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Choosing the right physical laparoscopic simulator? comparison of LTS2000-ISM60 with MISTELS: validation, correlation, and user satisfaction

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Abstract

BACKGROUND: The LTS 2000-ISM60 (LTS; Realsim Systems, Alburquerque, NM, USA) is a computer enhanced video-laparoscopic training system. Our purpose was to validate the LTS and to correlate its scoring performance with that of the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS), a widely used and well-validated physical simulator.

METHODS: Participants (n = 124) included medical students, residents, fellows, and attending surgeons from general surgery, gynecology, and urology in 3 Canadian universities. They were classified in groups based on laparoscopic experience: novice, intermediate, competent, and expert. Participants (n = 124) were tested on the LTS, and 74 were tested on both the LTS and the MISTELS. A user satisfaction questionnaire was completed after each performance.

RESULTS: LTS metrics showed a progressive improvement in total scores according to academic level as well as level of laparoscopic experience ($P < .001$). Good correlation was found between the LTS and the MISTELS ($r = .79$). Level of user satisfaction was highest with LTS.

CONCLUSIONS: Based on laparoscopic experience and academic level, the LTS has a comparable discriminating capability for level of performance with that of the MISTELS. The higher degree of user satisfaction attributed to the LTS could justify its use as a training and assessment tool for surgical specialties.

The domain of surgical education is undergoing major changes. The advancement of teaching methods, especially of simulation tools, is a boon to the teaching of techniques with steep learning curves, such as minimally invasive surgery. In general, laparoscopy is widely used in the fields of general surgery, gynecology, and urology. Laparoscopy is performed in a sometimes disorienting, two-dimensional, video-controlled environment and requires superior ambidexterity, hand–eye coordination, and depth perception. These skills may not be directly transferable from skills acquired performing open surgery, and many believe that

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they are not best learned by the "Halsted" model of graded responsibility, which has been prevalent in surgical education for the last century.[1–3] Residents' decreased workload, the increasing complexity of cases, and, most importantly, the patients' expectations that their surgeon will possess competent skills before operating on them, are all driving forces for a major paradigm shift in medical education, especially in surgical teaching.[4,5] The traditional experience-based model of education must evolve toward a program that requires documentation of proficiency.[4–6] The increasing quality and availability of simulation tools make the establishment of simulation programs and centers more accessible to universities. The opportunity to train outside the operating room enables the trainee to acquire technical skills in a safe and relaxed environment.[3,6–10] Because simulator training for any surgical technique requires an investment in both equipment and time, it is important that this investment be justified with proof of the value of simulators.[3,8] A laparoscopic simulator should be portable, reproducible, and flexible. Its metrics should be easy to administer and should give useful feedback information to the user, and the user should be satisfied that he or she is having an effective learning experience. How do you choose the right simulator? This study focused principally on physical simulators rather than virtual-reality simulators. Even with the options of motion analysis and upgrading software, the purchase of virtual-reality simulators at high cost may not be justified for every simulation center, except in a well-organized research context. Their haptics are still primitive, they are somewhat inflexible in terms of equipment, and their systems are not intuitive.[6] To some extent, they showed promising results compared with physical simulators, but this was not the object of the present study.

MISTELS

The MISTELS system (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills) was designed to objectively assess basic laparoscopic skills through a series of structured tasks performed under video guidance in a trainer box using standard laparoscopic instruments. Based on its psychometric qualities, which were validated in several published studies, it has become widely accepted for training and assessment of laparoscopic skills.[3,11–19]

Table 1 LTS task descriptions

Task no.	Description
1	Peg transfer
2	Ring manipulation (right)
3	Ring manipulation (left)
4	Cannulation (right)
5	Cannulation (left)
6	Roeder-type knot
7	Application of knot on vertical tube
8	Extracorporeal knot on horizontal tube
9	Intracorporeal knot and tension test
10	Cutting circle

