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Laparoscopic training on Thiel human cadavers: A model to teach advanced laparoscopic procedures

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Abstract
Background Nowadays, the laparoscopic approach represents the gold standard for a wide range of various basic and advanced procedures. To reduce the learning curve in advanced laparoscopic surgery, the search for new teaching tools is of utmost importance. Our experiences with a new teaching tool to train advanced laparoscopic procedures are reported.
Methods Hands-on training courses in colon, hernia, bariatric and vascular surgery using Thiel human cadavers (THCs) were organised by the Swiss Association of Laparoscopic and Thoracoscopic Surgery (SALTS). The courses were held by consultant surgeons expert in the field of minimal invasive surgery (MIS). At the end of each course, data was collected using a standardised, anonymous questionnaire using a Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree). Data are presented as mean ± standard deviation (SD), percentages (%) or total number (*n*), if indicated.
Results From January 2005 to May 2006, six courses (colon = 2; hernia = 2; bariatric = 1; vascular = 1) were organized with a total of 33 participants (31 consultant surgeons; two senior residents). The authenticity of tissue colour, tissue consistency and operative tactility, respectively, were stated for the courses as follows: colon (mean: 4.4/4.2/4.2), hernia (mean: 4.3/4.2/4.0), bariatric (mean: 4.5/4.8/4.3) and vascular (mean: 2.8/2.8/2.6) courses. A high mean overall satisfaction with the courses (colon: 4.0; hernia: 4.2; bariatric: 5.0 and vascular surgery: 4.1) was also observed. All participants of the colon, bariatric, hernia and vascular courses will recommend the courses to other surgeons.
Conclusion Training on THCs might be an excellent additional model to teach advanced bariatric, hernia and colon surgery. However, an important issue that remains to be defined is which training model (THC, anesthetized animals, virtual computer training, etc.) is the most appropriate for the curriculum of the skill or procedure that is being trained.

Keywords Thiel human cadaver · Eeducation · Laparoscopic surgery · Advanced laparoscopic procedures · Colon · Hernia · Bariatric · Vascular

Abbreviations

EAES	European Association of Endoscopic Surgeons
LS	Likert scale
MIS	Minimal invasive surgery
SAGES	Society of American Gastrointestinal and Endoscopic Surgeons
SALTS	Swiss Association of Laparoscopic and Thoracoscopic Surgery

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SETC	SwissEndos Training Centre
SD	Standard deviation
SSS	Swiss Society of Surgeons
TAPP	Transabdominal preperitoneal approach
TEP	Totally extraperitoneal approach
THC	Thiel human cadaver

Since 1985, when the first successful laparoscopic cholecystectomy was performed by Mühe [1], there have been major advances in minimal invasive surgery (MIS). Nowadays, the laparoscopic approach represents the gold standard for cholecystectomy, bariatric, antireflux, colorectal, and hernia surgery. However, laparoscopic surgery requires special skills and, even early in the development of MIS, there was a clear consensus among experts that education in MIS should be intensified. As a consequence, societies and regulatory bodies such as the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the European Association of Endoscopic Surgeons (EAES) have emphasized that the expanding scope of this technology should be coupled with validated training programmes that incorporate inbuilt measures of performance before progressing to real procedures and that minimum requirements for those performing laparoscopic surgery are needed [2, 3].

Today, training on pelvic trainers, cadavers [4], anaesthetized pigs [5], and more recently virtual-reality computer technology has also been applied to laparoscopic training [6, 7]. While phantom operations and virtual-reality computer training enable the acquisition of basic laparoscopic skills, training on anaesthetized pigs offers a unique possibility to teach advanced laparoscopic procedures under in vivo conditions. Nevertheless, this training tool is expensive, anatomical findings differ from the human anatomy, and finally the animals need to be put down.

