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Does rating with a checklist improve the effect of E-learning for cognitive and practical skills in bariatric surgery? A rater-blinded, randomized-controlled trial

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Abstract

Background Mental training of laparoscopic procedures with E-learning has been shown to translate to the operating room. The present study aims to explore whether the use of checklists during E-learning improves transfer of skills to the simulated OR on a Virtual Reality (VR) trainer for Roux-en-Y gastric bypass (RYGB).

Methods Laparoscopy naive medical students ($n=80$) were randomized in two groups. After an E-learning introduction to RYGB, checklist group rated RYGB videos using the validated Bariatric Objective Structured Assessment of Technical Skills (BOSATS) checklist while group without checklist only observed the videos. Participants then performed RYGB on a VR-trainer twice and were evaluated by a blinded expert rater using BOSATS. A multiple choice (MC) knowledge test on RYGB was performed. Suturing on a cadaveric porcine small bowel was evaluated using objective structured assessment of technical skill (OSATS).

Results Checklist group was better in the knowledge test (A 8.3 ± 1.1 vs. B 7.1 ± 1.3; $p \leq 0.001$) and there was a trend towards better VR RYGB performance (BOSATS) on the first try (85.9 ± 10.2 vs. 81.1 ± 11.5; $p=0.058$), but not on the second try (92.0 ± 9.7 vs. 89.3 ± 10.5; $p=0.251$). Suturing as measured by OSATS was not different (29.5 ± 3.0 vs. 29.0 ± 3.5; $p=0.472$).

Conclusion This study presents evidence that the use of a BOSATS checklist during E-learning helps trainees to improve their knowledge acquisition with E-learning. The transfer from mental training to the simulated OR environment seems to be partially enhanced by use of the BOSATS checklist. However, more research is required to investigate potential benefits.

Keywords Minimally invasive surgery · Obesity · Checklist · Training · Virtual reality · Multiple choice test

Abbreviations

BOSATS	Bariatric objective structured assessment of technical skill
MC	Multiple choice
MIS	Minimally invasive surgery
OR	Operating room
OSATS	Objective structured assessment of technical skills
RYGB	Roux-en-Y gastric bypass
VR	Virtual reality

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Obesity has been on the rise throughout the past decades becoming a worldwide disease; consequently, an increase in the number of obesity surgeries is well documented in the literature [1, 2]. Minimally invasive surgery (MIS) plays a significant role in obesity surgery. Surgeons are in need of different skills and abilities as compared to open surgery [3, 4]. The requirement for these specific technical skills has stimulated the development of new training programs outside of the operating room (OR) using different training modalities [5, 6]. Traditionally, residents and surgeons in training practice laparoscopic basic and advanced skills while assisting surgeons in the OR. If they have not acquired sufficient skills outside the OR, their MIS training is delayed [7, 8]. Virtual reality (VR) has demonstrated, throughout previous publications, to be a secure and competent training modality for MIS developing a virtual atmosphere for laparoscopic basic skills and operations [9, 10]. Other modalities have also been introduced for MIS training in a safe environment outside the OR. Box trainers provide training on drills, models and real tissue with real instruments and tissue feeling [11]. VR-trainers provide a validated and repeatable training of operative skills outside the OR [12, 13].

E-learning complements the technical skills training by adding mental training for key steps and other important knowledge needed for performance of laparoscopic surgeries. E-learning websites help surgeons and residents by implementing videos of different surgical procedures with surgical technique descriptions, the related anatomy, and peri- and post-operative management [14, 15]. E-learning has become popular over the last decade due to laparoscopic surgical video recording combined with the World Wide Web [16]. E-learning modalities have proven to be effective and mental training has been shown to translate to the OR, both alone and with the merger of other trainings i.e., VR-trainer [17]. The use of checklists for surgical training has been shown to enhance learning effects [9].

