraumaMan® e Porcino na prática cirúrgica do curso Suporte Avançado de Vida no Trauma (SAVT)

Tese apresentada à Faculdade de Medicina da Universidade de São Paulo para obtenção do título de Doutor em Ciências

Programa de: Clínica Cirúrgica

Orientador: Prof. Dr. Renato Sergio Poggetti

São Paulo

2016

University of São Paulo

Diogo de Freitas Valeiro Garcia

SurgeMan, TraumaMan and Porcine Model for the Surgical Skills Station of the Advanced Trauma Life Support - ATLS Course

São Paulo

2016

Dados Internacionais de Catalogação na Publicação (CIP)

Preparada pela Biblioteca da
Faculdade de Medicina da Universidade de São Paulo

Garcia, Diogo de Freitas Valeiro
Uso dos modelos SurgeMan®, TraumaMan® e Porcino na prática cirúrgica do curso Suporte Avançado de Vida no Trauma (SAVT) / Diogo de Freitas Valeiro Garcia. -- São Paulo, 2016.
Tese(doutorado)--Faculdade de Medicina da Universidade de São Paulo. Programa de Clínica Cirúrgica.
Orientador: Renato Sergio Poggetti.

Descritores: 1.Cuidados de suporte avançado de vida no trauma 2.Educação 3.Treinamento por simulação 4.Modelos anatômicos 5.Modelos animais 6.Procedimentos cirúrgicos operatórios

USP/FM/DBD-419/16

Dedicatória

Dedico à minha esposa Célia Petrossi Gallo Garcia, por sempre estar ao meu lado, por me apoiar em minha carreira acadêmica e por ser sempre minha primeira leitora e a primeira a assistir e criticar minhas aulas.

Aos meus filhos, Gustavo Gallo Garcia, Marina Gallo Garcia e Rodrigo Gallo Garcia que sofrem com minha ausência no tempo que me dedico ao trabalho, e espero que um dia entendam esse meu sacrifício e saibam que também sofro estando longe deles.

Aos meus pais, Armando Sergio Valeiro Garcia e Dora Paula de Freitas Valeiro Garcia por serem meus exemplos como pais e pessoas, por tudo que me proporcionaram e me fizeram chegar onde cheguei hoje.

Aos meus irmãos, Marcelo de Freitas Valeiro Garcia e Juliana de Freitas Valeiro Garcia, meus melhores amigos de toda a vida por estarem sempre comigo.

Ao Prof. Dr. Renato Sergio Poggetti por ser meu orientador na tese de Doutorado e em minha vida profissional. Meu exemplo de postura e caráter como professor, profissional e cirurgião.

Agradecimentos

Aos colegas que participaram com instrutores no trabalho: Octacilio Martins, Fernando Ferreira da Costa Novo, Rodrigo Vaz, Valdir Zamboni.

Aos colegas de elaboração do projeto e da realização do trabalho: Cristiane de Alencar Domingues, Newton Djin Mori, Francisco de Salles Collet e Silva.

Aos funcionários do Núcleo de ATLS da Universidade de São Paulo e do Comitê de Trauma Brasileiro do Colégio Americano de Cirurgiões por seu apoio e ajuda tanto neste projeto como em muitos outros: Claudia Quadrado e Raimunda Fontel de Lima.

Aos colegas da minha banca de qualificação, Joaquim Edson Vieira, Sandro Scarpelini, Almerindo Lourenço Júnior e Dario Viana Birolini por sua amizade e por suas valiosas contribuições na melhoria do projeto e da tese.

This thesis was written according to the following standards at the time of publication:

References: Adapted from International Committee of Medical Journals Editors (Vancouver)

University of São Paulo. Faculty of Medicine. Division of Library and Documentation. Guide for submission of dissertations, theses, and monographs. Prepared by Anneliese Carneiro da Cunha, Maria Julia L. A. Freddi, Maria F. Crestana, Marinalva de Souza Aragon, Suely Campos Cardoso, Valeria Vilhena. 3rd Ed. Sao Paulo: Library and Documentation Division, 2011.

Abbreviations of journal titles according to List of Journals Indexed in Index Medicus

Table of Contents

FIGURES LIST

TABLES LIST

GRAPHICS LIST

Abstract

Garcia DFV. *SurgeMan, TraumaMan and Porcine Model for the Surgical Skills Station of the Advanced Trauma Life Support - ATLS Course*. [Thesis]. São Paulo: "Faculdade de Medicina, Universidade de São Paulo"; 2016.

Introduction: Universities and hospitals require the use of suitable alternatives to animals for training wherever possible. The cost of the currently approved artificial mannequins often makes their use prohibitive in low-income countries. A low cost Brazilian artificial mannequin (SurgeMan®) has been developed. Our primary objective was to determine whether SurgeMan® would have equivalent learner and instructor satisfaction scores compared with the currently approved TraumaMan® and an animal model for the surgical procedures of Advanced Trauma Life Support ATLS®. Our secondary objective was to determine if user satisfaction scores for the SurgeMan® exceeded 80%. **Methods:** This was a prospective crossover cohort study with 3 models, SurgeMan® (SMan), TraumaMan® (TMan), and an animal model (Landrace pigs). A convenience sample of 36 students enrolled in ATLS® courses was divided into 9 groups, which were monitored by 1 instructor per group throughout the skills station rotations. Each group participated in all skills in each of the 3 models. The procedures performed were tube thoracostomy, cricothyroidotomy, pericardiocentesis, and diagnostic peritoneal lavage (DPL). Psychometric testing was completed by having students and instructors fill out a Likert Scale at the completion of each activity. Students and instructors were also asked about the adequacy of the models for performing the surgical skills, if they would or would not substitute the animal model for the SurgeMan® or the TraumaMan®, and about their preferred model, with and without ethical and financial issues. **Results:** The animal model and the TraumaMan® performed better than the SurgeMan® for all skills except pericardiocentesis, where there was no difference in the models. When no ethical or financial factors were taken in consideration, 58% of the students and 66% of the instructors chose pigs as their preferred model. When all ethical factors were considered, all students equally recommended the models (SMan 33%, TMan 30%, pigs 33%) and the SurgeMan® was the first choice for the instructors (SMan 66%, TMan 22%, pigs 11%). The students thought all models were adequate for learning ATLS® skills (SMan 81%, TMan 94%, pigs 86%). The Instructors scored only the animal model under 80% (SMan 88%, TMan 100%, pigs 77%) for learning those skills. **Conclusion**: The TraumaMan® performed better than the SurgeMan® in most procedures. Students and instructors found that both the TraumaMan® and the SurgeMan® are acceptable for learning and teaching ATLS® surgical skills.

Descriptors: advanced trauma life support care; education; simulation training; anatomic models; models, animal; surgical procedures, operative.

Resumo

Garcia DFV. *Uso dos modelos SurgeMan®, TraumaMan® e Porcino na prática cirúrgica do curso Suporte Avançado de Vida no Trauma (SAVT)* [Tese]. São Paulo: Faculdade de Medicina, Universidade de São Paulo; 2016.

Introdução: Universidades e hospitais solicitam alternativas para o uso de animais no treinamento médico sempre que possível. O custo dos manequins artificiais atualmente aprovados pelo Colégio Americano de Cirurgiões muitas vezes torna o seu uso proibitivo em países em desenvolvimento e subdesenvolvidos. Um manequim artificial de baixo custo (SurgeMan®) foi desenvolvido no Brasil. Nosso objetivo primário foi determinar se o SurgeMan® é adequado de acordo com o grau de satisfação dos alunos e instrutores do programa ATLS® quando comparado com o modelo TraumaMan® e o modelo animal, que são os atualmente aprovados para os procedimentos cirúrgicos do curso. Nosso objetivo secundário foi determinar se os índices de satisfação do usuário para SurgeMan® são superiores a 80%. **Métodos:** Foi realizado um estudo cruzado prospectivo com três modelos. Foram utilizados os modelos: SurgeMan® (SMan), TraumaMan® (TMan) e um modelo animal (suínos da raça Landrace). Uma amostra de conveniência de 36 estudantes candidatos a alunos do curso ATLS® foi alocada em nove grupos de quatro alunos e monitorados por um instrutor durante toda a estação de atividades cirúrgicas. Cada grupo participou de todas as atividades cirúrgicas em cada um dos três modelos. Os procedimentos realizados foram: drenagem pleural, cricotireoidostomia, pericardiocentese e lavagem peritoneal diagnóstica (DPL). Os testes psicométricos foram concluídos com os alunos e instrutores preenchendo um questionário com escala de Likert na conclusão de cada atividade. Os estudantes e instrutores também foram questionados sobre a adequação dos modelos para a realização da prática de atividades cirúrgicas do curso ATLS®, se eles substituiriam ou não o modelo animal pelo SurgeMan® ou pelo TraumaMan® e sobre suas preferencias de modelo considerando aspectos éticos e financeiros e sem levar estes em consideração. **Resultados**: O modelo animal e TraumaMan® tiveram desempenho melhor do que SurgeMan® para todas as habilidades, exceto pericardiocentese, onde não houve diferença estatística entre os modelos (Anova para medidas repetidas). Quando fatores éticos e financeiros não foram levados em consideração: 58% dos alunos e 66% dos instrutores escolheram o modelo animal. Quando os fatores éticos e financeiros foram considerados os modelos foram igualmente recomendados pelos alunos (SMan.33%, TMan 30%, Suínos 33%) e os instrutores escolheram o

SurgeMan® como primeira opção (SMan 66%, TMan 22%, Suínos 11%). Para a adequação de cada modelo para o aprendizado de habilidades no ATLS®, os alunos consideraram todos adequados (81% S.Man; 94% T.Man; 86% suínos; p = 0,184) e os instrutores consideraram apenas o modelo animal abaixo de 80% (SMan 88%, TMan 100%, Suínos 77%). **Conclusão:** TraumaMan® teve desempenho melhor do que SurgeMan® na maioria dos procedimentos. Os alunos consideram que tanto TraumaMan® quanto SurgeMan® são aceitáveis para a aprendizagem das habilidades cirúrgicas do ATLS®.

Descritores: cuidados de suporte avançado de vida no trauma; educação; treinamento por simulação; modelos anatômicos; modelos animais; procedimentos cirúrgicos operatórios.

1 Introduction

1 INTRODUCTION

For many years, trauma has been one of the biggest burdens on global care. It is estimated that 16,000 people die from injuries every day and several thousand more have some kind of sequelae [(1)]. Decreasing the number of deaths and injuries globally has been a major goal of many organizations worldwide. The United Nations and the World Health Organization (WHO) have developed a project called “Improving Global Road Safety". One of the goals of the initiative is to reduce global road traffic deaths and injuries by 50% by 2020. The World Health Organization (WHO), in partnership with the International Association for Trauma Surgery and Intensive Care (IATSIC), also published “The Guidelines for Essential Trauma Care” in 2004 [(1)]. This publication aims to improve trauma care globally, especially in middle- and low-income countries through some, mostly inexpensive, improvements in Trauma Care Facilities and Trauma Systems.

One suggested method of improving trauma patients’ care around the globe is through standardized trauma training. For example, Ali et al. [(2, 3)] has shown that a regular two-day course, Advanced Trauma Life Support (ATLS®), for doctors that provide care for trauma patients at a hospital in Trinidad (a low-income country) had increased the correct use of several therapeutic modalities, such as endotracheal intubation and early insertion of chest tubes in patients with severe chest injuries, compared to the period before such widespread trauma training. They also evaluated the effect on mortality rate and found a substantial decrease in patients with an injury severity score of 16 or higher, from 67% to 34%, after most of the doctors had been ATLS® -certified. The WHO supports the ATLS® course as an option to be taught in high-, middle-, and low-income countries [(1)].

The ATLS® course was developed in Nebraska in 1978. An orthopedic surgeon, Dr. James Styner, who had an airplane crash in a rural area of

Nebraska with his wife and 2 children, initiated it. His wife died at the scene and he and his children were taken to a rural hospital in the area. The primary care that they received at that facility was very poor. After that episode, he contacted the American College of Surgeons (ACS) and they began to develop the course [(4)]. It is currently the longest standing course worldwide and is taught in more than 60 countries [(1-3, 5)], including many with cultural and financial differences. The full course lasts 2 days, includes interactive lectures and practical skills stations. The target audience is doctors and physician assistants. An important part of the course is the Surgical Skills Station that consists of teaching the students basic emergency procedures, which include cricothyroidotomy, tube thoracotomy, diagnostic peritoneal lavage, and pericardiocentesis [(6)]. Currently, there are 4 approved models for that station, live animals, artificial manikins, human cadavers, and animal cadavers [(7)].

The majority of the teaching sites in the United States use the TraumaMan® [(8, 9)]. It is a high fidelity, high cost, artificial manikin (TraumaMan® -SIMULAB USA 13001 48th Avenue S Seattle, WA - USA), designed for teaching cricothyroidotomy, chest tube insertion, pericardiocentesis, needle decompression, and diagnostic peritoneal lavage. It has an anatomically similar form to the human body and includes a simulated human with 4 anatomically correct surgical zones. Its replaceable tissues give each student a "first cut" experience. The TraumaMan® system was evaluated and approved by the American College of Surgeons in 2001 as an alternative to live non-human models or cadavers for ATLS® [(8, 9)].