On the search to reduce the learning curve of advanced laparoscopic surgery, we started to teach different advanced laparoscopic surgical interventions on Thiel human cadavers (THCs). In contrast to standard formalin-embalmed human cadavers, the technique described by Thiel offers excellent conditions with well-preserved tissue colour, consistency and transparency without releasing harmful substances into the environment [8]. We report on our experience of using THCs to teach different advanced laparoscopic procedures.

Material and methods

Course location and infrastructure

The SwissEndos Training Centre (SETC) is a multidisciplinary centre for research and training in endoscopic surgery founded in 1992 by experts in the field of general, orthopaedic and gynaecological minimal invasive surgery (MIS) in collaboration with medico-technical enterprises that provide substantial financial, technical, and logistical support. Currently, about 40 courses are held per year, offering an extensive choice of practical training and specialised courses in surgery, gynaecology, orthopaedics, urology, and further disciplines under the supervision of nationally and internationally recognised experts and instructors in the field of MIS.

The SETC facility includes five modern fully equipped laparoscopic working places simulating the conditions encountered in the operating theatre as well as additional rooms for plenary discussions and didactic lectures. Furthermore, the SETC is located very close (300 metres) to a main district hospital where the course participants are able to attend live MIS performed by senior consultant surgeons in the operating theatres.

Setup and organization of the courses

Since 2003, in close collaboration with the anatomy unit of the University of Fribourg, Swiss Society of Surgery (SSS), and the Swiss Association of Laparoscopic and Thoracoscopic Surgery (SALTS), hands-on courses teaching various advanced laparoscopic interventions using THCs have been established. In contrast to cadavers fixed by conventional procedures using mainly formalin for conservation, which are of limited use for practical surgical courses due to their profound changes of colour, strength, and the fragility of organs and tissues, THCs do not release harmful substances into the environment since the formalin content of the fixation solution is drastically reduced with a final concentration of only 0.8%. Moreover, THCs offer the advantage that organs and tissue retrain their flexibility and plasticity. The articular joints remain freely movable, and the colour of the organs is very similar to the in vivo condition [8, 9].

Initially, three courses were held per year, covering the principal topics of colon-(left/right hemicolectomy), bariatric- (bilio-pancreatic diversion with duodenal switch or standard gastric bypass) and hernia surgery [totally extraperitoneal approach (TEP), transabdominal preperitoneal approach (TAPP)] surgery. In 2005, a vascular course (laparoscopic infrarenal aorto-bifemoral bypass) was also launched. In all courses, the faculty consisted of at least three senior consultant surgeons who were experts in MIS. The senior consultant surgeons, in collaboration with a team of instructors were responsible for the theoretical and practical teaching of the courses. Technical and logistical support was provided by partners from medico-technical enterprises.

Table 1 Details about course participants and their former surgical training

	Colon (n = 9)	Hernia (n = 9)	Vascular (n = 8)	Bariatric (n = 7)
Current academic position; n (%)				
Consultant surgeon	8 (89%)	8 (89%)	8 (100%)	7 (100%)
Senior resident	1 (11%)	1 (11%)	0	0
Former surgical education; n (%)				
>50 laparoscopic interventions	2 (22%)	3 (33%)	1 (13%)	1 (14%)
<50 laparoscopic interventions	7 (78%)	6 (67%)	7 (87%)	6 (86%)
Former minimal invasive training on formalin-embalmed cadavers; n (%)	1 (11%)	4 (44%)	2 (25%)	5 (71%)
Former minimal invasive training on anaesthetized animals; n (%)	6 (67%)	4 (44%)	4 (50%)	6 (86%)
Former virtual computer training; n (%)	3 (33%)	6 (66%)	2 (25%)	5 (71%)

All courses lasted one to two days and were separated into three major teaching modules. Module 1 was a plenary session teaching theoretical knowledge about pathophysiology of disease, diagnosis, operative indications and contraindications, familiarity with alternative treatments, comprehensive principles of pre- and postoperative care, and understanding of prevention, treatment of complications and the relative advantages and disadvantages of both open and MIS techniques. In addition, a detailed step-by-step briefing on anatomical, technical and practical aspects of the planned operative intervention on THC was given. Module 2 consisted of a live demonstration in the operating theatre in the affiliated main district hospital where the participants had the opportunity to study in detail the setup in the operating theatre, the patient positioning and dressing, the technical equipment and MIS performed by senior consultant surgeons.