Laparoscopic Roux-en-Y gastric bypass (RYGB) is one of the most frequently performed obesity surgeries [18, 19]. It has proven successful for sustainable weight-loss, improvement of comorbidities, and improvement of quality of life [20]. RYGB can be a technically challenging procedure for surgeons and trainees. In order to perform a safe and effective surgery, trainees should first learn the basic MIS technical skills [21]. Bariatric objective structured assessment of technical skill (BOSATS) is currently the only procedure-specific rating scale specifically created and validated for use in RYGB and has proven to enhance feedback and learning curves for obesity surgery trainees [22, 23].

The present study aimed to explore whether the use of checklists enhances the skills acquisition from E-learning. Therefore, the transfer from mental training to a simulated RYGB-operation performed on a VR-trainer is assessed.

Materials and methods

Participants

Medical students ($n=80$) between their third and sixth year (clinical years) of studies without experience in laparoscopic surgery were included in the study. Exclusion criteria were students who were not in their clinical years or who had already participated in basic laparoscopy training courses for more than 2 h, or who had experience assisting in laparoscopic surgeries for more than 2 h. Trainees were randomly allocated to either the checklist group or no checklist group. The randomization of subjects was performed using sealed envelopes by an employee of the Department of Surgery at Heidelberg University otherwise not involved in the study. Trainees were allocated to groups without stratification by gender or previous operative experience. Ethical approval was obtained from the Ethics Committee of the Medical Faculty at Heidelberg University prior to the beginning of the study (Code S-334/2011, Amendment 07/05/2012).

Study design and settings

This was a prospective, single-center, two-arm, parallel group randomized controlled trial in the MIS training center of the Department for General, Visceral, and Transplantation Surgery at Heidelberg University. The study protocol was officially registered in the German Clinical Trials Register (DRKS00010493) and was recently published [24].

Training for laparoscopic Roux-en-Y gastric bypass

All trainees had 10 h of basic laparoscopic technical skills training with a structured curriculum of laparoscopic suturing and knot tying exercises on box trainers first. The trainees then worked with E-learning modalities for 3 h as an introduction to RYGB after randomization. This was done in a standardized fashion by using the same room at the Department of Surgery at Heidelberg University Hospital with identical surrounding conditions in order to rule out any difference between trainees. All trainees were given an explanatory introduction by trained staff in a standardized way to begin the RYGB E-learning modalities on http://www.webop.de and http://www.websurg.com. During the introduction, trainees were asked to study and understand the anatomy, illustrations, and videos of the surgical technique. Following this general overview, all participants watched three anonymous RYGB videos to get a clearer view of the surgical techniques. Checklist group rated the correct performance of the operative technique with the BOSATS checklist for each video they

Table 1 Bariatric objective structure assessment of technical skills (BOSATS) scale

Step 1: Dissection of the gastro-phrenic ligament and creation of gastric pouch			
	1	2 3	4 5
Task			
Pull fundus of stomach Down (exposure)	Insufficient retraction; traumatic; insufficient exposure	Satisfactory retraction after some repositioning; suboptimal exposure	Appropiate retraction; optimal exposure
Dissect angle of His close to stomach while keeping tension on fundus	Dissection in incorrect plane; insufficient or too much tension; bleeding	Dissection in correct plane; appropiate tension majority of time; occasional tissue damage, bleeding	Dissection in correct plane; careful handling of tissue; appropiate tension at all times; minimal tissue damage, bleeding
Dissect along lesser curvature of stomach approx. 7 cm from the gastro-esophageal junction and keep close to stomach	Incorrect plane; incorrect anatomic location; excessive tissue trauma; bleeding with need of suction	Correct plane developed with some difficulty; moderate tissue damage; bleeding not requiring suction	Correct plane in correct anatomic location developed without difficulty or excessive tissue trauma, bleeding
Create a posterior tunnel	Dissection in incorrect plane; unnecessary force; bleeding requiring suction	Dissection in correct plane; occasional tissue damage; bleeding not requiring suction	Dissection in correct plane; careful handling of tissue, minimal tissue damage, bleeding
Introduce and apply a linear cutting stapler transversely to the stomach	Stapler applied in incorrect orientation; serosal damage to stomach	Stapler applied transversely after multiple repositioning attempts	Stapler applied transversely; no requirement for multiple repositioning attempts; no trauma