Table 2 Characteristics of both simulators

Characteristics	MISTELS	LTS
No. of tasks	5	10
Tensiometer		X
Advantages		
Cost (USD)	1500	18800
Electronic scoring		X
Interactive user feedback		X
Digital capture of performance		X
Portable	X	X

LTS

The Laparoscopic Training Simulator (LTS) 2000 with interactive sensory module (ISM) 60 is a portable physical simulator[20,21] based on the MISTELS and improved by integrating computer-based electronic scoring, interactive user feedback, and digital capture of performance data.[22,23] Ten laparoscopic tasks are available (Table 1). Five activities (tasks number 1, 7, 8, 9, and 10) were adapted from the MISTELS, and five (tasks numbers 2, 3, 4, 5, and 6) were added at the suggestion of laparoscopic experts (G. M. Fried and H. H. Hasson) and validated for the first time by Fichera et al in 2005.[23]

Comparison with the MISTELS is important to validate the LTS and to justify its higher capital cost. A basic description of the 2 simulators is found in Table 2. This multicentric multispecialty prospective study was undertaken to document the construct validity and the reliability of the LTS simulator. The performances, as well as user satisfaction levels, of the LTS and MISTELS were compared.

Methods

Equipment

The MISTELS is a bench-model simulator that includes 5 tasks in an inanimate box. Performance is scored by speed (time) and precision (penalties). The simulator consists of a laparoscopic trainer box measuring 40 × 30 × 19.5 cm covered by an opaque membrane. Two 12-mm trocars are placed through the membrane at convenient working angles on either side of the monocular optical system. The video monitor is placed in line with the operator. Alligator clips and Velcro within the simulator are used to secure materials for the various exercises. The optical system is standardized by its location and field of view. This enables the examinee to work independently. An instructor is present to standardize the testing, ensure appropriate placement of models for the tasks, and grade the student by recording elapsed time and penalty scores. The MISTELS is portable and can be easily carried in a briefcase-sized carrying bag and connected to any TV, monitor, or laptop.

The LTS is an inanimate physical simulator with a similar format to MISTELS, but it offers an automatic electronic scoring system. The system incorporates physical sensors embedded in each module to computerize scoring. Ten tasks are presented in a carousel and scored for speed and precision. A tensiometer is used to verify knot security for suturing tasks up to a disruptive force of 2.5 lb (1 kg). For the purpose of the study, setup conditions were standardized across centers. They include configuration of the floor mat (including height), position of the ISM60 carousel on the mat, position of the primary and secondary trocars, camera type, and light source. A stand-alone camera and external light source are fixed in the box. Although every task can either be manually or automatically started and ended, an instructor is present to standardize the testing during the study.

Subjects

The results of this study was undertaken within 3 surgical specialities (general surgery, gynecology, and urology) at 3 Canadian universities: the University of Montreal (principal investigating center), McGill University, and Dalhousie University. The candidates were medical students, residents, fellows, and attending surgeons with varying degrees of experience in laparoscopic surgery. Each center was asked to provide a minimum of 12 participants per specialty distributed equally by academic level. Each center was also asked to recruit 4 medical students. Therefore, each center was required to test a minimum of 40 candidates. In each center, a coinvestigator and a research assistant were responsible for recruitment. Most of the participants were informed of the project at the beginning of their rotation by their program director or his or her secretary. Advertising was also done at the beginning of each specialty's grand rounds. Most of the attending surgeons were recruited by one-on-one meetings. All participation was voluntary. The obtained results were coded and kept confidential. None of the information obtained during this study was used to evaluate the competency or technical ability of residents or physicians. The information will never be available or transmissible to program or department directors. To maintain confidentiality, testing was supervised by the research assistant only. Institutional Review Board approvals were obtained from the University of Montreal, McGill University, and Dalhousie University.

