Is the Thiel-embalmed cadaver model a good option for colorectal laparoscopic surgery training programs? A survey on trainees and professors

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Abstract

Background: Colorectal surgery is one of the most demanding surgical subspecialties, where trainees need to have a deep knowledge and understanding of the anatomy plus acquire specific technical skills. The use of human cadavers as a training modality is a very good option as they are anatomically identical to the patients. The Thiel-embalming method has demonstrated to allow laparoscopic surgical training.

Objective: The aim of this study was to evaluate the idoneity of Thiel embalmed cadavers for training the surgical skills necessary for laparoscopic colorectal surgery.

Design: Prospective observational study

Settings: University Medical Institution

Subjects: Trainees and faculties attending to the training course of laparoscopic colorectal surgery on Thiel-embalmed cadavers

Interventions: A specific questionnaire was designed to evaluate the training experience.

Main outcome measures: 11 questions about the Thiel cadavers, skills, and performance.

Results: 41 participants (24 trainees and 17 teachers) completed the questionnaire. 94.1% of teachers and 88% of trainees considered the Thiel cadaver to be a better model for laparoscopic surgery practice than animal models. 82.4% of the teachers and 72% of the trainees believed that training with a Thiel-embalmed cadaver should be a compulsory part of the training before performing colorectal surgery *in vivo*. However, 88% of the trainees and 70.6% of the teachers considered that this model lacked authenticity due to the absence of bleeding.

Limitations: Data obtained from only one course.

Conclusions: Laparoscopic surgical training using Thiel-embalmed cadaver models can be a realistic and feasible option to develop technical skills in surgical residents and junior consultants.

Introduction

The arrival of laparoscopic techniques has created a novel paradigm for surgical training, with a new learning model and a shift towards more structured laparoscopic training programs. Trainees need to acquire and perfection new surgical skills before performing in a patient to guarantee the best quality treatment (1, 2).

Colorectal surgery is one of the most demanding surgical subspecialties, where trainees need to have a deep knowledge and understanding of the anatomy plus acquire specific technical skills, including the correct use of numerous surgical instruments and devices. Healthcare pressure, increasing costs of

theater time, and the ethics of learning on human patients have contributed to the demand for teaching programs that allow for the development of basic laparoscopic skills in the laboratory. In the last decade, there has been a development of new synthetic and even virtual training models and their introduction in the market. The efficiency of each type of simulation depends on the complexity of the skills to be taught, the cost and the availability of each simulation model in the teaching center. The use of human cadavers as a training modality is a very good option as they are anatomically identical to the patients. They allow the surgeons to practice safely and to develop all their skills and even go through the full surgical procedures before performing them live (1–3).

The aim of this study was to evaluate the idoneity of Thiel embalmed cadavers for training the surgical skills necessary for laparoscopic colorectal surgery.

Methods

As part of an advanced colorectal laparoscopic training course that we organized in collaboration with the Department of Anatomy and Neurosciences (School of Medicine, Autonomía University of Madrid, Spain) we planned a prospective observational study to evaluate the satisfaction of the training of laparoscopic colorectal approaches on Thiel cadavers.

All methods were carried out in accordance with relevant guidelines and regulations. The human cadavers used in this Project were all obtained from the Body Donation Program of the Autonomía de Madrid University (UAM) <http://www.donarcuerpoalaciencia.com>. Donors were adults, of both sexes. According to applicable Spanish regulations as well as best practice recommendations from the Spanish Anatomical Society (SAE), everyone had, prior to death, signed a Donation Will for the stated purpose body use for Medical Training and Research. The Donation Will specifically authorized the publication of scientific images taken from the bodies or tissue samples.

All experimental protocols and procedures involving the use of donated bodies for the training activities reported in the present study, were approved by the Ethical committee or institutional review board of Universidad Autónoma de Madrid Body Donation Program Directive Board"

Procedures for the use and disposal of anatomical remains and embalming solutions was supervised by the UAM Health & Safety Committee, following applicable national and local environmental regulations.

Informed consent was obtained from all participants in the training courses for the publication of images taken during the course sessions. A statement to confirm that **written informed consent** was obtained from all subjects or if subjects are under 18, from a parent/ legal guardian.

Participants included faculties (expert coloproctologists) and trainees (junior consultants or advanced residents).