Table 1 (continued)

			to stomach wall
Remove all tubes from the stomach before firing the stapler	Not done	Done after delay; with prompting	Done without delay or making sure the tube is not stapled (by movement)
Fire stapler	Uncontrolled fire with excessive pull on the stomach	Controlled fire; some slippage of stomach between jaws	Smooth, controlled fire
Develop a posterior tunnel towards the angle of His	Dissection in incorrect plane; unnecessary force; bleeding requiring suction	Dissection in correct plane; occasional tissue damage; bleeding not requiring suction	Dissection in correct plane; careful handling of tisse, minimal tissue damage, bleeding
Introduce and apply another linear cutting stapler to the stomach	Stapler applied in an incorrect orientation; serosal damage to stomach	Stapler applied correctly; multiple repositioning attempts	Stapler applied correctly; no repositioning required; no trauma to stomach wall
Fire stapler	Uncontrolled fire with excessive pull on the stomach	Controlled fire; some slippage of stomach between jaws	Smooth, controlled fire
Confirm complete transection of stomach	Not confirmed	Confirmed briefly without adequate visualization	Methodical confirmation of complete transection
Time:			

Table 1 (continued)

Step 2: Location of Treitz ligament and measurement			
	1	2 3	4 5
Task			
Location of ligament of Treitz	Not found	Rough movements; poor orientation	Smooth movements; correct orientation
Measure approximately 40–60 cm of jejunum distal to the ligament of Treitz	Length not measured	Measured, however individual measurements not of the same size; poor orientation	Measured methodologically; each measurement of the same size; correct orientation
Time:			

Step 3: Creation of gastro-jejunal anastomosis with linear stapler technique			
	1	2 3	4 5
Task			
Create a gastrotomy in the gastric pouch	No entry into gastric lumen; poor relation between grasper and energy source; excessively large or small; penetration of posterior bowel wall; bleeding	Entry into gastric lumen; appropriate size; more than one attempt required	Entry into gastric lumen; appropriate size; no extra movements required
Create an enterotomy in the Roux limb	No entry into bowel lumen; poor relation between grasper and energy source; excessively large or small; penetration of bowel wall	Appropriate size and entry into bowel lumen; not placed in antimesenteric location	Appropriate size and placement of enterotomy; good relation of grasper and energy source; no extra movements required

Table 1 (continued)

Introduce one limb of linear cutting stapler into gastric pouch and the other into Roux limb	Unclear of how to insert the staple device; drives staple jaws blindly into the enterotomies	Inserts the stapler, but lacks appreciation of the ideal angle for insertion	Inserts staple jaws with ease; controlled manner; correct angle
Ensure both limbs are symmetrical before firing the stapler	Does not ensure symmetry, antimesenteric location of stapler before closing of jaws	Limbs either nonsymmetrical or not in antimesenteric border before closure of jaws	Correct symmetry and antimesenteric position before closure of jaws
Fire stapler	Uncontrolled fire with excessive pull on the bowel and widening of enterotomies	Controlled fire; some slippage of bowel from jaws	Smooth, controlled fire; no widening of enterotomies
Time:			

Step 4: Creation of jejuno-jejunal anastomosis with linear stapler technique			
	1 2	3	4 5
Task			
Create enterotomies in Bilio-pancreatic and Roux limbs	Poor relation between grasper and energy source; excessively large or small; penetration of posterior bowel wall	Appropriate size enterotomy; not placed in antimesenteric location	Appropriate sized and placed enterotomies; no extra movements. Good relation of grasper and energy source
Insert the limbs of linear cutting stapler into the enterotomies	Unclear of how to insert the staple device. Drives staple	Inserts the stapler with hesitation and lacks appreciation of	Inserts staple jaws with ease; controlled manner; correct angle