Because timing of exposure to laparoscopic surgery and timing of surgical skills teaching activities can vary considerably during residency training across specialties and universities, it was decided to classify the participants according to their self-estimated laparoscopic experience as well as their level of training (academic level). After recruitment, the participants were divided into 4 groups based on their self-estimated level of experience as defined by the Accreditation Council for Gynecologic Endoscopy for gynecology and by the Society of American Gastrointestinal Endoscopic Surgeons for general surgery. This classification separated the participants using a combination of the quantity (levels 1 to 3) and complexity (level 4) of procedures performed. Complexity was defined as difficulty of the surgery itself or its requirements for superior technical abilities and experience (Table 3).

Table 3 Laparoscopic experience levels

Novice
Has no previous experience in laparoscopy
Has performed <5 laparoscopic procedures
Intermediate
Has performed 6–49 laparoscopic procedures
Competent
Has performed ≥50 standard laparoscopic procedures
Expert
Has performed ≥50 advanced procedures

The required number of participants was calculated from data obtained during a previous study comparing 2 simulators, including the MISTELS (five tasks shared with LTS and the same scoring system).[24] It was expected that the number of participants would give enough power (80%) to detect significant difference of at least 15% (320 points of a maximum of 2100) between categories at the alpha level of 5%. A minimum of 30 participants/category (novice, intermediate, competent, and expert) was needed (n = 120). It was estimated that by recruiting participants equally distributed by academic level (easier for recruitment), we would get enough subjects in each experience level. By the middle of the study, data were analyzed. The correlation between the simulators was found to be >.80. Only the LTS was tested thereafter to facilitate recruitment (less testing time).

Research design and procedures

The study was conducted during a 12-month time period. Informed consent was obtained from each participant. A demographic questionnaire was answered by each participant and automatically entered in the computer. A questionnaire listing all types of surgeries (basic and complex) that could be performed in the involved surgical specialties was distributed to each participant. It served to quantify and evaluate their laparoscopic experience as first surgeon and to classify them into 1 of the 4 categories. Each participant had a unique identifying number consisting of digits identifying the study center, the specialty, and the order of participation. A demonstration CD for the LTS was shown to all candidates before initial testing. The CD demonstrated guidelines for performing each structured task. The participant was then prompted to perform the peg-transfer task (number 1) to gain familiarity with the simulator; this was followed by testing the same task. Each task or group of related tasks was again demonstrated by playing the CD before performing the exercise. An average of 60 minutes was expected for each participant to complete the 10 tasks. Each task had a predetermined maximal execution time; if it was not completed within the allotted time, the score was recorded as zero. In each study center, the participants were then asked to also perform tasks on the MISTELS physical simulator. The 5 tasks on the MISTELS were expected to take an average of 40 to 60 minutes to complete. To minimize external practice effect, participants were asked to perform on both simulators within 2 weeks without additional exposure to any simulator.

Outcome measures

The scores from performance on the LTS were automatically entered on an Excel spreadsheet. The MISTELS scores were recorded manually on the same program. Immediate and automatic feedback was available after each task on the LTS (time required, number of penalties, and score). Similar verbal feedback was given after each MISTELS task. A user satisfaction questionnaire was completed by each candidate after using each simulator. In this postperformance questionnaire, each user was asked to assess his or her satisfaction with the simulator by expressing it on a 10-cm visual analog scale.

Statistical analysis

The construct validity of the LTS was assessed using global scores (the sum of all tasks). Analysis of variance (ANOVA) was used to evaluate differences between the 4 experience categories and 8 academic levels (medical student to attending) defined previously. Scheffe posthoc comparison was used to identify differences between experience categories and academic levels. Reliability of the LTS was assessed using Cronbach's alpha as a measure of internal consistency of tasks. The concordance between the 2 simulators was assessed. Mean total scores for all tasks on both simulators were correlated (10 tasks plus 5 tasks). Intraclass correlation was calculated using Z transformation of total scores to compare resident performance between simulators. To control for possible learning effect of the LTS on the performance on the MISTELS, the resident ranks on each instrument were also correlated. User satisfaction was appraised on a visual analog scale (range 0 to 100). Scores were measures in millimeters on a 10-cm scale. Means were compared using ANOVA.