Thiel cadaver preparation

The protocol for Thiel embalming is named after its creator, Professor Walter Thiel, in 1992. It is characterized by a sophisticated process that allows preservation of cadavers, preserving most of the features of a living body. The method consists in a vascular perfusion followed by immersing the body over a period of at least 1–2 months in an embalming fluid containing (in different proportions): boric acid 3%, mono-ethylene glycol 10%, ammonium nitrate 10%, potassium nitrate 5%, stem solution-II 2%, sodium sulfite 7%, and formalin 2%. Differently from fresh-frozed cadavers, Thiel embalmed cadavers last longer, around 3 years, beyond this period they should be cremated. This embalming procedure allows for a better 'life-like' preservation of tissues and textures, like those found in vivo.

Methodology of the Course

The full-day course included lectures followed by the laboratory training of different laparoscopic colorectal procedures (right hemicolectomy, left hemicolectomy and lower anterior resection of rectum) on the Thiel-embalmed cadavers. Before practicing on the cadaver, the faculty discussed several surgical techniques and details of the anatomy, such as right and left hemicolectomy, anterior rectal resection with total mesorectal excision and abdominoperineal resection. These theoretical sessions were accompanied by instructive videos to improve the understanding of each step.

Surgical procedures were performed on Thiel cadavers in the skills lab of the Autonoma University of Madrid, School of Medicine's Department of Anatomy and Neurosciences. The cadavers were donated for medical education and scientific research through the University's voluntary body-donation program.

Eight Thiel-embalmed cadavers were prepared for this course and each one was assigned to three trainees resembling a normal colorectal approach, with a surgeon, a first assistant, and a second assistant with the camera (Fig. 1). The cadaver was placed in reverse Trendelenburg position with the legs separated. The laparoscopic devices were provided by sponsors and were equal to those used in a normal hospital operating room (Optics, camera, suction devices, ultrasonic scalpels, endostaplers, sutures, Lone star retractor system, etc.). The three trainees in each group changed their positions during the practice, so that all of them performed a part of the technique as the main surgeon (Fig. 2A). One faculty member was assigned to each group as supervisor to guide the trainees and answer any question arising during the procedures (Fig. 2B).

A specific questionnaire was designed to evaluate the training experience. This questionnaire has been previously validated for the evaluation of laparoscopic surgery courses (4). It evaluated the opinion of both, trainees and faculties and included 11 questions about the Thiel cadavers, skills, and performance. At the end of the course all trainees and Faculties attending the course were requested to answer the questionnaire anonymously.

Results

The questions included in the questionnaire and the results obtained from both, trainees and faculties are shown in Table 1. There was a total of 41 participants (24 trainees and 17 teachers). Among of the

teachers 35.3% were women and 64.7% were men, whereas among the trainees 56% were women and 44% men. Upon evaluation of the participants' training and experience as surgeons, 60% were residents, 24% were staff members with < 7 years experience and 16% were Staff members with > 7 years experience. All the faculties were colorectal staff surgeons with over 10 years experience in laparoscopic surgery. All the participants had previous experience with colorectal surgeries on animal models.

Table 1

Feedback questionnaire (11 questions) and answers provided by course participants, classified as students or Faculty.

Feedback questionnaire (n = 41)	Answer	Students (n = 24)	Faculties (n = 17)
Question 1	Yes	36%	82,4%
Had you ever heard of the Thiel embalming method before this course?	No	64%	17,6%
Question 2	I have, but I have never worked with a Thiel cadaver	77,8%	42,9%
If Yes, please chose one of the following:	I have used a Thiel cadaver for anatomic dissections	11,1%	7,1%
	I have used it for laparoscopic training	11,1%	50%
Question 3	Yes	84%	94,1%
Can you differentiate the tissues on a Thiel cadaver?	No	16%	5,9%
Question 4	Yes	100%	100%
Does the tissue elasticity allow realistic manipulation of the cadaver?	No	0%	0%
Question 5	Yes	88%	94,1%
In your opinion, is the appearance of the Thiel cadaver like that of a body in vivo?	No	12%	5,9%
Question 6	Yes	88%	70,6%
Does the lack of bleeding reduce verosimilarity in the Thiel model?	No	12%	29,4%
Question 7	Yes	44%	29,4%
Is visceral tissue consistency of the Thiel model less than that of the in vivo model?	No	56%	70,6%
Question 8	Yes	88%	94,1%
Do you consider the Thiel cadaver a better model to practice colorectal laparoscopy surgery than pig or other animal models?	No	12%	5,9%
Question 9	Yes	72%	82,4%
Do you believe training with/practicing on a Thiel cadaver should be a compulsory part of the			

preparatory training for colorectal surgery in vivo? Feedback questionnaire (n = 41)	Answer	Students (n = 24)	Faculties (n = 17)
Question 10 Do you think the practice with the Thiel cadaver has been useful for the students?	No	28%	17,6%
	Yes	100%	100%
Question 11 How do you rate the practice with the Thiel cadaver?	No	0%	0%
	Excellent	80%	100%
	Good	20%	0%
	Average	0%	0%
	Poor	0%	0%
	Very poor	0%	0%