Alternatively, some international sites, especially in low-income countries, use animals, because the TraumaMan® costs in those countries are much higher than using animals. Most sites use live pigs for performing the surgical skills stations. Other animals used include dogs and rabbits. Some sites in low-income countries use animal cadavers for training. Some of those sites have had issues with animal protective societies that may make it impossible to continue to use live animals for ATLS® surgical skills training. In addition, the use of animals in education or research mandates the implementation of the 3Rs, refinement, reduction, and replacement [(10)]. A Brazilian company has developed a low-cost manikin for ATLS® courses, the SurgeMan® (Medical Training Models; Rua Professor Ivo Corseuil, 304 Porto Alegre - RS | Brasil). The cost of this model can be almost 10 times less than TraumaMan® in some middle- and low-income countries. It is designed for teaching cricothyroidotomy, chest tube insertion, pericardiocentesis, needle decompression, and diagnostic peritoneal lavage. The replacement parts are different for each one of the procedures and can be changed separately, as, unlike the TraumaMan®, it does not have an artificial skin covering the whole model.

The TraumaMan® has been used for many years in the United States and has replaced live animals in the vast majority of ATLS® sites there. However, financial constraints would make that same alternative not possible in lower income countries. In that context, a lower cost manikin, such as SurgeMan®, may be a more accessible option.

2 Objectives

2 OBJECTIVES

Our primary objective was to determine whether the SurgeMan® would have equivalent learner and instructor satisfaction compared with the currently approved TraumaMan® and animal models for the surgical procedures of ATLS®, using a self-assessment questionnaire (Table 2). Our secondary objectives were to determine whether user satisfaction scores for the SurgeMan® would have an 80% acceptance rate (increase of 30% over a proportion of 50% preference) among the participants, and to evaluate students and instructors' opinions on the artificial models as substitutes for the animal model.

3 Methods

3 METHODS

A prospective crossover study was undertaken at the ATLS® site of the University of São Paulo Medical School in Brazil, after approval by the Ethical Committee for Research Projects of the Hospital das Clínicas University of São Paulo and according to the American College of Surgeons “Policies, Procedures, and Protocols for the Surgical Skills Practicum” of the ATLS® Course. A convenience sample of 36 doctors who had not taken the ATLS® course yet, but were future candidates for taking an ATLS® course, and 9 experienced instructors with an active status, according to the Committee on Trauma of the American College of Surgeons, were included in the study. Informed consent was obtained for all participants. The sample was calculated estimating a 30% relevant difference in preference rate of the 45 participants. We used Pearson's chi-squared test for two-sample proportions with a $P = 0.05$ and a power of 80%. We did not increase the power or the estimated difference to avoid increasing the number of animals necessary for the study.

We randomly assigned the doctors to 9 groups (Groups A–I), each one with 4 students and 1 instructor. We had 3 turns of 3 rotations each. In each one of the 3 rooms, we had a different manikin. The same instructor monitored the students during the entire practical activity. The total time of each skills station is 60 minutes with a 10-minute break between rotations. Procedures included in the skills station were cricothyroidotomy, tube thoracostomy, pericardiocentesis, and diagnostic peritoneal lavage.

Providers performed all the procedures on the 3 models included in the study, 2 artificial models, TraumaMan® (Figure 1 - 2) and SurgeMan® (Figure 3 - 4), and an animal model (Figure 5). Simulab Corporation (SIMULAB USA 13001 48th Avenue S Seattle, WA – USA) provided TraumaMan® and its replacement parts and MTM (Medical Training Models; Rua Professor Ivo Corseuil, 304 Porto Alegre - RS | Brasil) provided SurgeMan® and its replacement parts. Animals were under anesthesia and monitored by a veterinarian during all the procedures. Costs of the animal model simulation were covered by the Brazilian Committee on Trauma of the American College of Surgeons. Nine female Landrace pigs were used (1 animal per rotation), weighing between 10 and 12 kilograms and aged between 2 and 3 months. They were submitted to fasting for 12 hours, without solid food, but with free access to water. Physical examination was performed to evaluate the pigs for any anomalies, which would endanger the study. No animal was excluded. The animals were sedated before the procedure with ketamine and midazolam intramuscularly and induced with propofol intravenously. They underwent endotracheal intubation and mechanical ventilation with the following initial parameters: Tidal volume 27 (Vt) = 12 mL/kg, respiratory rate (RR) = 15 breaths/min and positive end-expiratory pressure (PEEP) = 3 cmH_2O.

All students performed all of the 4 procedures on the artificial models. After each student performed the procedure, the instructors changed the replaceable parts so every student would use a new piece and perform all the techniques from the beginning, simulating a skin incision. Only 1 student per rotation performed the cricothyroidotomy on each live animal, as, in that model, it cannot be done more than 1 time. Two students performed the diagnostic peritoneal lavage (DPL) on the animal model simultaneously (surgeon and assistant) and all 4 students performed chest tube insertion with 2 incisions in each hemithorax of the animals.

Group rotation was randomly assigned. Some groups performed first on the animal model and others on an artificial model according to the schedule in Table 1.

We collected information about the instructors and students' graduation and post-graduation status, demographic data, specialization, and field of practice (public or private).

Psychometric testing was completed by having students and instructors fill out a Likert Scale [11] (5 - excellent, 4 - good, 3 - satisfactory, 2 - poor, 1 -

very poor) at the completion of each activity, with questions about the efficacy of the models for the learning of each one of the procedures. The participants were also queried about the adequacy and their recommendation of the artificial models as substitutes for the animal model, about which model they would choose, with and without ethical and financial issues, and if they thought that the models were adequate or not for teaching the ATLS® Surgical Skills station.

3.1 Statistical analysis

The answers based on the Likert Scale were divided into 3 groups for statistical analysis: 1 - excellent/good, 2 – satisfactory, and 3 - poor/very poor. This division was necessary due to the very small number of answers in 2 groups (excellent and very poor) that made their individual statistical analysis not significant. The groups were compared using the model for estimation of generalized equations and their means were compared by ANOVA for repeated measures. For categorical yes/no questions, we used the Fisher exact test. For answers with more than two possible options, we used the likelihood-ratio test. We considered a $P = 0.05$ as statistically relevant.

Figure 1 - TraumaMan® (TraumaMan® - SIMULAB USA 13001 48th Avenue S Seattle, WA – USA)

Figure 2 - Group of students and instructor (white coat) during a practical station with artificial model TraumaMan®, performing a diagnostic peritoneal lavage (DPL)

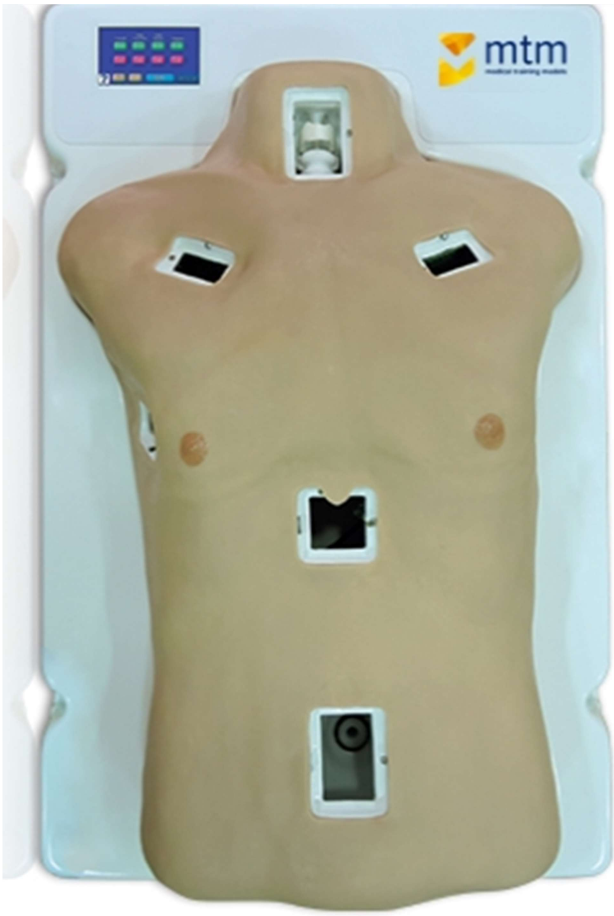


Figure 3 - SurgeMan® - (Medical Training Models; Rua Professor Ivo Corseuil, 304 Porto Alegre - RS | Brasil). Replacement parts were taken out to expose the procedure areas

Figure 4 - Group of students and instructor (white coat) during a practical station with SurgeMan®

Figure 5 - Group of students during a practical station with a live animal performing a tube thoracostomy. Animals were under anesthesia and monitored by a veterinarian (Wearing white and red striped shirt)

Table 1 - Group rotation occurred according to the following schedule: there were 4 students per group and the same instructor was with that group for all 3 models. The rotations were 60-minutes each with a 10-minute break between each

Rotation 1 (8:00 – 11:20 am)

	SurgeMan®	TraumaMan®	Animal
8:00–9:00 am	Group A	Group B	Group C
9:10–10:10 am	Group B	Group C	Group A
10:20–11:20 am	Group C	Group A	Group B

Rotation 2 (11:50 am – 3:10 pm)

	SurgeMan®	TraumaMan®	Animal
11:50am–12:50 pm	Group D	Group E	Group F
1:00–2:00 pm	Group E	Group F	Group D
2:10–3:10 pm	Group F	Group D	Group E

Rotation 3 (3:40 – 7:00 pm)

	SurgeMan®	TraumaMan®	Animal
3:40–4:40 pm	Group G	Group H	Group I
4:50–5:50 pm	Group H	Group I	Group G
6:00–7:00 pm	Group I	Group G	Group H

Table 2 - Questionnaires were filled out by the students and instructors after they completed all 3 activities using the Likert Scale of Procedures for the scaling of the responses

Questionnaires for SurgeMan®, TraumaMan®, and Animal model comparison —*For Faculty and Students*

Questionnaire 1 - For the surgical procedures, please rate the effectiveness of the model in learning and teaching the skill using the following Likert Scale (1 - Very Poor, 2 - Poor, 3 - Satisfactory, 4 - Very Good, 5 - Excellent)

ATLS® skills: Animal model

	Very Poor (1)	Poor (2)	Satisfactory (3)	Very Good (4)	Excellent (5)
Chest Tube					
Pericardiocentesis					
DPL					
Cricothyroidotomy					

ATLS® skills: TraumaMan® model

	Very Poor (1)	Poor (2)	Satisfactory (3)	Very Good (4)	Excellent (5)
Chest Tube					
Pericardiocentesis					
DPL					
Cricothyroidotomy					

ATLS® skills: SurgeMan® model

	Very Poor (1)	Poor (2)	Satisfactor y (3)	Very Good (4)	Excellent (5)
Chest Tube					
Pericardiocentesis					
DPL					
Cricothyroidotomy					

Questionnaire 2: Suitability of Models

1. Recognizing the concerns for using animal models for learning and teaching surgical skills and the need to find a suitable non-animal model for ATLS® skills, please rate the degree to which you think the SurgeMan® and TraumaMan® models are suitable.

Scores

	1	2	3	4
TraumaMan®				
SurgeMan®				

2. General recommendation:

Would you recommend TraumaMan® as a substitute for the animal model?

Yes ☐ Neutral ☐ No ☐

Would you recommend SurgeMan® as a substitute for the animal model?

Yes ☐ Neutral ☐ No ☐

3. Overall, if there were no ethical, financial, or animal model concerns, which model would you recommend?

Animal ☐ TraumaMan® ☐ SurgeMan ® ☐ No preference ☐

4. Overall, considering all factors, financial, ethical, and animal rights concerns, which model would you recommend?

Animal ☐ TraumaMan® ☐ SurgeMan® ☐ No preference ☐

5. Overall, indicate suitability (yes/no) for ATLS® skills teaching and learning.

Animal Yes ☐ No ☐

SurgeMan® Yes ☐ No ☐

TraumaMan® Yes ☐ No ☐

General Comments (use additional page if needed):

4 Results

4 RESULTS

The information on participants' graduation and post-graduation status, specialty and clinical practice are shown in Table 3. Most students and instructors were from the state of São Paulo with 1 instructor from the state of Amazonas. Instructors had graduated more than 5 years before the study and all students less than 5 years before. Most of the students (95%) and instructors (66%) graduated from a public University. All instructors and 72% of the students did a residency in general surgery. 78% of the students and 89% of the instructors did their residency in a public hospital and 58% of the students and 78% of the instructors worked at a public hospital at the time of the study.

The participants' answers about the adequacy of each model for the procedures are shown in Graphics 1–8 and Tables 4–11 and are divided by procedure.

4.1 Tube thoracostomy comparisons of models divided by students and instructors (Graphics 1–2 and Tables 4–5)

Students had more “Very good/excellent” ratings for the animal (83%) and for the TraumaMan® (83%), than for the SurgeMan® (25%), for tube thoracostomy. The SurgeMan®, TraumaMan®, and animal model were considered ”regular” by 50%, 17%, and 8% of the students, respectively. No student found the TraumaMan® “bad/very bad,” however, 8% and 25% considered the animal and the SurgeMan® “bad/very bad,” respectively. All instructors considered TraumaMan® as “very good/excellent” for chest tube insertion, 67% rated the animal model as such, and 11% rated the SurgeMan® “very good/excellent.” 78% of the faculty considered the SurgeMan® “regular” and 33% had the same opinion about the animal model. Only 1 instructor considered the SurgeMan® “bad/very bad.”