ANOVA was used to assess the relationship between performance and some characteristics of the participants. The following variables were included to assess their possible effect on score performance: age, sex, handedness, specialty, previous simulator training (approximate number of hours on a physical or a virtual-reality simulator). $P < 5\%$ was considered significant.

Results

Sample

In total, 124 subjects were recruited. At the University of Montreal, the 78 participants tested included 11 junior residents (postgraduate years (PGY) 1 and 2), 20 senior residents (PGY 3–5), 9 fellows, 29 attending surgeons, and 9 medical students. At McGill University, 24 subjects were tested: 8 junior residents, 12 senior residents, 1 fellow, and 3 attending surgeons. At Dalhousie University, 22 participants were recruited: 7 junior residents, 8 senior residents, 3 attending surgeons, and 4 medical students. All 3 specialties were represented across the 3 participating university centers: 30 participants in general surgery, 59 in gynecology, and 22 in urology. A subgroup of 74 participants was tested on both the LTS and the MISTELS. No subjects explicitly refused to participate, but many did not find time in their schedule to perform the testing (a ratio of 3 potential informed subjects was required for each 1 subject finally tested).

Construct validity of the LTS

There was a significant progression of scores according to the levels of laparoscopic experience (Table 4 and Figs. 1 and 2) and training. The difference was even stronger when levels of training were grouped (Table 5). As shown in these tables, scores obtained on the MISTELS were comparable with those on the LTS in terms of progression across levels of experience and training.

Table 4 Scoring performance according to level of experience

	LTS score			MISTELS score		
	N	Mean	SD	N	Mean	SD
Experience level						
Novice	23	567.3	302.5	17	45.2	16.9
Intermediate	34	764.4	341.9	24	55.8	19.2
Competent	36	841.4	256.3	19	59.1	17.3
Expert	30	1022.3	280.1	13	74.6	14.2
P		$<.001$			.001	
Posthoc test results		N<E;N<C; I<E			N<E; I<E	

N = novices; I = intermediate; E = experts; IN = number of subjects; SD = standard deviation.

Figure 1 Performance on LTS versus experience.

Reliability of the LTS

Cronbach's alpha for the 10 tasks was evaluated at .68. The MISTELS' reliability was comparable with the results of previous studies at .83.

Concordance between the 2 simulators

Intraclass correlation was calculated at .79 [.68 to .86] ($P < .001$) for Z scores to compare resident performance between simulators. The 10 tasks of the LTS were compared with the 5 tasks of the MISTELS; those results are presented in the Comments section (Table 6).

User satisfaction level on both simulators

The mean level of user satisfaction was 75.9 (SD 13.6) for the LTS and 69.4 (SD 16.2) for the MISTELS ($P = .012$). The results of the open question are discussed in the Comments section.

Influence of demographic characteristics on score performance

ANOVA according to age, specialty, and study center demonstrated a variation of total mean scores only according to the specialty. General surgery participants had better overall total scores than those in the 2 other specialties ($F = 7.5$, $P = .009$).

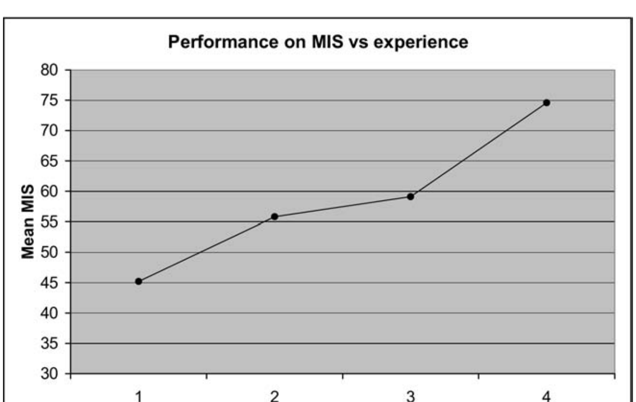

Figure 2 Performance on MISTELS versus experience.