Module 3 involved surgical training by performing MIS on a THC. Generally, in colorectal and hernia courses a practical training unit consisted of two participants and an instructor (teacher) per THC. However, to assure that each participant had the opportunity to perform the whole surgical procedure as both surgeon and assisting surgeon, vascular and bariatric training courses required two THCs per training unit.

Data collection

Data was collect using a Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree) on a standardized, anonymous questionnaire analyzing more than 20 prospective data items about different course topics, including detailed personal data, personal laparoscopic experience and former training on animal or cadaveric models, tissue colour, and consistency, the efficiency of the theoretical teaching and live surgery modules, technical equipment, authenticity of anatomical findings and the overall satisfaction with the courses. Data are given as mean ± standard deviation (SD), percentages (%) or as absolute numbers (n), if indicated.

Results

Course participants and their previous surgical training (Table 1)

From January 2005 to May 2006, six courses (colon n = 2, hernia n = 2, bariatric n = 1, and vascular n = 1) on advanced laparoscopic surgery were organized with a total of 33 (colon n = 9, hernia n = 9, bariatric n = 7, and vascular n = 8) participants (25 Swiss citizens and eight from countries of the European Union). While the majority of the course participants were consultant surgeons [colon n = 8 (89%), hernia n = 8 (89%), vascular n = 8 (100%), and bariatric n = 7 (100%)] working in public or private clinics, only a small number of them had performed more than 50 laparoscopic interventions as surgeon or assisting surgeon in colon n = 2 (22%), hernia n = 3 (33%), vascular n = 1 (12%) and bariatric n = 1 (14%) surgery throughout their precedent clinical practice. From all courses, 12 (36%) participants had previous training on formalin-embalmed human cadavers, 6 (18%) on anaesthetized animals, and 16 (48%) on virtual computer systems.

Quality assessment of the THC model to teach advanced MIS (Table 2)

The participants stated a high instructive impact of the theoretical and live surgery teaching modules in all courses: colon 4.0 ± 0.8, vascular 4.3 ± 0.4, hernia 4.2 ± 0.3 and bariatric 4.6 ± 0.4 surgery. During practical training, no offensive odours by THCs were reported by any student. Furthermore, the authenticity of the training conditions and

Table 2 Quality assessment of the THC model to teach advanced MIS

	Colon (n = 9)	Hernia (n = 9)	Vascular (n = 8)	Bariatric (n = 7)
I was not disturbed by odours during training on THCs.	5.0 ± 0	5.0 ± 0	5.0 ± 0	5.0 ± 0
Is the quality of tissue and organ colour of THCs comparable to in vivo?	4.4 ± 0.3	4.3 ± 0.5	2.8 ± 0.6	4.5 ± 0.1
Is the quality of organ consistence of THCs comparable to in vivo?	4.2 ± 1.0	4.2 ± 0.9	2.8 ± 1.1	4.8 ± 0.3
Are anatomical conditions on THCs authentic to in vivo findings?	4.5 ± 0.3	4.2 ± 0.4	3.0 ± 1.3	4.7 ± 0.3
Is the operative tactility during training on THCs comparable to in vivo surgery?	4.2 ± 0.4	4.0 ± 0.3	2.6 ± 0.9	4.3 ± 0.4
Is training on THCs superior to anaesthetized animal models?	4.6 ± 0.4	4.4 ± 0.3	3.0 ± 0.5	5.0 ± 0
Is the THC model superior to virtual computer training models?	5.0 ± 0	5.0 ± 0	5.0 ± 0	5.0 ± 0
The theoretical teaching and live surgery modules are of high teaching value.	4.0 ± 0.8	4.2 ± 0.4	4.3 ± 0.4	4.6 ± 0.4
The technical equipment and authenticity of the training conditions at the SETC are of high standard.	4.2 ± 0.3	4.2 ± 0.2	4.5 ± 0.3	4.6 ± 0.2
The courses will help me to improve my laparoscopic skills in my future clinical practice.	5.0 ± 0	5.0 ± 0	4.2 ± 0.5	5.0 ± 0
Overall, I am very satisfied with the course.	4.0 ± 0.3	4.2 ± 0.2	3.7 ± 0.6	4.7 ± 0.2
I will recommend the course to other surgeons.	5.0 ± 0	5.0 ± 0	4.1 ± 0.2	5.0 ± 0