The analysis of the difference between models, instructors and students’ opinions, and the relationship between model and opinions for tube thoracostomy is shown in Table 4. The difference between the SurgeMan® and the TraumaMan® (*P* < 0.001) and the SurgeMan® and the animal model (*P* = 0.002) were significant. We found no difference between the TraumaMan® and the animal model (*P* = 0.321).

Opinions of instructors and students were different only when comparing the SurgeMan® and the animal model with more “regular” for instructors about SurgeMan® and about the animal model and more “very good/excellent” for the animal model among students (*P* = 0.008).

The relationship between models and student/instructor opinion was not significant between the SurgeMan® and the animal model (independent result). The other 2 comparisons were influenced by the difference in opinions of students and instructors.

When comparing means of the Likert Scale of all participants there was no difference (*P* = 1.00) between the means of the animal model (4.14) and the TraumaMan® (4.09) and both were better (*P* = 0.001) than the SurgeMan® (3.03) (Table 5).

4.2 Pericardiocentesis comparison of models divided by students and instructors (Graphics 3–4 and Tables 6–7)

Students had more “very good/excellent” responses for the animal (61%) than for the TraumaMan® (44%) and for the SurgeMan® (44%). The TraumaMan® was considered “regular” by 50% of the students, SurgeMan® by 47% and the animal by 22%. 6% of the students found the TraumaMan® “bad/very bad,” 17% considered the animal and 8% the SurgeMan® “bad/very bad.” 89% of instructors considered the TraumaMan® as “very good/excellent” for pericardiocentesis, 44 % for the animal model, and 44% for the SurgeMan®. 56% of the faculty considered the SurgeMan® “regular,” 22% had the same opinion about the animal model and 11% for the TraumaMan®. No instructor considered the SurgeMan® or the TraumaMan® “bad/very bad” and 3 instructors found the animal model “bad/very bad.”

The analysis of the difference between models, instructors and students’ opinions, and relationship between models and opinions for pericardiocentesis is shown in Table 6. The difference between the SurgeMan® and the TraumaMan® (P = 0.025) was significant. We found no difference between the TraumaMan® and the animal model (P = 0.081) or the SurgeMan® and the animal model (P = 0.24).

The opinions of the instructors and the students were different only when comparing the SurgeMan® and the TraumaMan® (P = 0.016).

The relationship between the models and student/instructor opinion was significant between the SurgeMan® and TraumaMan® (P = 0.029). The other 2 comparisons were influenced by the opinions of students and instructors. When comparing means of the Likert Scale of all participants, there was no difference (P > 0.05) between the means of the models (Table 7).

4.3 Diagnostic Peritoneal Lavage comparisons of models divided by students and instructors (Graphics 5–6 and Tables 8–9)

The students had more “very good/excellent” ratings for the animal model (86%) than for the TraumaMan® (81%) and for the SurgeMan® (28%). The TraumaMan® was considered “regular” by 17% of the students, the SurgeMan® by 44% and the animal model by 6%. 3% of the students found the TraumaMan® “bad/very bad,” 8% considered the animal model and 10% the SurgeMan® “bad/very bad.” 89% of instructors considered TraumaMan® as very “good/excellent” for DPL, 78% for the animal, and 22% for SurgeMan®. 67% of the faculty considered the SurgeMan® “regular,” 22% had the same opinion about the animal and 11% about the TraumaMan®, respectively. No instructor considered the animal model or the TraumaMan® “bad/very bad” and one instructor (11%) found the SurgeMan® “bad/very bad.”

The analysis of the difference between models, instructors and students’ opinions, and the relationship between model and opinions for DPL is shown in Table 8. The difference between the SurgeMan® and TraumaMan® (P < 0.001) and the SurgeMan® and the animal model (P < 0.001) was significant. We found no difference between the TraumaMan® and the animal model (P = 0.186).

Opinions of instructors and students were not different when comparing the models. The relationship between models and student/instructor opinion was not significant between the 3 models of the study.

When comparing means of the Likert Scale of all participants, there was significant difference (P < 0.001) between the means of the 3 models (Table 9). The animal model score was 4.39, TraumaMan® 3.92, and SurgeMan® 2.94.

4.4 Cricothyroidotomy comparison of models divided by students and instructors (Graphics 7–8 and Tables 10–11)

The students had more “very good/excellent” responses for the TraumaMan® (64%) than for the animal model (50%) and for the SurgeMan® (28%). The TraumaMan® was considered “regular” by 31% of the students, SurgeMan® by 42%, and the animal model by 19%. 6% of the students found the TraumaMan® “bad/very bad,” 31% considered the animal model and 31% SurgeMan® “bad/very bad.” 78% of instructors considered the TraumaMan® as very “good/excellent” for cricothyroidotomy, 22% rated the animal model “good/excellent,” and 33% gave the SurgeMan® this rating. 44% of the faculty considered SurgeMan® “regular,” 56% had the same opinion about the animal model, and 22% gave the TraumaMan® that rating. No instructor considered the TraumaMan® “bad/very bad” and 2 instructors (22%) found the SurgeMan® and the animal model “bad/very bad.”

The analysis of the difference between models, instructors and students’ opinions, and the relationship between model and opinions for crycothyroidotomy is shown in Table 10. The difference between the SurgeMan® and the TraumaMan® (*P* = 0.04) was significant. We found no difference between the TraumaMan® and the animal model (*P* = 0.948) or the SurgeMan® and the animal model (*P* = 0.60).

The opinions of the instructors and the students were not different when comparing the models. The relationship between models and student/instructor opinion was not significant between the 3 models of the study.

When comparing means of the Likert Scale of all participants there was no difference (*P*=0.704) between the means of the animal model (3.37) and the SurgeMan® (3.0). The TraumaMan® mean (3.8) was significantly higher than the SurgeMan® (*P* = 0.004) and the animal model (*P* = 0.016, Table 11).

4.5 Suitability of the models

We asked the participants to classify the adequacy of the SurgeMan® and the TraumaMan®, given the restrictions on the use of animal models. The TraumaMan® had 53% “excellent,” 31% “very acceptable,” 11% “acceptable,” and 3% “inadequate” ratings by students’ opinions. The SurgeMan® had 11% “excellent,” 44% “very acceptable,” 33% “acceptable,” and 8% “inadequate” ratings by students’ opinions (Graphic 9).

The rating of the instructors about the same question was that the TraumaMan® was 89% “excellent” and 11% “very acceptable.” The SurgeMan® was rated 11% “excellent,” 67% “very acceptable,” and 22% “acceptable” by the instructors (Graphic 10). After statistical analysis, we found no difference between the scores (*P* = 0.454) of the models or between students and instructors’ opinions (*P* = 929) (Tables 12–13).

4.6 Recommendation of the models for the ATLS® course

Students and instructors were queried if they would recommend the SurgeMan® or TraumaMan® as substitutes for the animal model. 33% (12) of the students and 44% (4) of the instructors recommended the SurgeMan® and 64% (23) of the students and 89% (8) of the instructors recommended the TraumaMan® as substitutes for the animal model (Graphic 11–12). We did not find a significant difference between the opinions of the students and instructors (P = 0.109). There was a stronger recommendation for TraumaMan® compared to SurgeMan® ($P < 0.001$) (Table 14).

We asked the participants which model they would recommend for the course with no considerations to ethical and financial issues (Graphic 13–14). 62% of the students chose the animal model, 30% the TraumaMan®, and 8% the SurgeMan®. 67% of the instructors chose the animal model, 33% the TraumaMan®, and no instructor chose the SurgeMan®.

The same question was asked, with the participants considering ethical and financial issues (Graphic 15–16). In this case, 33% of the students chose the SurgeMan®, 31% the TraumaMan®, and 33% the animal model; and 67% of the instructors chose the SurgeMan®, 22% the TraumaMan®, and 11% the animal model.

4.7 Adequacy of each model for the ATLS® course

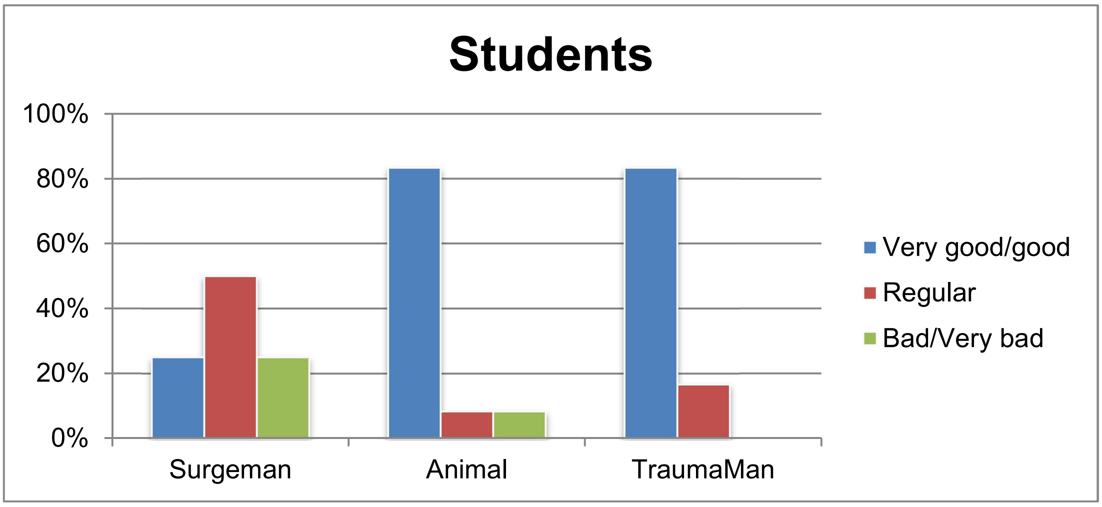
We asked the participants to indicate the suitability of each model for ATLS® skills teaching and learning. 94% of the students found the TraumaMan® adequate, 81% found the SurgeMan® adequate, and 86% found the animal model adequate. The instructors' opinion was 100% for the TraumaMan®, 89% for the SurgeMan®, and 78% for the animal model. There was no difference between instructors and students' opinions (*P* = 0.184)(Table 14).

Table 3 - Students and instructors' demographic data, graduation, and post-graduation status

Participants' information	Student	Instructor	Total
City			
Without information	11 (30.6)	1 (11.1)	12 (26.7)
Manaus	0 (0)	1 (11.1)	1 (2.2)
Santo André	1 (2.8)	0 (0)	1 (2.2)
São Paulo	23 (63.9)	7 (77.8)	30 (66.7)
Sorocaba	1 (2.8)	0 (0)	1 (2.2)
Total	36 (100)	9 (100)	45 (100)
State			
Without information	11 (30.6)	1 (11.1)	12 (26.7)
AM	0 (0)	1 (11.1)	1 (2.2)
SPA	25 (69.4)	7 (77.8)	32 (71.1)
Total	36 (100)	9 (100)	45 (100)
Graduation University			
Without information	0 (0)	1 (11.1)	1 (2.2)
Public	34 (94.4)	6 (66.7)	40 (88.9)
Private	2 (5.6)	2 (22.2)	4 (8.9)
Total	36 (100)	9 (100)	45 (100)
Did residency			
No	8 (22.2)	0 (0)	8 (17.8)
Yes	26 (72.2)	9 (100)	35 (77.8)
Residency hospital			
Without information	0 (0)	1 (11.1)	1 (2.7)
Public	28 (77.8)	8 (88.9)	36 (97.3)
Total	28 (100)	9 (100)	37 (100)

Tube thoracostomy comparison of models divided by students and instructors

Graphic 1 - Students' answers for tube thoracostomy, based on Likert Scale



Graphic 2 - Instructors' answers for tube thoracostomy, based on Likert Scale

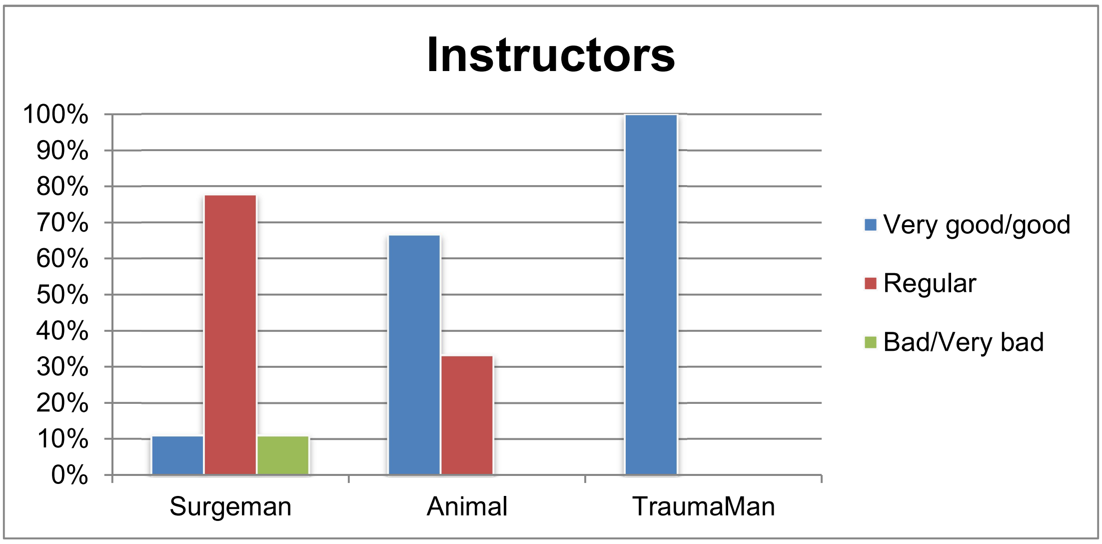


Table 4 - Likert scale results per model and difference in opinion for tube thoracostomy according to model difference and student/faculty opinion

Students	**SurgeMan®**	**Animal model**	**TraumaMan®**
Very good/good	9 (25%)	30 (83%)	30 (83%)
Regular	18 (50%)	3 (8%)	6 (17%)
Bad/Very bad	9 (25%)	3 (8%)	0

Instructors	**SurgeMan®**	**Animal model**	**TraumaMan®**
Very good/good	1 (11%)	6 (67%)	9 (100%)
Regular	7 (78%)	3 (33%)	0
Bad/Very bad	1 (11%)	0	0

Statistical Analysis	**SMan/TMan**	**SMan/Animal**	**TMan/Animal**
Model	$P < 0.001$	$P = 0.002$	$P = 0.321$
Student/Instructor	$P = 0.743$	$P = 0.008$	$P = 0.399$
Model x Student/Instructor	$P = 0.001$	$P = 0.962$	$P = 0.004$

According to the results in Table 4, at the level of significance of 5 %, there is a significant difference between the SurgeMan® and the other 2 models, but no difference between the TraumaMan® and the animal model. SMan: SurgeMan®; TMan: TraumaMan®; Animal: Animal model.