When considering the Thiel-embalming method, 82.4% of the teachers answered that they had heard about it, compared with only 36% of the trainees. Among the participants who knew this embalming method, 42.9% of the teachers and 77.8% of the trainees had never operated on a Thiel-embalmed cadaver: only one teacher (7.1%) and one student (11.1%) had done previous anatomic dissections with cadavers embalmed with this method. When asked if the appearance of the cadaver in this model was like that *in vivo*, 94.1% of trainees and 88% of faculty responded affirmatively.

However, 88% of the trainees and 70.6% of the teachers considered that the Thiel model lacked authenticity due to the absence of bleeding and 29.4% of the teachers felt that visceral tissue consistency was reduced when compared with the human alive.

94.1% of teachers and 88% of trainees considered the Thiel cadaver to be a better model for laparoscopic surgery practice than the pig or other animal models. 82.4% of the teachers and 72% of the trainees believed that training with a Thiel-embalmed cadaver should be a compulsory part of the training before performing colorectal surgery *in vivo*.

When asked for their opinion about the course, 100% of the teachers and 80% of the trainees felt it was excellent and only 20% of the trainees qualified it as good.

Discussion

Laparoscopic surgery requires special skills and an increasingly specialized training. Human cadavers have recently begun to be used for laparoscopy training since they provide an anatomic model that resembles a real patient (1, 2). Fresh-frozen cadavers have been proposed as a useful model, but they can have increased costs since they must be kept in a large freezer and can present risk of infectious transmission (3). Furthermore, within three hours of de-freezing, the tissue begins to deteriorate, tissue quality decays and, consequently, they can only be used for a limited time. In the search for other

embalming methods that achieved a better preservation, Thiel developed a formula that importantly reduced smell (when compared to fresh-frozen or formalin) and optimally preserved tissue, color consistency and transparency (5, 6). This embalming method is based on water and contains glycol, several salts and conservatives with low levels of formalin (0.8% in the immersion liquid). With the Thiel method, tissue decay is significantly slower, allowing the use of the cadaver for a longer period and repetition of the training sessions if necessary (7, 8).

The main reported disadvantage with this embalming method, if compared with animal models, is the lack of blood flow (7). In our course, 88% of our trainees and 70.6% of faculty thought that the Thiel-embalmed cadaver was an unrealistic model due to the lack of bleeding. In addition, 29.4% of the faculty and 44% of the trainees felt that the visceral tissue was less consistent/solid than an in vivo model. However, these cons are even more outstanding in any other cadaver models. Animal models can be considered an alternative for cadaveric simulation based on the realistic texture and appearance of the tissues, but the anatomical lay-out of the different structures presents significant differences. The logistics and necessary facilities plus the animal wellbeing policies can weigh against these training models.

Another characteristic of the Thiel method is that it provides exceptional disinfection qualities with a minimal exposure to the noxious chemical products, although the expenses for embalming can be relatively high and the fixation process may take as long as six months. The use of conventional formalin embalming is limited by the resulting tissue rigidity, consistency, and texture, by the strong smell and the impossibility of creating a pneumoperitoneum for laparoscopic training. (5, 8, 9)

Despite the Thiel cadaver model creates good conditions for laparoscopic surgery skill practice and excellent tissue preservation, it is not widely spread, and has only been used in 10% of the world's Anatomy laboratories (10, 11). In the present study only one teacher and one trainee had used a Thiel cadaver for anatomic dissections and only 11.1% of the trainees had done any practice or laparoscopic procedures with a Thiel cadaver.

Nevertheless, even though Thiel cadavers provide a very appropriate model for surgical training, they have also some limitations that affect their usefulness as a surgical training medium. Firstly, the availability of cadavers is limited by the number of voluntary donations, the high cost of the embalment procedures and the requirement for specific facilities dedicated to cadaver storage, conservation, and dissection. (2, 12, 13). Secondly, their useful life is restricted, meaning that they must be used within a certain period and only a limited number of surgical procedures can be performed in each cadaver. The quality of cadaver tissue can vary widely depending on the time from death to preservation and the period in storage (1).