Data are given as (mean ± SD) on a Likert scale; THC = Thiel human cadaver; SETC = SwissEndos Training Centre; n = total number of participants

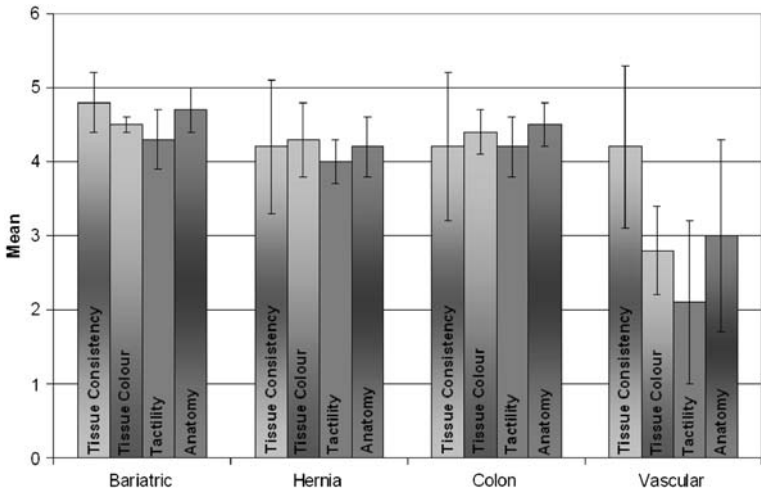

Fig. 1 Quality assessment of tissue colour, consistency, anatomy, and operative tactility Likert scale, data are presented as mean ± SD

the technical equipment at the SETC were found to be almost as realistic (colon 4.2 ± 0.8, hernia 4.2 ± 0.3, vascular 4.5 ± 0.4 and bariatric 4.6 ± 0.4 surgery) as in a real operating theatre.

While the highest authenticity of tissue colour compared to in vivo situations was reported for bariatric training (4.5 ± 0.1), slightly lower agreement was stated for colon (4.4 ± 0.3) and hernia (4.3 ± 0.4) surgery. Furthermore, tissue and organ consistency were also assessed as realistic for bariatric (4.8 ± 0.3), colon (4.2 ± 1.0), and hernia (4.2 ± 0.9) courses. The lowest agreement regarding tissue colour (2.8 ± 0.6) and consistency (2.8 ± 1.1) was observed by the participants of the vascular course. Moreover, when asked about the equality of anatomical findings comparing THC to in vivo situations, agreement or strong agreement was stated by participants of the colon (4.5 ± 0.3), hernia (4.2 ± 0.4), and bariatric (4.7 ± 0.5) training courses. Neither agreement nor disagreement was reported for the vascular (3.0 ± 1.3) course.

Analyzing operative tactility encountered during training on THCs compared to in vivo surgery, almost as realistic conditions were quoted by the participants of the bariatric (4.3 ± 0.4), colon (4.2 ± 0.4), and hernia (4.0 ± 0.3) courses. The tactile conditions simulated by THC models were again ranked as being not very realistic for laparoscopic vascular surgery (2.6 ± 0.9) training (Fig. 1).