The student/instructor opinion was different in the SurgeMan®/Animal with more “regular” for instructors regarding the SurgeMan® and animal model and more “very good/excellent” for the animal model among students.

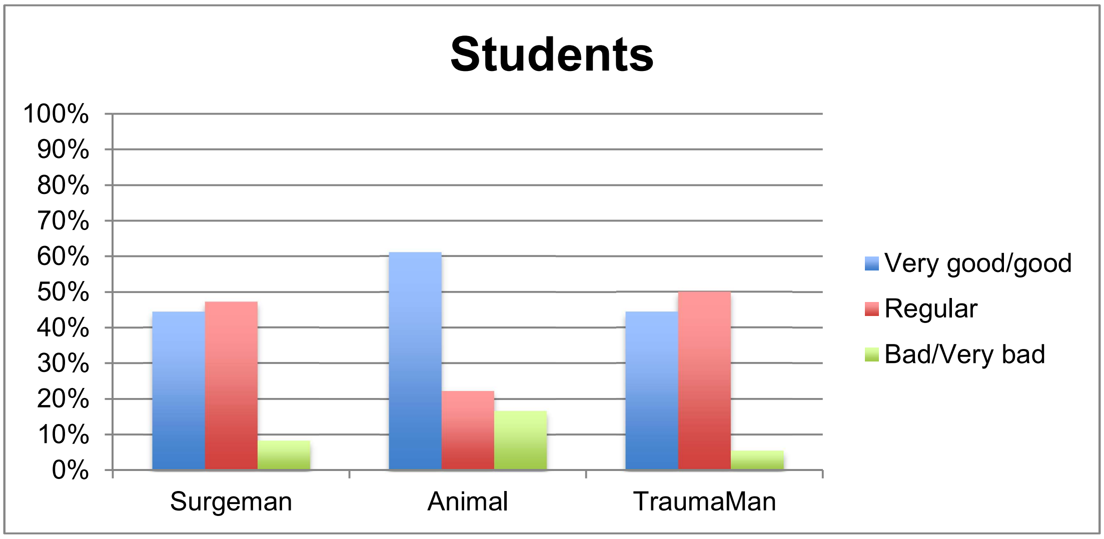
The relationship between models and student/instructor opinion was not significant between SurgeMan®/Animal (independent result). The other 2 comparisons were influenced by the difference in opinions of students and instructors.

Table 5 - Comparison of means of Likert Scale of students' opinions for tube thoracostomy per model

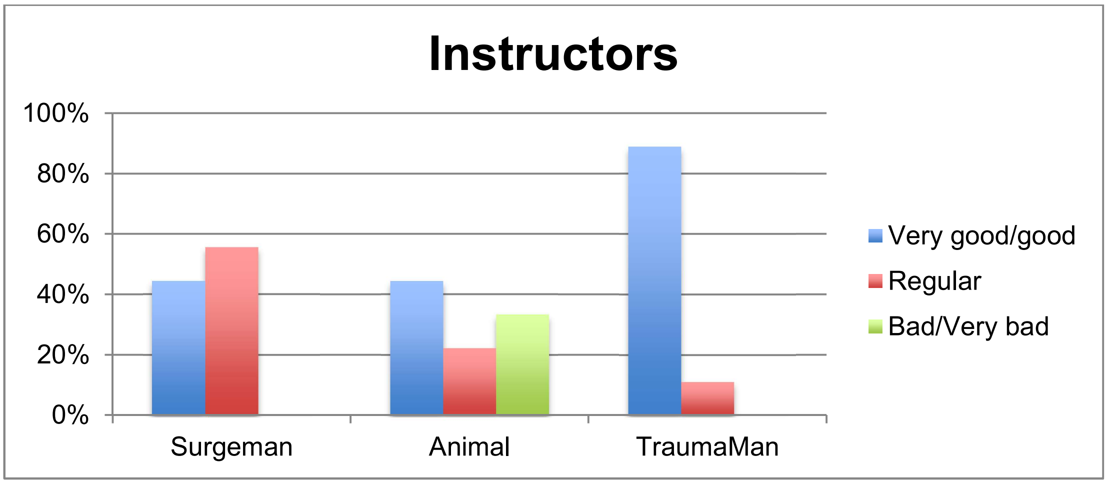
	Tube thoracostomy – Mean (SD)	
TraumaMan®	4.09 (0.66)	TraumaMan® vs SurgeMan®: $P < 0.001$
SurgeMan®	3.03 (0.89)	SurgeMan® vs Animal model: $P = 0.001$
Animal model	4.14 (0.91)	TraumaMan® vs Animal model: $P = 1.00$

Pericardiocentesis comparison of models divided by students and instructors

Graphic 3 - Students' answers based on Likert Scale for Pericardiocentesis



Graphic 4 - Instructors' answers based on Likert Scale for pericardiocentesis



Pericardiocentesis comparison of models divided by students and instructors

Table 6 - Likert scale results per model for pericardiocentesis and statistical analysis of the difference in opinion by procedure according to model difference and student/instructor opinion for pericardiocentesis

Students	**SurgeMan®**	**Animal Model**	**TraumaMan®**
Very good/good	16 (44%)	22 (61%)	16 (44%)
Regular	17 (47%)	8 (22%)	18 (50%)
Bad/Very bad	3 (8%)	6 (17%)	2 (6%)

Instructors	**SurgeMan®**	**Animal Model**	**TraumaMan®**
Very good/good	4 (44%)	4 (44%)	8 (89%)
Regular	5 (56%)	2 (22%)	1 (11%)
Bad/Very bad	0	3 (33%)	0

Statistical Analysis	**SMan/TMan**	**SMan/Animal**	**TMan/Animal**
Model	$P = 0.025$	$P = 0.24$	$P = 0.081$
Student/Instructor	$P = 0.016$	$P = 0.66$	$P = 0.314$
Model Student/Instructor	$P = 0.029$	$P = 0.50$	$P = 0.067$

According to the results in Table 6, at the level of significance of 5 %, there is a significant difference between SurgeMan® /TraumaMan® and TraumaMan®/Animal. There was no statistical difference between student/instructor opinion.

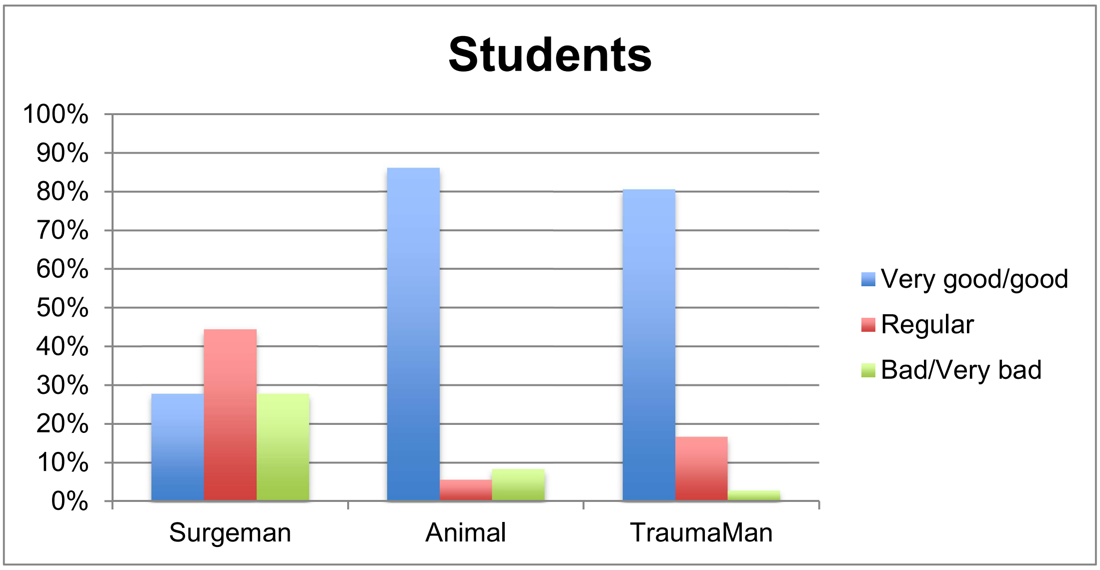
The relationship between the models and student/instructor opinion was significant between SurgeMan®/Animal model. The other 2 comparisons were not influenced by the difference in opinions of students and instructors. SMan: SurgeMan®; TMan: TraumaMan®; Animal: Animal model.

Table 7 - Comparison of means of Likert Scale of students' opinions for pericardiocentesis per model.

	Pericardiocentesis – Mean (SD)	Comparison
TraumaMan®	3.51 (0.82)	TraumaMan® vs SurgeMan®: *P* = 0.804
SurgeMan®	3.46 (0.82)	SurgeMan® vs Animal model: *P* = 0.75
Animal model	3.76 (1.1)	TraumaMan® vs Animal model: *P* = 0.09

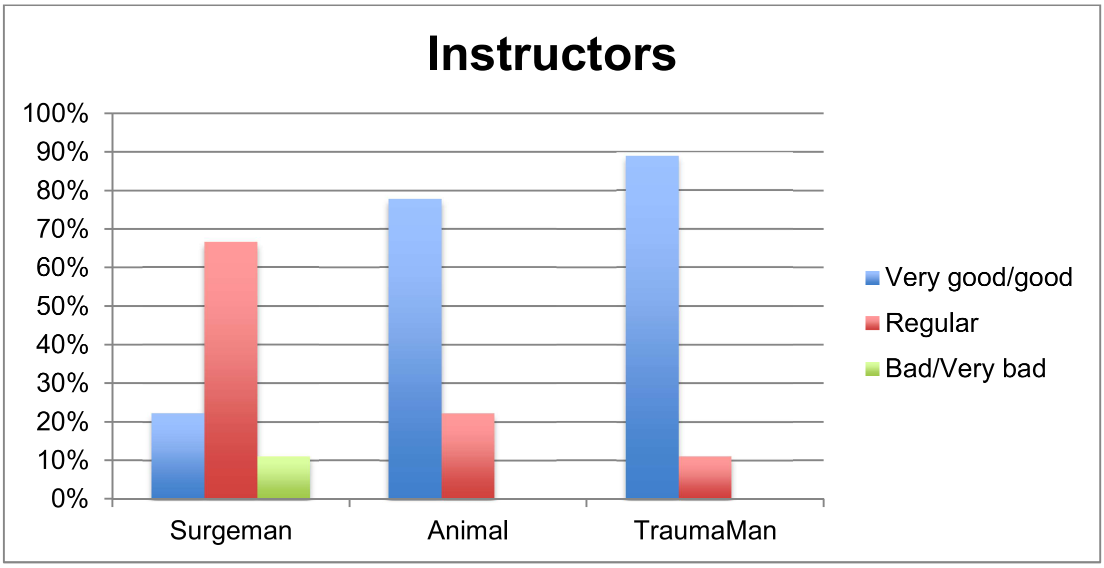
Diagnostic Peritoneal Lavage comparison of models divided by students and instructors

Graphic 5 - Students' answers based on Likert Scale for DPL



DPL: diagnostic peritoneal lavage

Graphic 6 -Instructors' answers based on Likert Scale for DPL



DPL: diagnostic peritoneal lavage

Diagnostic Peritoneal Lavage comparison of models divided by students and instructors

Table 8 - Likert scale results per model and difference in opinion by procedure, for DPL, according to model difference and student/instructor opinion

Students	**SurgeMan®**	**Animal model**	**TraumaMan®**
Very good/good	10 (28%)	31 (86%)	29 (81%)
Regular	16 (44%)	2 (6%)	6 (17%)
Bad/Very bad	10 (28%)	3 (8%)	1 (3%)