Table 1 (continued)

Insert the limbs of linear cutting stapler into the enterotomies in Roux and Bilio-pancreatic limbs	Unclear of how to insert the staple device. Drives staple jaws blindly into BP and Roux limb	Inserts the stapler with hesitation and lacks appreciation of the ideal angle for insertion	Inserts staple jaws with ease; controlled manner; correct angle
Ensure both limbs are symmetrical and stapler in antimesenteric border	Does not ensure limb symmetry and antimesenteric position before enclose of jaws	Limbs either non-symmetrical or not on antimesenteric border before closure of jaws	Correctly ensure symmetry and antimesenteric position before closure of the jaws
Fire stapler	Uncontrolled fire with excessive pull on the bowel and widening of enterotomies	Controlled fire; some slippage of bowel from jaws	Smooth, controlled fire; no widening of enterotomies
Time:			
Total Time:			
Additional measures			
	1	2 3	4 5
Help needed during performance	Ask a lot of questions and needed assistance	Few questions and few assistance needed	Few questions but no assistance needed
Total score:			

watched (Table 1) after receiving a standardized introduction for the use of OSATS, while no checklist group did not use a checklist while watching the videos.

Post-test

Both groups performed a post-test on the VR-trainer (LapMentor II, 3D Systems, Rock Hill, USA) after the E-learning sessions, offering a simulation of four, previously validated major steps of the RYGB-procedure [12, 25]. All steps were performed twice, on different days. The performance was rated by a blinded expert with a modified BOSATS checklist. The rater underwent dedicated training to enable consistent assessment based on BOSATS. Additionally, the rater himself was a surgeon proficient in bariatric surgery. The BOSATS checklist includes different aspects of the procedure, not only rating whether or not a step is performed, but also how well it is performed. Each item is judged on a scale of 1–5. The BOSATS checklist was shortened to match the four major steps with sub-steps offered by the VR-trainer (maximum of 115 points): (1) Dissection of the gastrophrenic ligament and creation of the gastric pouch (max. 55 points), (2) Location of Treitz ligament and measurement (max. 10 points), (3) Creation of gastro-jejunal anastomosis (max. 25 points), (4) Creation of the jejuno-jejunal anastomosis (max. 20 points) (Table 1).

Additional tests

The additional test included placing laparoscopic sutures on a 3-cm standardized incision on cadaveric porcine small bowel in a box-trainer. This was again rated by a blinded expert with a modified objective structured assessment of technical skill (OSATS) originally developed by Chang et al. [10]. The OSATS checklist consists of a procedure-specific component and a global rating checklist, thus taking into account not only whether or not the procedure is performed correctly but also rating the quality of the performance. To match our setup, delivery and removal of suture were not evaluated; therefore, a maximum amount of 37 points were possible. Additionally, a knot quality checklist, measuring accuracy, tightness at base, tension and opposition of edges on a 5-point scale [26], was used to evaluate the performance.

As a last step, all trainees had to take a non-validated multiple choice (MC) technical knowledge test consisting of ten questions with one correct answer each to evaluate their knowledge on the RYGB technique after the training curriculum (Table 2). Questions were based on the knowledge taught during the E-learning materials and additional literature.

Statistical analysis

For both groups, the distribution of continuous data was presented using mean and standard deviation (SD), and for categorical variables, absolute and relative frequencies were used. Performances between both groups were compared using a t test, after assessing data for normality. The BOSATS is compared for each step separately as well as the sum of all steps. Due to the exploratory nature of the study, resulting p values were interpreted descriptively. Analyses were performed using SPSS version 22. Sample size calculation was done based on data by Zevin et al. [22] and adopted to the modified BOSATS. Details concerning the calculation can be found in the study protocol [24].

Results

Eighty trainees were randomized into a checklist group ($n = 36$) and no checklist group ($n = 44$). Baseline characteristics were distributed equally between groups (Table 3). All trainees completed the study.