Table 5 Scoring performance according to levels of training

	LTS score			MISTELS score		
	N	Mean	SD	N	Mean	SD
Training level						
Juniors (J) (MS, PGY 1)	25	547.9	292.0	16	40.5	19.5
Seniors (S) (PGY 2 through 4)	42	863.0	283.1	28	61.9	17.1
Experts (E) (PGY 5,F,A)	56	866.5	327.7	28	63.5	18.2
P		<.001			.001	
Posthoc test results		J<S; J<E			J<S; J<E	

MS = medical student; F = fellows; A = attendings.

Comments

The main objective of this study was to validate a computer enhanced video-laparoscopic system (the LTS 2000-ISM60) by demonstrating its construct and concurrent validity (compared with that of the MISTELS).

The MISTELS is one the most studied physical simulators and has been extensively validated. Its content validity was established through an inquiry on the pertinence of the chosen tasks involving 44 experienced laparoscopic surgeons and using global rating scales. When the scoring performance of the MISTELS was assessed, participants' scores improved progressively with level of training ($n = 215$, $P < .0001$), and over time residents improved their scores ($n = 24$, $P < .0001$).[7,12,17,18] The MISTELS has been shown to discriminate between competent and noncompetent laparoscopic surgeons, and, accordingly, can be used to evaluate an individual's skill set.[16] The MISTELS has also been shown to be reliable (interrater and test–retest reliabilities of .889 and .991, respectively, and internal consistency of .86).[19] Recently, in a study of 40 subjects, the MISTELS as part of the Fundamentals of Laparoscopic Surgery program did predict independently intraoperative laparoscopic performance.[25]

Table 6 Correlation of the physical simulators' scores according to tasks

	Total LTS	Common LTS	Unique LTS
MISTELS total	.79	.74	.69
LTS unique	.57	.69	

The LTS has been the object of some studies so far.[20,21,22] In 2002, Hasson et al found that training (on average 5.9 hours) with this new simulator resulted in significant improvement of laparoscopic skills.[22] The LTS system was tested on 45 practicing laparoscopists in general surgery and gynecology and was shown to detect levels of laparoscopic expertise. A learning-curve progression on the simulator was seen at intermediate levels (PGY 3) after clinical exposure (1 month) to advanced laparoscopic procedures.[23]

In this present study, to assess an aspect of LTS construct validity, the progression of performance was measured according to academic level (classification used in previous studies described) and laparoscopic experience. A statistically significant progression was demonstrated between the junior and senior and between the junior and expert academic levels. A statistically significant progression was demonstrated between all of the experience categories except between novices and intermediates and between competents and experts. For the latter, some reasons were proposed. First, we did not recruit 40 participants in 2 of the 3 centers, and we did not succeed in obtaining 12 participants/specialty in all 3 centers. One of the participating centers was already the object of many simulation studies, which made recruitment difficult because of overexposure. We also believed that acceptance to participate varied enormously depending on the person presenting the project. Accordingly, the specialty and study center of the principal investigator were over represented because the project was the first of its kind going on (large degree of enthusiasm) and because recruitment was mainly done individually. The main reason for the unfilled categories was the unavailability of participants for the amount of time required by the study (60 to 90 minutes). Because an insufficient number of participants was recruited in some academic levels, for example, in the fellow section (37% of what was expected), in 2 specialties (urology 61% and surgery 83%), and in 2 universities (55% and 60%), it can be presumed that the progression of scores could have been influenced. However, a preliminary analysis performed mid-study did find a satisfying correlation between the LTS and the MISTELS according to study centers and to specialties: It varied from .74 to .80. Thereafter, we decided to focus on the available subjects to obtain our final desired number. Our recruitment did include 124 participants, adequately representing each of the 3 experience levels.