Cadaver models with this embalming method have proven to be anatomically superior to pigs in training procedures involving colorectal surgery (9, 10). In our course, 94.1% of the faculty and 88% of the trainees considered the Thiel model to be superior to pigs or other animal models for laparoscopic surgery training sessions. Yiasemidou et al described that among surgeons the satisfaction level with

currently used simulation models was low (65.4% of the participants in their study were dissatisfied with previous simulation models). However, the participants in their study found Thiel cadavers suitable for surgical simulation, realistic, and have reduced odour. They even concluded that the use of Thiel cadavers can be even more cost-effective than other simulation models¹⁴. A recently published study conducted on pelvic floor procedures simulation also confirmed our results. The participants recognized that Thiel cadavers present more similarities to patients than other simulation methods. The Thiel cadaveric method was considered by most responders to be the best for the simulation of surgical procedures on the pelvic floor and perineum. Most of the surgeons surveyed recommended conducting these courses with Thiel cadavers for different colleagues in other specialties as a reliable simulation method for training for difficult surgical procedures¹⁵.

Consequently, whenever possible, cadaveric models should be of choice for postgraduate training in surgical skills, allowing for a better real-life scenario visualization and providing the best opportunity to learn diverse surgical techniques in the human anatomy (3).

Given the high degree of satisfaction of the participating residents and staff in these workshops (100% of the faculty and 80% of the trainees considered it excellent), a standardized plan for similar courses should be explored to be included in the National Training Programs (12, 14). Thiel cadaver courses can be a great tool as a training model to teach, reinforce and improve technical skills in surgical practice. They can also be helpful to evaluate performance of specific procedures and could become part of the skills considered in the end-of training evaluation of surgical residents (8).

Costs associated with the use of a Thiel-embalmed cadaver for medical education are 10–20% greater than those of a formalin-preserved cadaver, but, as it can be reutilized and preserved without decaying or need for constant refrigeration, the long-term exploitation of a Thiel-embalmed cadaver could potentially be less costly.

Certainly, low incidence or high-risk procedures continue to be a concern in some medical training programs (9, 10). Many surgical residents have not been exposed to or performed these uncommon procedures on a patient during their clinical training. This issue has led to the need for alternative training methods that can compensate this lack of clinical exposure and allow the trainees to acquire the necessary skills and practical experience to master different techniques. Possibilities for this include employing simulation or animal and cadaveric models. The Thiel-embalmed cadaver can be a reasonable option to complement the surgical trainee's clinical experience in environments in which not enough of these high-risk or low-frequency procedures are performed. In our course, 82.4% of the faculty and 72% of the trainees believed that training with a Thiel cadaver ought to be compulsory during residency training in preparation to performing live colorectal surgery. This could also allow standardization of surgical procedures and a more precise evaluation of surgical capacities across the surgical training system, something that is essential to guarantee that the surgeons-to-be can perform these procedures safely, precisely, and efficiently (1, 13, 14).

Conclusions

Laparoscopic surgical training using Thiel-embalmed cadaver models can be a realistic and feasible option to help develop technical skills in surgical residents and junior consultants. In colorectal surgery, Thiel-embalmed cadaver models allow mastering of specific operations in human anatomy as a previous step to *in vivo* performance.

Declarations

COI/Disclosure:

The authors have no related conflicts of interest to declare.

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Authors' contributions:

- Data acquisition: Maria Isabel Prieto-Nieto, Ines Rubio-Perez, Alexander Forero Torres, Beatriz Diaz San Andrés Díaz, Luis Asensio Gómez.
- Drafting of manuscript: Maria Isabel Prieto-Nieto, Inés Rubio-Perez, Francisco Clascá, Jaime Ruiz-Tovar, Hector Guadalajara Labajo
- Critical revision of manuscript: Francisco Clascá, Jaime Ruiz-Tovar.

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Figures

Figure 1

Set-up of the Thiel cadavers in the cadaver laboratory of the Department of Anatomy and Neurosciences (School of Medicine, Autonoma University of Madrid) for the colorectal surgery skills cours

Figure 2

Organization of teams for the course, resembling a normal colorectal approach. Three trainees rotated positions: lead surgeon, first assistant, and a second assistant with the camera. A faculty member guided the steps of each procedure and answered questions. Note the good quality and realistic appearance of the tissues in the screen.