Twenty four of all students (63%) had experienced MIS education on anaesthetized animals during their former surgical education. On comparing the overall learning effect by training on a THC model and anaesthetized animals, agreement or strong agreement to the superiority of the THC model was found for colon (4.6 ± 0.4), hernia

(4.4 ± 0.3), and bariatric (5.0 ± 0) courses. Neither agreement nor disagreement was found for vascular (3.0 ± 0.5) training.

Furthermore, a stronger learning effect for training on the THC model compared to virtual computer training was confirmed by all students (colon, bariatric, hernia, and vascular: 5.0 ± 0). Except for vascular training (4.2 ± 0.5), all course participants strongly agreed that the courses will help to improve their future laparoscopic performance in daily practice (colon, hernia. and bariatric: 5.0 ± 0).

The level of overall satisfaction with the courses was found as follows: bariatric (4.7±), hernia (4.2±) colon (4.0±) and vascular (3.7±) courses. All participants reported that they will recommend the courses to other surgeons (bariatric 5.0 ± 0, colon 5.0 ± 0, hernia 5.0 ± 0 and vascular 4.1 ± 0.2).

Discussion

Switzerland still does not have a standardized curriculum for MIS education and there is also no clear statement on the minimal requirements for those performing MIS. In a recently performed survey among Swiss surgical residents, attending surgeons and chief surgeons, 85% of residents, 71% of attending surgeons, and 38% of chief surgeons stated that their residency programme does not prepare them adequately to perform advanced MIS, and moreover 89% of chief surgeons think that they could improve their laparoscopic performance through adequate training courses [10, 11].

Today, there is a clear consensus among experts that operations on pelvic trainers and computer-based virtual-reality simulators can teach basic laparoscopic skills, enabling novice surgeons to progress along the early part of the learning curve [12, 13]. In contrast, there is still no clear consensus on which training tool is best for acquiring advanced laparoscopic procedures skills. Currently, the most frequently used tools to train advanced laparoscopic surgical procedures are operating on formalin-fixed cadavers, anatomical models, and anaesthetized animals.

Therefore, to improve advanced laparoscopic training and to reduce the learning curve of advanced laparoscopic procedures, we started MIS training on THC since these cadavers do not release harmful substances into the environment and in addition the high standards of preservation result in the colour of the organs being very similar to in vivo conditions, tissue and organs retaining their flexibility and plasticity and the articular joints remaining freely movable.

Except for the vascular course, the participants on all other courses agreed or strongly agreed that tissue colour, tissue consistency, anatomical conditions, and the quality of operative tactility during training on THCs are comparable to in vivo findings. The poorer results reported by the participants of the vascular course are related, as stated by all vascular course participants, to the fact that there is a major lack of authenticity if vascular surgery is trained on non-perfused blood vessels. Comparing the THC model to virtual computer training, all course students strongly agreed that the THC model is superior because important training features of the THC model, such as correct positioning of the patient, preparation of the operative field, installation and set up of the technical equipment and surgical team, correct trocar placement, and the creation of the pneumoperitoneum cannot be learned adequately on virtual computer models. Those students of the bariatric, colon, and hernia surgery courses who had undergone training on anaesthetized pigs furthermore agreed or strongly agreed that THC training is more realistic than working on animal models because the anatomy is much more authentic whereas the participants of the vascular course qualified the two training models as being equal. Although THC training was also stated to be superior regarding the authenticity of anatomy, the training of handling large blood vessels and how to cope with bleeding complications is more realistic and can be better obtained by training on anaesthetized animals or anatomical models. Therefore, education on anatomical and/or on anaesthetized animal models remains important, especially for vascular surgery [14].

In all courses, we found that satisfaction with the theoretical teaching, technical equipment, and the overall satisfaction with the courses was very high. These findings demonstrate that the SETC, with its affiliated main district hospital, in collaboration with experts in the field of MIS and the Anatomy of the University of Fribourg offers an ideal and unique infrastructure to teach advanced MIS.