Instructors	**SurgeMan®**	**Animal model**	**TraumaMan®**
Very good/good	2 (22%)	7 (78%)	8 (89%)
Regular	6 (67%)	2 (22%)	1 (11%)
Bad/Very bad	1 (11%)	0	0

Statistical Analysis	**SMan/TMan**	**SMan/Animal**	**TMan/Animal**
Model	$P < 0.001$	$P < 0.001$	$P = 0.186$
Student/Instructor	$P = 0.89$	$P = 0.486$	$P = 0.207$
Model - Student/Instructor	$P = 0.33$	$P = 0.902$	$P = 0.312$

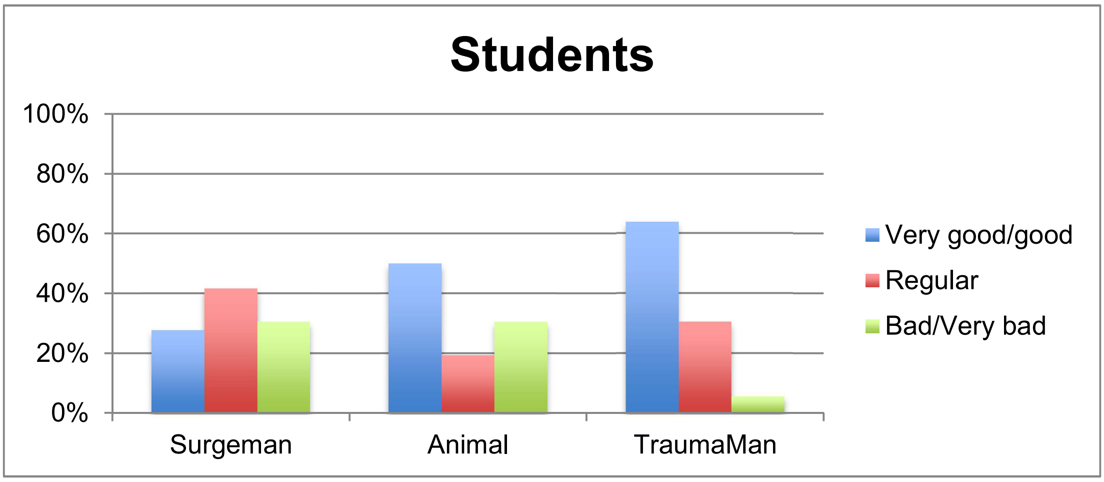
According to the results in Table 8, at the level of significance of 5%, there is a significant difference between SurgeMan®/TraumaMan® and SurgeMan®/Animal. There was no statistical difference between student/instructor opinion. The relationship between models and student/instructor opinion did not influence the results of the comparisons between models. SMan: SurgeMan®; TMan: TraumaMan®; Animal: Animal model.

Table 9 - Comparison of means of Likert Scale of students' opinions for DPL per model

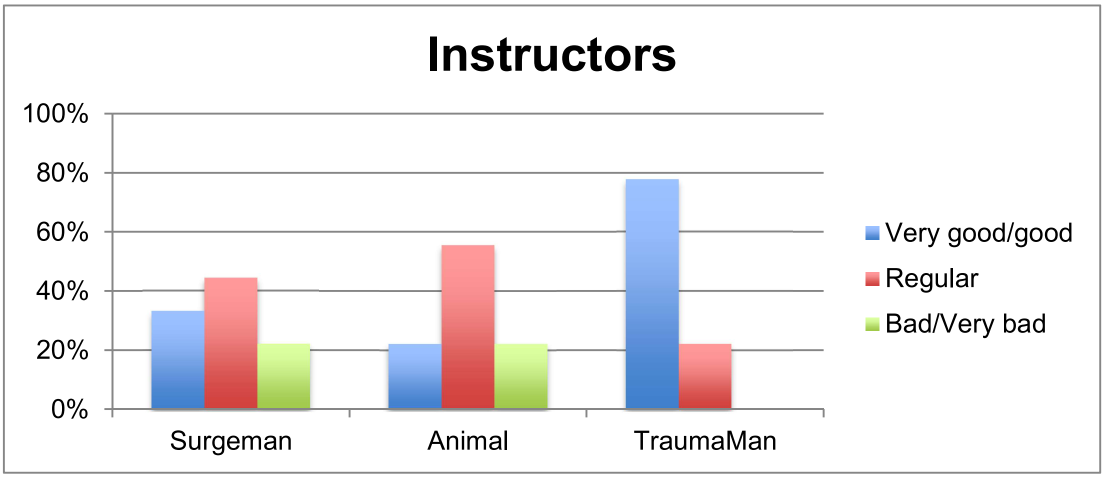
	DPL – Mean (SD)		
TraumaMan®	3.92 (0.65)		
		P < 0.001	P=0.028
SurgeMan®	2.94 (0.86)		
		P < 0.001	
Animal model	4.39 (0.93)		

Cricothyroidotomy comparison of models divided by students and instructors

Graphic 7 - Students' answers based on Likert Scale for cricothyroidotomy



Graphic 8 - Instructors' answers based on Likert Scale for cricothyroidotomy



Cricothyroidotomy comparison of models divided by students and instructors

Table 10 - Likert scale results per model and difference in opinion by procedure for crycothyroidotomy according to model difference and student/instructor opinion

Students	**SurgeMan®**	**Animal Model**	**TraumaMan®**
Very good/good	10 (28%)	18 (50%)	23 (64%)
Regular	15 (42%)	7 (19%)	11 (31%)
Bad/Very bad	11 (31%)	11 (31%)	2 (6%)

Instructors	**SurgeMan®**	**Animal Model**	**TraumaMan®**
Very good/good	3 (33%)	2 (22%)	7 (78%)
Regular	4 (44%)	5 (56%)	2 (22%)
Bad/Very bad	2 (22%)	2 (22%)	0

Statistical Analysis	**SMan/TMan**	**TMan/Animal**	**SMan/Animal**
Model	$P = 0.04$	$P = 0.948$	$P = 0.60$
Student/Instructor	$P = 0.43$	$P = 0.295$	$P = 0.11$
Model - Student/Instructor	$P = 0.70$	$P = 0.054$	$P = 0.15$

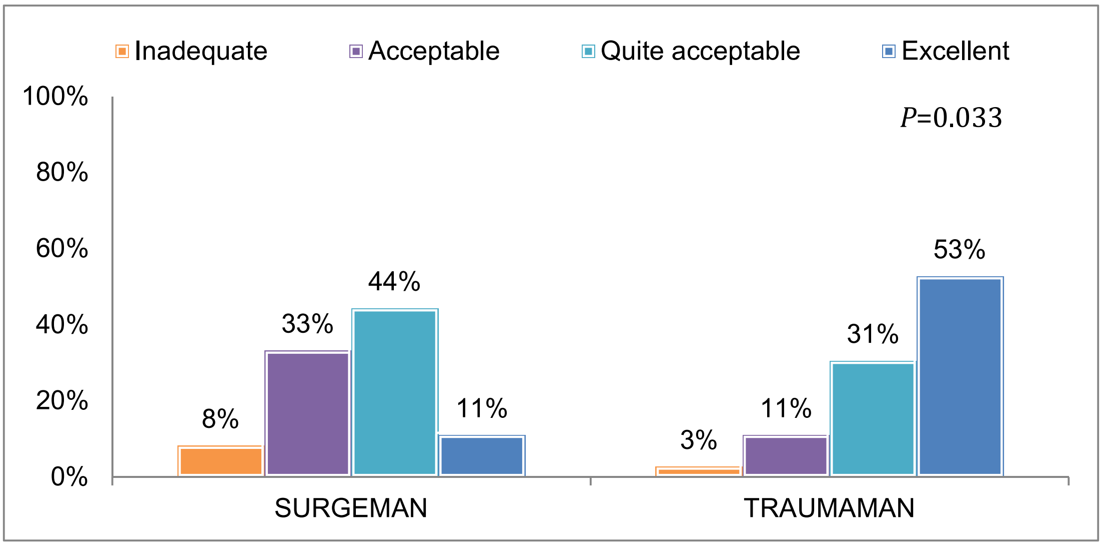
According to the results in Table 10, at the level of significance of 5%, there is a significant difference between SurgeMan®/TraumaMan®. There was no statistical difference between student/instructor opinion. The relationship between models and student/instructor opinion was not significant in the 3-model comparison. SMan: SurgeMan®; TMan: TraumaMan®; Animal: Animal model.

Table 11 - Comparison of means of Likert Scale of students' opinions for cricothyroidotomy per model

	Cricothyroidotomy – Mean (SD)		
TraumaMan®	3.8 (0.87)	P = 0.004	P=0.016
SurgeMan®	3.0 (1.03)	P = 0.704	
Animal Model	3.37 (1.26)		

Suitability of the artificial models

Graphic 9 - Students' opinion: Recognizing the concerns for using animal models for learning and teaching surgical skills and the need to find a suitable non-animal model for ATLS® skills, please rate the degree to which you think the SurgeMan® and TraumaMan® models are suitable, using the Likert Scale (not suitable - acceptable - very acceptable - excellent)



Suitability of the artificial models

Graphic 10 - Instructors' opinion: Recognizing the concerns for using animal models for learning and teaching surgical skills and the need to find a suitable non-animal model for ATLS® skills, please rate the degree to which you think the SurgeMan® and TraumaMan® models are suitable using the Likert Scale (not suitable - acceptable - very acceptable - excellent)

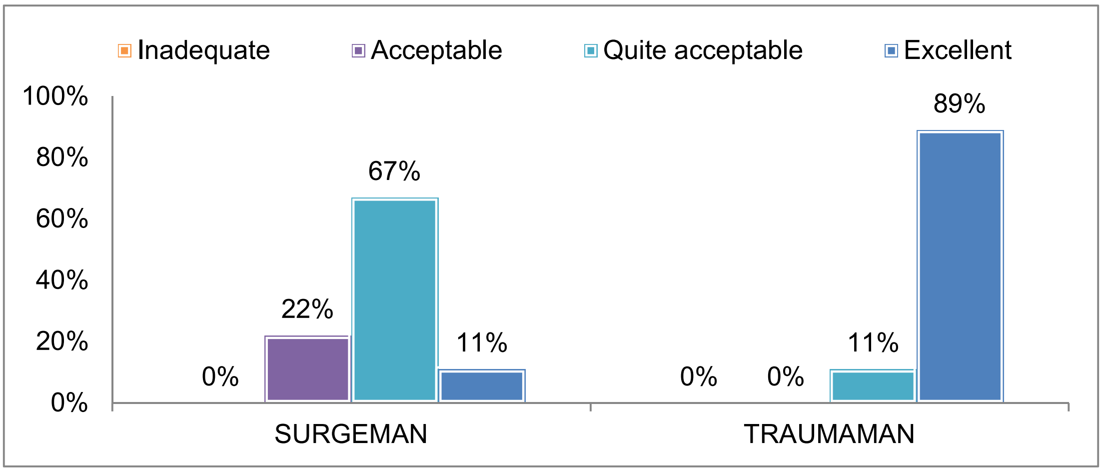


Table 12 - Comparison of scores of the models' suitability to the ATLS® course

Scores	Student	Instructor	Total	*P*
SurgeMan®				
1 - Inadequate	3 (8, 3)	0 (0)	3 (6, 7)	
2 - Acceptable	12 (33, 3)	2 (22, 2)	14 (31, 1)	
3 - Very Acceptable	16 (44, 4)	6 (66, 7)	22 (48, 9)	0.510
4 - Excellent	4 (11, 1)	1 (11, 1)	5 (11, 1)	
Total	36 (100)	9 (100)	45 (100)	
TraumaMan®				
1 - Inadequate	1 (2, 8)	0 (0)	1 (2, 2)	
2 - Acceptable	4 (11, 1)	0 (0)	4 (8, 9)	
3 - Very Acceptable	11 (30, 6)	1 (11, 1)	12 (26, 7)	0.180
4 - Excellent	19 (52, 8)	8 (88, 9)	27 (60)	
Total	36 (100)	9 (100)	45 (100)	

According to the results in Table 12, at a significance level of 5%, the opinions of students and instructors do not differ in scores for the SurgeMan® and the TraumaMan®.