BOSATS scores and training time for both RYGBs performed on the VR-trainer are found in Table 4. For the first RYGB on the VR-trainer, there was a trend towards better BOSATS for the checklist group (Table 4), resulting mainly from the differences in steps 2 and 4. For the second RYGB on the VR-trainer, results were similar for both groups. However, step 4 still showed a trend towards a better performance in the checklist group (Table 4). The total BOSATS scores improved from the first to the second try of the VR RYGB within both group [Mean difference: 6.1 (1.4;10.8); $p = 0.013$] and no checklist group [Mean difference: 8.2 (5.0;11.3); $p < 0.001$] (Fig. 1).

In the MC knowledge test, the checklist group scored higher than the group without checklist (8.3 ± 1.1 vs. 7.1 ± 1.3; $p < 0.001$) (Fig. 2). In the laparoscopic suturing and knot tying on the cadaveric porcine small bowel, both groups performed similar with regard to OSATS scores and knot quality (first try OSATS score: checklist 29.5 ± 3.0 vs. no checklist 29.0 ± 3.5; $p = 0.472$, first try knot quality score: checklist 4.5 ± 1.2 vs. no checklist 4.4 ± 1.2; $p = 0.855$; second try OSATS score: checklist 29.7 ± 3.0 vs. no checklist 29.7 ± 2.8; $p = 0.913$; second try knot quality score: checklist 4.3 ± 1.3 vs. no checklist 4.6 ± 0.8; $p = 0.280$).

Discussion

In the present study, the use of a BOSATS checklist for scoring operation videos during E-learning for RYGB resulted in partially improved scores for RYGB procedures performed on a VR-trainer. Besides, the checklist group also demonstrated a significantly better knowledge acquisition as reflected in improved MC test results compared to the no checklist group.

Gianotti et al. [12] suggested that VR-trainers can be easily used for training and certification in obesity surgery. Furthermore, other studies found that VR-training improves technical performance in the OR [27, 28]. Therefore, VR simulation was chosen to evaluate laparoscopic skills for RYGB. Prior training in laparoscopic knot tying and suturing aimed to teach medical students laparoscopic basic skills (such as depth perception and instrument handling) in order to allow a detection of procedure-specific skills rather than the speed of familiarization with laparoscopic instruments. However, even mastering basic skills requires structured training. Therefore, a complex procedure such as RGYB, with different reported learning curves between 30 and 500 procedures for optimal perioperative outcomes [29–31], will not be mastered in two attempts. Nevertheless, this study aimed to evaluate the very initial learning curve and how it can be influenced by using a checklist during E-learning. With a focus on general technical aspects and identification of a simple anatomy during E-learning, we assumed that the differences can best be seen in the initial procedures performed.

Table 2 Multiple choice knowledge test

1. Which ligament should be dissected as a first step of a Laparoscopic Roux-en-Y gastric bypass (RYGB)?

A) Gastro-colic C) Gastro-phrenic
B) Spleno-renal D) Gastro-splenic

2. For the gastric pouch, dissection should begin at the lesser curvature of the stomach _____ cm from the gastro-esophageal junction.

A) 7 cm C) 4 cm
B) 10 cm D) 12 cm

3. For the gastric pouch, a posterior tunnel has to be dissected towards the _________.

A) Incisura Angularis C) Angle of His
B) Pylorus D) Spleen

4. For the Roux limb creation, which ligament should be found?

A) Round ligament C) Hepato-duodenal
B) Treitz D) Gastro-colic

5. For the Roux limb creation, what gastrointestinal segment needs to be measured?

A) Duodenum C) Jejunum
B) Ileum D) Colon

6. What is the approximate length of the Roux limb?

A) 25-35 cm C) 100 cm
B) 70-90 cm D) 40-60 cm

7. For the gastro-jejunal anastomosis, what is the location for the jejunum's enterotomy?

A) Anterior location C) mesenteric location
B) Anti-mesenteric location D) Posterior location