Although, our experiences with the THC training model are promising, suggesting that THCs might be an excellent tool to train advanced laparoscopic procedures, there are also restrictions. First of all, the number of available cadavers is limited since all cadavers are personal donations by will to the Anatomy of the University of Fribourg. Moreover, due to the relatively complex embalming technique, the total costs per cadaver are around 3000 Euro. Therefore, to keep the course fees to an acceptably low level of between 200 and 400 Euro per student, the SETC requires funding from medical industry partners. Therefore, to diffuse the conflict of interests between the surgeons and medical industry, we advocate that national or international surgical or regulatory boards such as the EAES or SAGES should form a common training cooperation between officially designated training centres and the industry. The formation of such training centres will contribute to reducing costs since the management of technical and human resources can be optimized. A key element of an improved resource management will also be individualized

education in laparoscopic training. While operating on pelvic trainers or computer-based simulators should be mainly used to acquire standard skills in laparoscopic surgery, training on anaesthetized pigs or THCs should be restricted to teaching advanced laparoscopic procedures to experienced laparoscopic surgeons. This approach will further reduce the cost and the number of animals or THCs required for laparoscopic training.

Conclusion

Our experience with training advanced MIS demonstrates that the THC model is an additional excellent tool to train bariatric, hernia, and colon surgery. However, before THC training can be routinely incorporated into the surgical curriculum, further studies and experiences with this training tool are needed. First of all, it is necessary to show that there is a transfer of laparoscopic skills from the THC model into daily practice and second, another important issue that remains to be defined is which training model (THC, anesthetized animals, virtual computer training, etc.) is the most appropriate for the curriculum of the skill or procedure that is being trained.

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References

1. Mühe C (1986) Cholecystektomie durch das Laparoskop. Langenbecks Arch Klein Chir 369:804
2. European Association of Endoscopic Surgeons (1994) Training and assessment of competence. Surg Endosc 8:721–722
3. Society of American Gastrointestinal Endoscopic Surgeons. (1991) Granting of privileges for laparoscopic general surgery. Am J Surg 161:324–325
4. Miko I, Furka I, Gamal EM, Metzger P, Sapy P (1997) Details of teaching, learning and training in laparoscopic surgery. Acta Chir Hung 36:230–232
5. Kirwan WO, Kaar TK, Waldron R (1991) Starting laparoscopic cholecystectomy-the pig as a training model. Ir J Med Sci 160:243–246
6. Villegas L, Schneider BE, Callery MP, Jones DB (2003) Laparoscopic skills training. Surg Endosc 17:1879–1888
7. Ali MR, Mowery B, Kaplan B, DeMaria J (2002) Training the novice in laparoscopy-More challenge is better. Surg Endosc 16:1732–1736
8. Thiel W (1992) The preservation of the whole corps with natural colour. Ann Anat 174:185–195
9. Groscurth P, Eggli P, Kapfhammer J, Rager G, Hornung JP, Fasel JDH (2001) Gross Anatomy in the Surgical Curriculum in Switzerland: Improved Cadaver Preservation, Anatomical Models, and Course Develompent. New Anat 265:254–256
10. Räder S, Hahnloser D, Clavien PA (2006) Is training of minimal invasive surgeons in Switzerland adequate? Swiss Knife (special edition) 2006:27. (Abstract)
11. Steinke W, Allemann F (2006) Future professional education in laparoscopic surgery as seen by the chief surgeons in Switzerland – A representative survey. Swiss Knife (special edition): 16. (Abstract)
12. Scott DJ, Bergen PC, Rege RV, Laycock R, Tesfay ST, Valentine RJ, et al. (2000) Laparoscopic training on bench models: Better and more cost effective than operating room experience? J Am Coll Surg 191:272–283
13. Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, et al. (2002) Virtual reality training improves operating room performance: Results of a randomized, double-blinded study. Ann Surg 236:458–463
14. von Segesser LK, Westaby St, Pomar J, Loisance D, Groscurth P, Turina M (1999) Less invasive aortic valve surgery: rationale and technique. Eur J Cardiothorac Surg 15:781–785