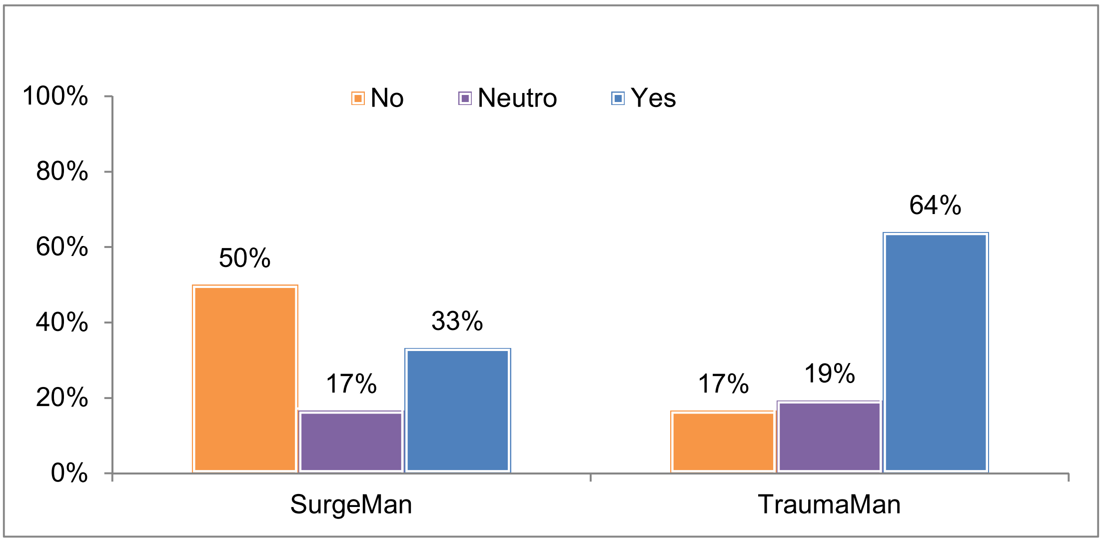
Table 13 - Comparison of model (SurgeMan® and TraumaMan®) and student/instructor in relation to the scores

Scores	Student	Instructor	Total
SurgeMan®			
1 - Inadequate	3 (8,3)	0 (0)	3 (6,7)
2 - Acceptable	12 (33,3)	2 (22,2)	14 (31,1)
3 - Very Acceptable	16 (44,4)	6 (66,7)	22 (48,9)
4 - Excellent	4 (11,1)	1 (11,1)	5 (11,1)
Total	36 (100)	9 (100)	45 (100)
TraumaMan®			
1 - Inadequate	1 (2,8)	0 (0)	1 (2,2)
2 - Acceptable	4 (11,1)	0 (0)	4 (8,9)
3 - Very Acceptable	11 (30,6)	1 (11,1)	12 (26,7)
4 - Excellent	19 (52,8)	8 (88,9)	27 (60)
Total	36 (100)	9 (100)	45 (100)
Comparison	***P***		
Model	0.454		
Student/Instructor	0.929		

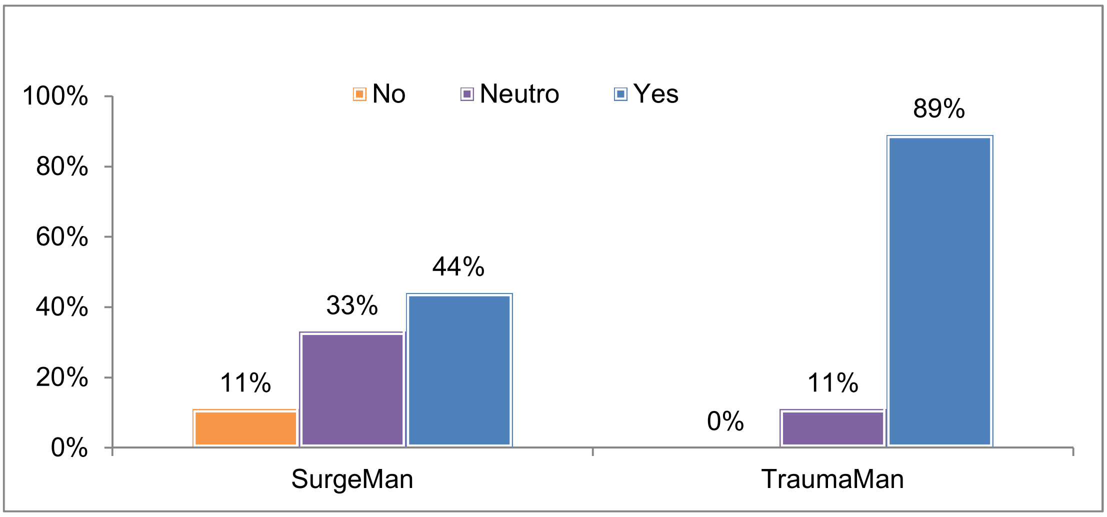
According to the results in Table 13, at a significance level of 5%, scores did not differ according to model (SurgeMan® or TraumaMan®) or with the student/instructor opinion.

Would you recommend the SurgeMan® and TraumaMan® as substitutes for the animal model?

Graphic 11 - Students' opinions on: Would you recommend the SurgeMan® and TraumaMan® as substitutes for the animal model?

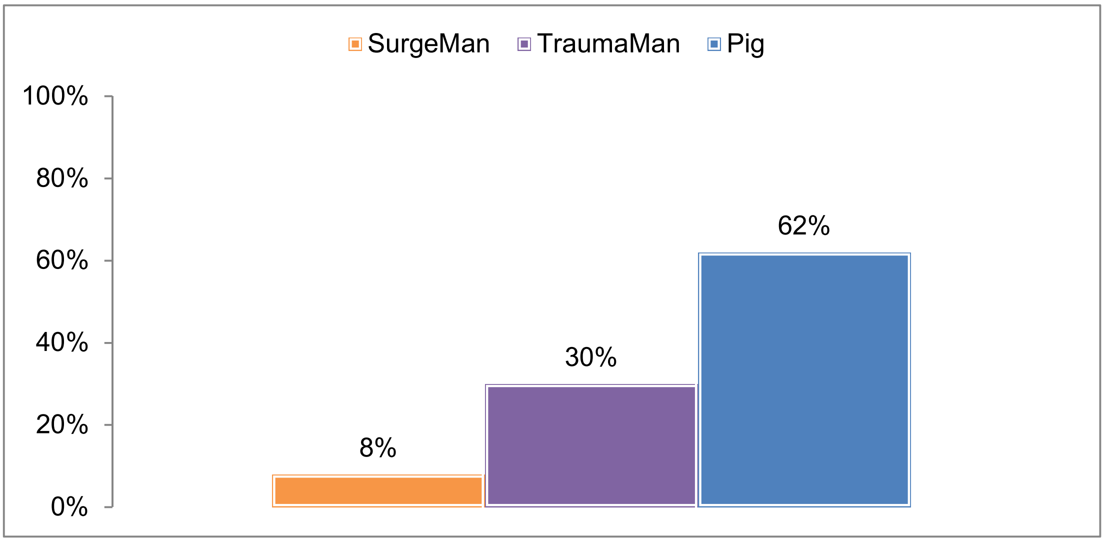


Graphic 12 - Instructors' opinions on: Would you recommend the SurgeMan® and TraumaMan® as substitutes for the animal Model?

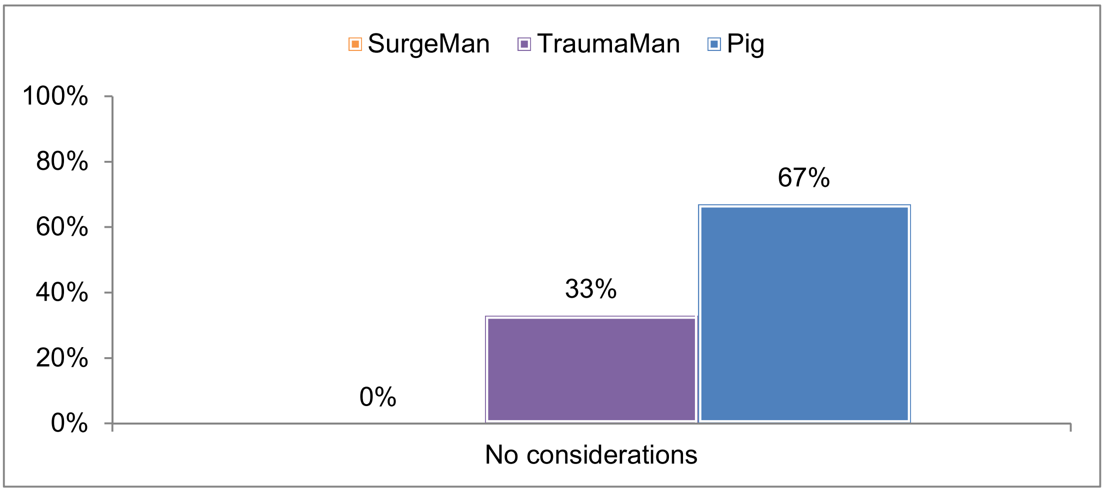


Which model would you recommend if there were no ethical, financial, or animal model concerns?

Graphic 13 - Students' opinions on: Which model would you recommend if there were no ethical, financial, or animal model concerns?

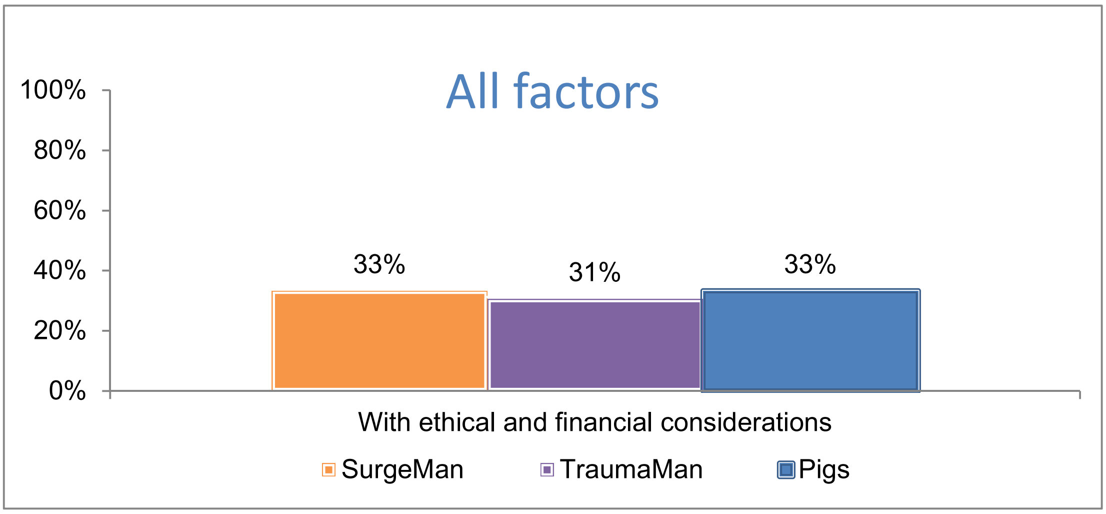


Graphic 14 - Instructors' opinions on: Which model would you recommend if there were no ethical, financial, or animal model concerns?

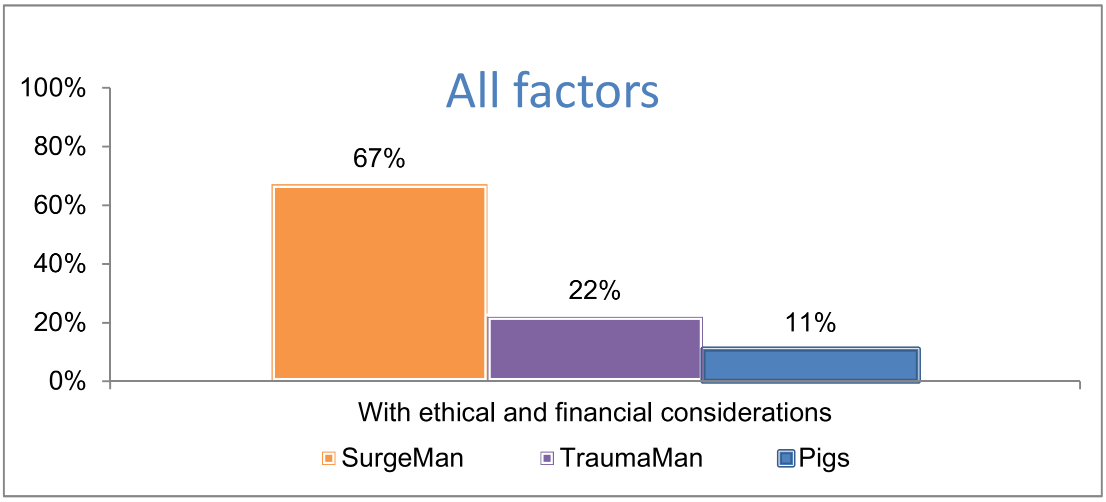


Which model would you recommend considering all factors: financial, ethical, and animal rights concerns?

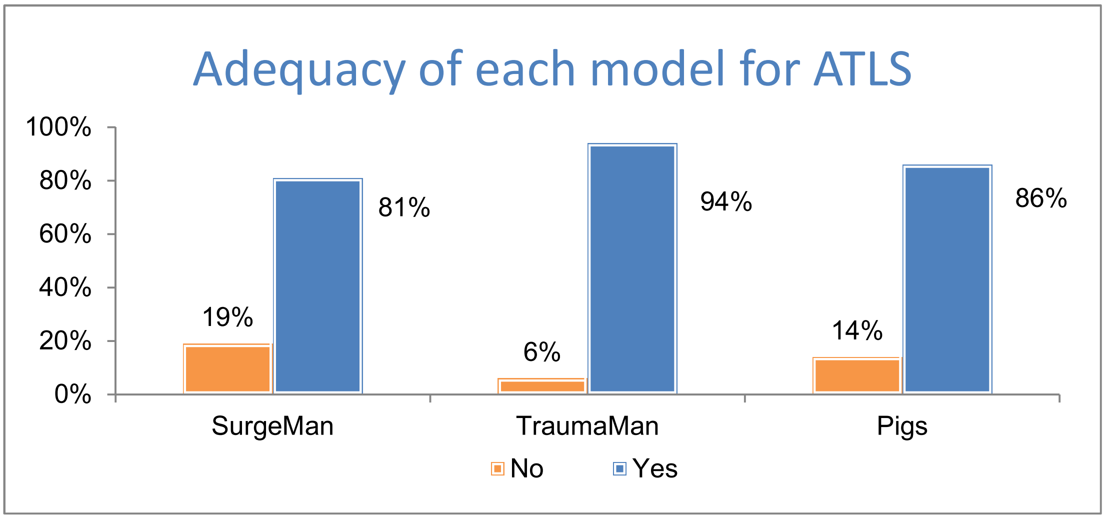
Graphic 15 - Students' opinions on: Overall, considering all factors, financial, ethical, and animal rights concerns, which model would you recommend?