8. Which instrument is mainly used for the creation of enterotomies?

A) Dissector/Maryland C) Scissors
B) Harmonic scalpel D) Grasper

9. For the creation of the Bilio-pancreatic limb, does the surgeon measure the alimentary limb?

A) YES B) NO

10. How many staple fires are usually required for a jejuno-jejunal anastomosis?

A) 1 staple C) 2 staples
B) 3 staples D) 4 staples

Table 3 Demographics

	Group with checklist $n=36$	Group without checklist $n=44$	p value
Age (mean ± SD)	23.4 ± 3.5	23.1 ± 3.5	0.696
Sex			0.928
Male	20	24	
Female	16	20	
University semester (mean ± SD)	6.6 ± 1.4	7.3 ± 1.8	0.100

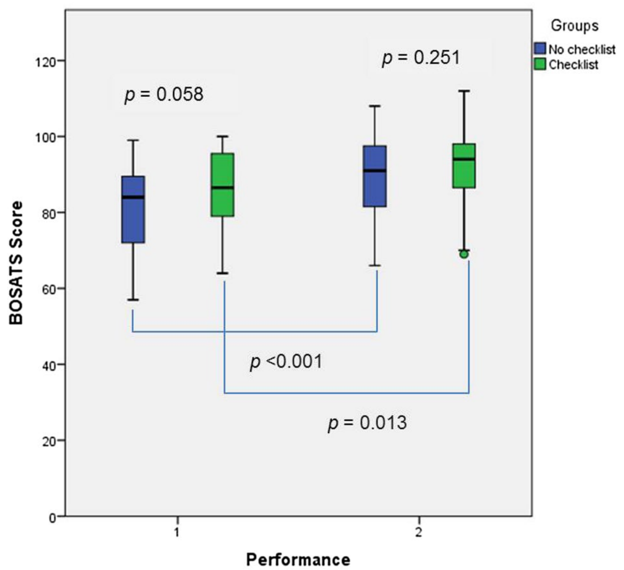

Fig. 1 Comparison of performance in the BOSATS checklist between checklist group and no checklist group and comparison in the total BOSATS scores from the first and the second try on the VR RYGB within both groups

The structured curriculum, based on videos and written information, is likely to have helped trainees by understanding the anatomy involved in the surgery, as well as the explanation of surgical principles, management, and their practical implementation performed by real surgeons. As trainees from the present study improved their performance on the second RYGB, these results indicate that VR-training could be a helpful adjunct for surgical education. On the other side, these findings need to be interpreted carefully, since group differences were significant, but small. Therefore, more research on the learning curve as well as on transferability and practical relevance is needed to confirm this finding.

The checklist contributed to a better cognitive understanding of the procedure since trainees scored significantly higher in the multiple choice knowledge test and partially improved skill transfer to a simulated bariatric procedure. Zevin et al. [22] concluded that the implementation of the

Table 4 Results for RGYB performed on the Virtual Reality Trainer

	Group with checklist	Group without checklist	p value
First RYGB			
Overall BOSATS	85.9 ± 10.2	81.1 ± 11.5	0.058
Step 1	40.8 ± 5.9	38.9 ± 5.9	0.159
Step 2	8.2 ± 1.1	7.4 ± 1.3	0.004
Step 3	19.1 ± 2.5	18.3 ± 3.1	0.275
Step 4	15.4 ± 2.4	14.4 ± 2.9	0.098
Total time (min)	18.1 ± 3.5	18.0 ± 3.5	0.973
Second RYGB			
Overall BOSATS	92.0 ± 9.7	89.3 ± 10.5	0.251
Step 1	42.2 ± 2.8	41.9 ± 5.3	0.805
Step 2	8.8 ± 0.9	8.5 ± 1.4	0.235
Step 3	20.2 ± 2.8	19.2 ± 2.9	0.136
Step 4	16.5 ± 1.6	15.6 ± 2.5	0.093
Total time (min)	14.5 ± 3.9	14.0 ± 2.9	0.475