Graphic 16 – Instructors' opinions on: Overall, considering all factors: financial, ethical, animal rights concerns, which model would you recommend?



Graphic 17 - Students' opinion on: Overall, indicate suitability (yes/no) of the model for ATLS® skills teaching and learning



Graphic 18 - Instructors' opinion on: Overall, indicate suitability (yes/no) of the model for ATLS® skills teaching and learning

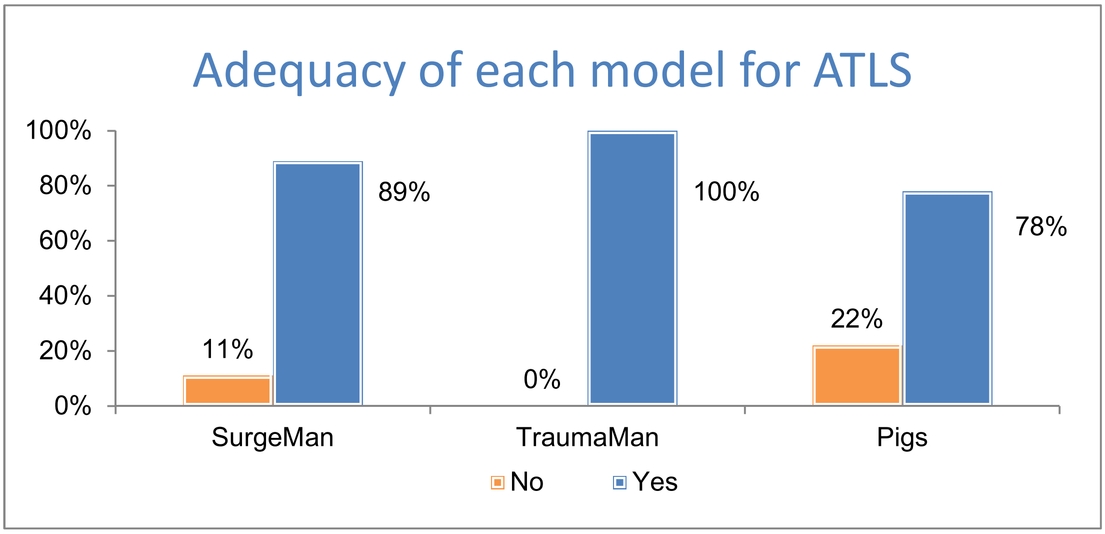


Table 14 - Comparison between student and instructor in relation to the recommendation of different models

Recommendation of models	Student	Instructor	Total	*P*
Would you recommend the SurgeMan® as a substitute for the animal model?				
Yes	12 (33,3)	4 (44,4)	16 (35,6)	
Neutral	6 (16,7)	3 (33,3)	9 (20)	0.109*
No	18 (50)	1 (11,1)	19 (42,2)	
Total	36 (100)	9 (100)	45 (100)	
Would you recommend the TraumaMan® as a substitute for the animal model?				
Yes	23 (63,9)	8 (88,9)	31 (68,9)	
Neutral	7 (19,4)	1 (11,1)	8 (17,8)	0.165*
No	6 (16,7)	0 (0)	6 (13,3)	
Total	36 (100)	9 (100)	45 (100)	
Which model would you recommend (with no issues)?				
SurgeMan®	3 (8,3)	0 (0)	3 (6,7)	
TraumaMan®	11 (30,6)	3 (33,3)	14 (31,1)	
Animal	21 (58,3)	6 (66,7)	27 (60)	0.597*
No preference	1 (2,8)	0 (0)	1 (2,2)	
Total	36 (100)	9 (100)	45 (100)	
Which model would you recommend (considering all issues)?				
SurgeMan®	12 (33,3)	6 (66,7)	18 (40)	
TraumaMan®	11 (30,6)	2 (22,2)	13 (28,9)	
Animal	12 (33,3)	1 (11,1)	13 (28,9)	0.272*
No preference	1 (2,8)	0 (0)	1 (2,2)	
Total	36 (100)	9 (100)	45 (100)	
Adequacy of SurgeMan® for learning and teaching the skills of the ATLS® course				
Yes	29 (80,6)	8 (88,9)	37 (82,2)	
No	7 (19,4)	1 (11,1)	8 (17,8)	1.000**
Total	36 (100)	9 (100)	45 (100)	
Adequacy of TraumaMan® for learning and teaching the skills of the ATLS® course				
Yes	34 (94,4)	9 (100)	43 (95,6)	
No	2 (5,6)	0 (0)	2 (4,4)	1.000**
Total	36 (100)	9 (100)	45 (100)	
Adequacy of the animal model for learning and teaching the skills of the ATLS® course				
Yes	31 (86,1)	7 (77,8)	38 (84,4)	
No	5 (13,9)	2 (22,2)	7 (15,6)	0.614**
Total	36 (100)	9 (100)	45 (100)	

5 Discussion

5 DISCUSSION

Standardized trauma training can improve trauma care in both high- and low-income countries (1-3, 12, 13). There are some intensive courses that offer basic information and training that are necessary to provide good patient care. Nonetheless, those are usually very sophisticated programs, with very high quality standards and developed for high-income countries. If those programs are to be expanded for low-income countries, they should encompass some characteristics, such as, up to date information, objectivity, short duration, low costs, feasibility in an environment with limited resources, and reproducibility using accessible and inexpensive instruments (13).

The ATLS® course is the most widely used course, has a tremendous impact worldwide, and has contributed substantially to the improvement of trauma care. More than 1 million doctors were trained by ATLS® in more than 60 countries (12). The globalization of the course has raised some issues related to different realities, both financial and ethical. Some low- and middle-income countries in Latin America and Africa have had the program for many years but are still struggling to distribute the courses and increase the number of doctors trained. For example, it was implemented in Brazil in the late 1980's and, to present day, the Brazilian ATLS® program has trained more than 28,000 doctors (13). According to the Brazilian Federal Medical Council, there were 425,939 doctors working in Brazil in 2016 (14), demonstrating that we were able to train a little less than 7% of all doctors in our country. Other countries in Latin America have the same problem of training too few doctors. For many years, Brazil has been among the top 3 countries in the region in number of courses completed per year, with a median of 150 courses per year, so the problem in other countries may be even bigger. This situation is due to several challenges that ATLS® faces outside the United States, especially in lower income countries. Those include, but are not limited to, high costs, small number of students trained by each course, and a large demand for instructors.

The costs for implementing the ATLS® program in a new country are estimated to be around $80,000 dollars, according to the WHO [(1)]. In addition, there are fees ($40 plus taxes) for each student that are paid to the American College of Surgeons. Another important cost is associated with the use of live or artificial models in the surgical skills stations. Those practical skills are a very important part of the course, as they teach life-saving procedures such as cricothyroidotomy, chest tube insertion, pericardiocentesis, and diagnostic peritoneal lavage.

The program trains a maximum of 16–24 students per course, with an obligatory 4:1 student/instructor ratio in the practical activities, including the surgical skills stations. This limited number of students makes it harder to broaden the program to rural areas and smaller cities far from the main centers. The costs for travel and shipping are very high, and the instructors' availability for each course is limited; therefore, sometimes it is not possible to justify the investment for only 16 doctors.

The course is also very demanding for the instructors. After taking a preparatory course in didactics as part of the program, they have to teach 4 courses in the period of 4 years. During each course, they must participate in a very intense educational experience that includes several repeated practical rotations on both days of the course, usually with very little or no financial compensation.

Conversely, the centralized control by the American College of Surgeons, the small numbers of students per course, and the very intense practical activities to a limited number of providers, are the main factors that made the ATLS® course world-renowned for its very high quality standard.

Cost versus quality for the ATLS® course is usually not discussed in the United States, as the finances are not a significant barrier for the program there. However, some changes in the program, considering only U.S. finances, and thinking only about very high quality standards, can affect trauma training, and consequently, trauma care on a worldwide scale. One example of this is the use of live animals, instead of an artificial model (TraumaMan® - Simulab), in the vast majority of ATLS® sites in the U.S. That movement started after 1994 and escalated in the beginning of the 2000's. Initially, there was some pressure to substitute artificial manikins for the live animals, but with the increased pressure from the public and the appearance of many animal protection societies, that became a priority in medical research and training. In 1994, a movement was started to close live-animals labs in medical schools in the United States, 77 of 125 schools had live animals, which were used in their curricula. Now it is estimated that only 8 schools still use animals for training medical students [(15)].

The ACS also supports the use of animals in education or research with the implementation of the 3 Rs: refinement, reduction, and replacement, introduced in 1959 by British scientists William M.S. Russell and Rex L. Burch in their paper, *The Principles of Humane Experimental Technique* [(7, 10)]. The Academy of Surgical Research also states, in their Guidelines for Training in Surgical Research with Animals, that the use of animals for surgical training should only be used in those instances where suitable alternatives are not available.

The solution to that problem in the U.S. was to utilize the TraumaMan®, which costs approximately $25,000–$30,000 [(16)] per model and another $600 per course of 16 providers. That cost can be much higher with import taxes and shipping costs included. For example, in Brazil it can cost as much as $100,000 for each one and $2000 per course of 16 students. That would make its use unfeasible. There have been many protests in Brazil and in Latin America against the use of animals for training and research in medicine. Due to the ethical issues related to the use of live animals and the financial issues related to the use of ACS approved manikins for the ATLS® courses, the Brazilian Committee on Trauma (COT) of the ACS searched for an alternative that would be feasible in Brazil. A company called Medical Training Models (MTM - Rua Professor Ivo Corseuil, 304 Porto Alegre - RS | Brasil) has developed a low-cost manikin for ATLS® courses, called

SurgeMan®. In 2011, the Brazilian COT presented the model to the ACS and was authorized to begin using it for courses in Brazil, contingent upon the commitment to perform a study analyzing its adequacy for the course. That demand by the ACS promoted the initial push to use a low cost manikin for the ATLS® course, as neither 1 of the previously authorized manikins had been evaluated by a formal study. That same belief is also held by most instructors and surgeons, as reported in previous studies [(17-19)]. In that context, and due to our commitment to the ACS, we performed this study to evaluate a low cost manikin for middle- and low-income countries. Our intention was to test a more viable option, to increase the number of courses of ATLS®, both in Brazil and in other low- and middle-income countries. It could also help to replace the use of animals in medical schools for training doctors in emergency procedures.

Although there are hundreds of studies that show the advantages of training with simulators when compared to no training, we found few studies comparing 2 or more simulation modalities. We found 3 studies using a manikin, on which all procedures could be performed in the same course or activity [(16, 18, 20)]. However, in 2 studies, participants only tested the artificial model and comparison was made based on a previous experience [(16, 18, 20)]. Only 1 study used both models at the same time in a randomized design [(18)]. A recent methodological review on simulation training studies by Lineberry et al. [(21)] had similar findings. That study also critiques some common flaws of studies comparing different manikins. The first common issue is a small sample size that would under power the study. Studies included in that review had samples ranging from 6 to 82 participants per group, with a median of fifteen participants. In our study, we used a convenience sample of 36 future students to improve external validity, as the crossover design, which would be better than using 3 groups of 12 students per model.

Our sample of participants was chosen from the Brazilian COT databank and we included students that were registered for future ATLS® courses. As our study was performed in the State of São Paulo, most of our participants were from the same state. São Paulo is the richest state of Brazil and 1 of the wealthiest regions of Latin America. This may produce some bias in participants' opinions as both students and instructors could underestimate financial issues. Conversely, most of our participants either had their training, or were, at the time of the study, working in a public hospital or university. Those institutions usually have to confront larger financial issues than the private ones. That could lead participants to overestimate financial issues compared to the general population. Another bias for external validity could be the level of specialization of our participants. General surgeons comprised the majority of instructors, which is comparable to the usual group of instructors of an ATLS® course. Nonetheless, our sample of students had more than 70% with some training in general surgery, which differs from the usual group of participants in ATLS® courses, which has more generalists and emergency medicine doctors.

When scoring the procedures, the animal model and the TraumaMan® had better scores than the SurgeMan® for tube thoracostomy. There are some different findings from other studies. For example, in Hall et al.'s study (18) students had a preference for the animal model. The difference from that study is that participants performed the activities on only 1 model, so the preference may be associated to a preconception, rather than a real comparison, as in our study. In Ali et al. (16), they compared participants with previous experience with animal training during an ATLS® course, who all performed the surgical skills only on the TraumaMan® and they did not find differences in students and instructors' opinions. Another study compared the TraumaMan® and pigs, only for chest tube insertion, with feedback from experts and students on different aspects of both models (22). Participants found that the TraumaMan® was superior to the animal model only in teaching anatomical landmarks, while the animal model was superior in teaching tissue handling, dissection, and chest drain fixation.