Step 1 = dissection of the gastro-phrenic ligament and creation of gastric pouch

Step 2 = location of Treitz ligament and measurement

Step 3 = creation of gastro-jejunal anastomosis with linear stapler technique

Step 4 = creation of jejuno-jejunal anastomosis with linear stapler technique

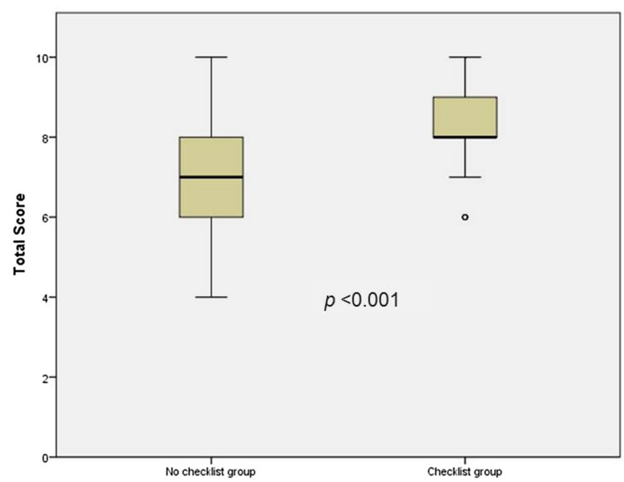

Fig. 2 Comparison of Multiple Choice Test scores between checklist group and no checklist group

BOSATS score checklist is expected to simplify practice for future bariatric surgery certification. In the literature, there are studies that used the modality of video rating surgical skills using different checklists. A study by Alam et al. [32] showed that the use of an OSATS checklist for video rating appears useful and reliable for dermatologic surgical skills evaluation. The use of a checklist to rate surgical videos prior to hands-on training as means of surgical education was not well explored so far and seems promising, although more research is needed.

OSATS is considered valid for feedback or measuring progress of training [33]. Results in the present study showed no significant difference between both groups regarding the OSATS score while suturing a cadaveric porcine small bowel. Direct rating with an OSATS score checklist by an expert helped trainees to understand each step in laparoscopic suturing. Nickel et al. [34] concluded in a previous publication that direct OSATS rating was better than endoscopic video rating for differentiating between students or novices and experts and should remain the standard approach for the discrimination of experience levels. In the present study, participants already had 10 h of previous laparoscopic suturing experience. Thus, even though trainees performed the cadaveric suturing twice, there was no significant difference between performances. This was useful in the present study as a control test since the groups had identical training and did not differ in the suturing skills.

Limitations of the study

Trainees were medical students and had limited surgical skill and obesity surgery experience, and this may limit transferability to more experienced surgical trainees. On the other hand, the inclusion of laparoscopy-naïve medical students allowed a better differentiation of intervention effects as the study groups were very homogenous concerning surgical experience. In addition, the students had a total of 10 h laparoscopy training using the box trainer and the VR-trainer before performing the virtual RYGB after extensive E-learning for this procedure. Originally, BOSATS was not developed for medical students and therefore it might not be possible to compare students with experienced surgeons with this score. In this study however, it was only used to compare two homogeneous groups which also underwent previous training in laparoscopy. Thus, the results of the present study enable improved use of E-learning for bariatric surgery training curricula.

Conclusion

In the present study, surgical trainees were given a checklist to accelerate the acquisition of cognitive skills during E-learning for obesity surgery and to improve translation to practical performance of obesity surgery in a simulated virtual training environment. Knowledge acquisition was higher after training with the checklist and proved beneficial. Translation to practical and technical performance of a virtual RYGB was partially improved. Further studies should investigate the benefits of incorporating checklists into training curricula.

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Compliance with ethical standards

Disclosures Javier R. De La Gaza M.D., Mona W Schmidt, Karl-Friedrich Kowalewski, M.D.˒ Laura Benner, Philip C. Müller M.D., Hannes Kenngott M.D., Lars Fischer M.D., Beat P. Müller-Stich M.D., Felix Nickel M.D. have no conflict of interest or financial ties to disclose.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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