For pericardiocentesis, there was no difference between the means of the Likert Scale for all participants as shown in Table 7. When we looked for the students and instructors' opinions separately, there was a preference for the animal model (61%) by students and for the TraumaMan® (89%) by the faculty. Statistical analysis showed a significant difference only between the SurgeMan® and the TraumaMan® and it was dependent on the difference between the opinion of students and instructors, with the latter favoring the TraumaMan®. Ali et al. (16) had shown a preference by students favoring the TraumaMan®. We did not find any other study comparing pericardiocentesis in an animal model versus an artificial model. That may have occurred because the pericardiocentesis procedure is now optional during the ATLS® course and, when performed, it is usually guided by ultrasound. Utilizing ultrasound guidance may turn it into a more attractive procedure to both faculty and students. If done, it should not increase the cost of the manikin, in order to maintain each model's affordability. For example, an inexpensive, reusable model for ultrasound guided pericardiocentesis was presented by Zerth et al. (23). It was made with plain gelatin, a golf ball, and a balloon, with a very positive feedback from users, according to the authors.

The opinions of students and instructors did not differ about DPL. The animal model had a statistically significant higher mean (4.39) for Likert Scale compared to the TraumaMan® (3.92) and the SurgeMan® (2.94). However, we did not find a significant difference when comparing opinions about the TraumaMan® and the animal model. The current ATLS® course version also made this procedure optional and, as occurred for pericardiocentesis, there were not many studies comparing models for DPL. In the Ali et al. (16) and the Hall et al. (18) studies, students had a preference for the animal model compared to the TraumaMan® . Another previous study comparing DPL models had shown better performance and student preference for a simulator (SimDPL) (24). However, they only tested the Seldinger technique and results were better regarding anatomic landmarks and positioning. We, and the other 2 previous studies, evaluated the open DPL technique, and the choice of the participants for live animals maybe due to the presence of bleeding tissue and the smaller influence of anatomical landmarks for this procedure.

It has been shown by other studies that the anatomic landmarks and positioning are better in artificial models and human cadavers than in animals

[20, 25–27], especially for cricothyroidotomy. Our findings may support that suggestion as the TraumaMan® (3.8) had better Likert means than the animal (3.37) and the SurgeMan® (3.0) for that procedure (Table 11). When analyzing opinions, we found that only the TraumaMan® and the SurgeMan® had a difference favoring the first 1. Students and instructors' opinions were not different and did not interfere with the difference between models. There are some studies comparing models for cricothyroidotomy and the results are conflicting. A study comparing cadavers and a canine model has shown better efficacy results in the cadaver group with a accuracy placement of 96% versus 67% in the canine model [27]. A study comparing the TraumaMan® and previous experience with a porcine model and another randomized trial comparing the TraumaMan® and a porcine model had greater preference for the artificial model [16, 25]. The 3 studies highlighted the anatomical difference between animals and humans as the main reason for preference in this procedure. One paper comparing a model made with porcine larynxes, and 1 model made with synthetic rubber trachea and skin, showed a preference for the animal model. In this case, perhaps when the anatomical advantage is taken out, better tissue handling and dissection on the animal model may explain students' preferences [28]. In the Hall et al. study [18], students had a preference for the animal model in all procedures and they did not specifically discuss cricothyroidotomy.

Past studies have failed to show a difference in learning efficacy after training students in porcine or artificial models [18-20]. Nonetheless, they were all underpowered and they have also suggested performing multicenter studies that could have the number of students necessary to show a difference, if there is 1. The preference of model also varies from 1 study to another. Hishikawa et al. [19] reported better self confidence in the simulator group and Hall et al. have shown students' preference for the animal model in his studies [18, 20]. Our findings have shown no difference in students' preference between the TraumaMan® and the pig model. The SurgeMan® had lower scores than the other models, but 50% of the students found it satisfactory and 25% good/excellent.

We asked students and instructors about the suitability of the SurgeMan® and the TraumaMan® as substitutes for the animal model. 53% of the students considered the TraumaMan® excellent and 89% of the instructors also stated that, as shown in Graphics 9 and 10. However, after statistical analysis, we did not find a difference between models and students and instructors' opinions (Tables 12–13). 64% of the students indicated the TraumaMan® could be a substitute for the live animal models and 33% suggested SurgeMan® as a substitute. 89% of instructors suggested the TraumaMan® as a substitute and 44% chose the SurgeMan®. The higher recommendation by instructors may reflect past experience with ethical issues when using animal models.

In our study, 62% of the students and 67% of the instructors chose live animals as a first option when not considering any ethical or financial issues. When considering all ethical and financial issues, there was no difference in preference among models for students and 67% of instructors chose the SurgeMan®. Students' findings are similar to Hall et al. [(18)], where all the volunteers that performed surgical skills procedures in both models (the TraumaMan® and pig) indicated a preference for live animal training; in that study it was not associated with the procedure. Instructors' preference, considering all factors, suggests previous ethical and financial problems that may have made them look for an artificial option with lower cost. Those findings may suggest that, although there is a clear and expected preference for the TraumaMan®, when the financial issue is an important matter, as in most middle and low-income countries, a lower cost artificial model, such as the SurgeMan® can be an acceptable option.

The smaller preference for the SurgeMan® by the students in our study may be due to the fact the all participants have performed the procedure in all 3 models and it was anticipated that a high cost model, such as the TraumaMan®, would score better than a lower cost model.

The preference for live tissue can be easily justified in courses that aim for bleeding control and for some complex procedures. Nonetheless, there is no evidence in the literature that would justify it for emergency procedures. Actually, there are many studies that have shown that there is not a relevant difference between live and artificial models for that kind of training [16, 18, 20, 22, 25]. We also think that the theory behind training non-specialized doctors in a forty-minute practical skills station, is to standardize the technique used for the procedure, and for that, a low-cost manikin can be as efficient as a high fidelity manikin or live animals. In fact, the anatomical points may be better in the artificial models than in pigs, as suggested by some previous studies [16, 25, 26]. Training for those emergency procedures can also be analyzed based on established theories of the ways in which motor skills are acquired and expertise is developed.

One of the most accepted theories of motor skill acquisition in the surgical literature is Fitts and Posner's three-stage theory (Table 15) [29]. In the first stage (cognition), the learner intellectualizes the task. That is the only phase that can be achieved in an ATLS® course. During this phase, the provider learns the distinct steps of the procedure. For example, in chest tube insertion they learn how to prepare the surgical field, how to perform proper local anesthesia, and the steps of the procedure itself. For the next steps of the theory, (integration and automation), they need practice and feedback. That can only be achieved in clinical practice, under supervision. For that phase, a low-cost model should be considered as a suitable alternative to the use of live animals.

Table 15 - Fitts and Posner's three-stage theory of motor skill acquisition

Stage	Goal	Activity	Performance
Cognition	Understand the task	Explanation, demonstration	Erratic, distinct steps
Integration	Comprehend and perform mechanics	Deliberate practice, feedback	More fluid, fewer interruptions
Automation	Perform the task with speed, efficiency and precision	Automated performance requiring little cognitive input	Continuous, fluid, adaptive

We found that all models tested in our study had a considered adequacy rate for ATLS® courses above 80% by students' opinions (SMan 81%, TMan 94%, pigs 86%) (Graphic 17). Instructors' opinions about the adequacy of the models, may again suggest a tendency for substituting the animal model for an artificial manikin (SMan 89%, TMan 100%, and pigs 78%) (Graphic 18).

6 Conclusion

6 CONCLUSION

Although the TraumaMan® performed better than the SurgeMan® in most procedures, students and instructors found that both the TraumaMan® and the SurgeMan® are acceptable for teaching and learning ATLS® surgical skills.

All 3 models had an adequacy rate over 80% in students' opinions, and only the animal model had a 78% recommendation rate by instructors.

The TraumaMan® had a 64% recommendation rate by students and as a substitute for the animal model and SurgeMan® had 33%. The instructors' recommendation was 89% for the TraumaMan® and 44% for the SurgeMan®. Without ethical or financial considerations, pigs were the first option, with a 62% preference for students and 67% for instructors. When ethical and financial aspects were considered, students equally chose all models and 67% of the instructors chose the SurgeMan®.

7 References

7 REFERENCES

1. Mock C LJ, Goosen J, et al. Guidelines for Essential Trauma Care. Geneva, WHO; 2004.

2. Ali J, Adam R, Stedman M, Howard M, Williams JI. Advanced trauma life support program increases emergency room application of trauma resuscitative procedures in a developing country. J Trauma. 1994;36(3):391-4.

3. Ali J, Adam R, Butler AK, Chang H, Howard M, Gonsalves D, et al. Trauma outcome improves following the advanced trauma life support program in a developing country. J Trauma. 1993;34(6):890-8; discussion 8-9.

4. American College of Surgeons. Advanced Trauma Life Support (ATLS) student manual. 9th ed. Chicago, IL: American College of Surgeons; 2012.

5. Kortbeek JB, Al Turki SA, Ali J, Antoine JA, Bouillon B, Brasel K, et al. Advanced Trauma Life Support, 8th edition, the evidence for change. J Trauma. 2008;64(6):1638-50.

6. American College of Surgeons. Advanced Trauma Life Support (ATLS) instructor manual. 9th ed. Chicago, IL: American College of Surgeons; 2012.

7. Statement on the Use of Animals in Research, Education, and Teaching. Bull Am Coll Surg. 2002;87(10):16.

8. Gambhir R, Agrawal A. Training in trauma management. Med J Armed Forces India. 2010;66(4):354-6.

9. Simulab Corporation. TraumaMan product information. http://simulab.com/traumaman/about.

10. Academy of Surgical R. Guidelines for training in surgical research with animals. J Invest Surg. 2009;22(3):218-25.

11. Likert R. A technique for the measurement of attitudes. Arch Psychol. 1932;140:1-55.

12. Mohammad A, Branicki F, Abu-Zidan FM. Educational and clinical impact of Advanced Trauma Life Support (ATLS) courses: a systematic review. World J Surg. 2014;38(2):322-9.

13. Birolini D. Trauma: a social and medical challenge. J Am Coll Surg. 2008;207(1):1-6.

14. Medicina CFd. Número total de inscrições principais no Conselho Federal de Medicina. Site internet 2016; http://portal.cfm.org.br/index.php?option=com_estatistica.

15. Wadman M. Medical schools swap pigs for plastic. Nature. 2008;453: 140-1.

16. Ali J, Sorvari A, Pandya A. Teaching emergency surgical skills for trauma resuscitation-mechanical simulator versus animal model. ISRN Emergency Medicine. 2012;2012:1-6.

17. Daly SC, Wilson NA, Rinewalt DE, Bines SD, Luu MB, Myers JA. A subjective assessment of medical student perceptions on animal models in medical education. J Surg Educ. 2014;71(1):61-4.

18. Hall AB, Riojas R, Sharon D. Comparison of self-efficacy and its improvement after artificial simulator or live animal model emergency procedure training. Mil Med. 2014;179(3):320-3.

19. Hishikawa S, Kawano M, Tanaka H, Konno K, Yasuda Y, Kawano R, et al. Mannequin simulation improves the confidence of medical students performing tube thoracostomy: a prospective, controlled trial. Am Surg. 2010;76(1):73-8.

20. Hall AB. Randomized objective comparison of live tissue training versus simulators for emergency procedures. Am Surg. 2011;77(5):561-5.

21. Lineberry M, Walwanis M, Reni J. Comparative research on training simulators in emergency medicine: a methodological review. Simul healthc. 2013;8(4):253-61.

22. Berkenstadt H, Munz Y, Trodler G, Blumenfeld A, Rubin O, Ziv A. Evaluation of the Trauma-Man® Simulator for training in chest drain insertion. Eur J Trauma. 2006;32(6):523-6.

23. Zerth H, Harwood R, Tommaso L, Girzadas DV, Jr. An inexpensive, easily constructed, reusable task trainer for simulating ultrasound-guided pericardiocentesis. J Emerg Med. 2012;43(6):1066-9.

24. Bowyer CM, Liu AV, Bonar JP. Validation of SimPL – a simulator for diagnostic peritoneal lavage training. Stud Health Technol Inform. 2005;111: 64-7.

25. Iverson K, Riojas R, Sharon D, Hall AB. Objective comparison of animal training versus artificial simulation for initial cricothyroidotomy training. Am Surg. 2015;81(5):515-8.

26. Stefanidis D, Yonce TC, Green JM, Coker AP. Cadavers versus pigs: which are better for procedural training of surgery residents outside the OR? Surgery. 2013;154(1):34-7.

27. McCarthy MC, Ranzinger MR, Nolan DJ, Lambert CS, Castillo MH. Accuracy of cricothyroidotomy performed in canine and human cadaver models during surgical skills training. J Am Coll Surg. 2002;195(5):627-9.

28. Cho J, Kang GH, Kim EC, Oh YM, Choi HJ, Im TH, et al. Comparison of manikin versus porcine models in cricothyrotomy procedure training. Emerg Med J. 2008;25(11):732-4.

29. Reznick RK, MacRae H. Teaching surgical skills - changes in the wind. N Engl J Med. 2006;355(25):2664-9.