Regarding the classification system, it can be argued that some participants classified in the intermediate category should have been in the novice group and that some in the competent category could have been upgraded to the expert group. The classification as competent is somewhat arbitrary, ie, based on the number of basic and advanced procedures done. A participant who had performed ≥50 basic procedures was considered competent. Could a participant who has performed 100 simple procedures be considered expert (defined as ≥50 advanced procedures performed)? The distinction between competent and experts can be quite subtle. Recall bias problems concerning the numbers and types of cases done could have also caused misclassification. No time range was included. For example, were those surgeries performed during their residency done 10 years ago or during the past 3 years? To prevent misclassification, the best method, although much more time consuming, would have been to count the number of each surgery type performed by reviewing each participant's surgical protocols for the previous 12 months. The subjects would have been classified according to their estimated number of cases done in the last 5 years (cases in 1 year × 5). The recruitment time frame would have probably been affected and slowed by such logistics considering 3 university centers and their archives. *A combination of both classifications (by level of academic year and by level of experience) could be suggested to permit comparison among simulators and among other evaluation tools for technical skills, such as global rating scales.*

When looked at closely, 2 of 10 tasks greatly influenced the total score (2100 points), and indeed, were highly discriminating. Task number 1 (peg- transfer task), being an exercise already included in many simulators and validated a number of times, was considered untouchable. However, closer analysis of task number 9, the intracorporeal knot (with an innovative tension test), was needed. If the knot slipped, the participant failed the entire task (a loss of 480 points). This corresponds to 26% of the total score; thus, performance on this task had a great impact. By changing the penalty attributed to this task, essentially deducting only 50 points when the knot failed, internal consistency increased to .76 from .68). Still, we do not recommend changing the scoring system. Task number 9 required a secured square knot to be tied in a silk suture. As demonstrated in the introductory video, 2 half knots must be oppositely thrown to obtain a final square knot. In an operating room setting, the surgeon usually chooses a knot according to his or her ability or how secure the knot needs to be, which could vary, for example, according to whether a hole on the intestine is to be closed or a vessel is to be tied. When the same task is performed on the LTS simulator, using a surgeon's knot or doing a third throw would certainly add solidity to the square knot, thus increasing the chance of success on the tension test. If the trainee succeeds in tying a secure intracorporeal knot on the LTS, his or her basic skills are probably well acquired, *and the patient will not bleed*. This task incorporates abilities essential to proficiency in a laparoscopic simulation setting and must have a high attributed score.

We realize that some tasks have an increased coefficient of difficulty compared with their MISTELS counterpart. But is this not desirable in an improved simulator? A person who succeeds in performing harder tasks has most probably acquired better skills overall.

The reliability of the studied simulator was found to be .68 (Cronbach's alpha) compared with that of the MISTELS at .82. The question is: How can a 10-task test be less reliable than a 5-task test? Because 5 five tasks are shared, the 5 new tasks obviously decrease the homogeneity of the entire test. This can mean 2 things: Either the new tasks are measuring the same skills with more measurement errors and do not add anything, or they measure a new dimension more or less in concordance with the original tasks. Table 5 illustrates quite well what was found. With the LTS, no significant correlation was found between the 5 new tasks and the 5 shared ones. It is tempting to hypothesize that the new tasks might measure different psychometric abilities. Separate analysis of the LTS' new tasks, or even a combination of the MISTELS' tasks and the LTS' tasks, might be a possible solution.

LTS scoring performance correlated well with that of the MISTELS (.79) but not as closely as expected. The true correlation is probably higher because the correlation between the two measures was reduced (attenuated) by the imperfect reliability of each measure. Again, the LTS' new tasks are a determining factor for its internal consistency. Accordingly, if the goal is to create a similar test, the LTS' tasks have to be homogenized to the MISTELS' tasks. If we accept the difference between the instruments, then the 2 instruments measure a common dimension, but LTS adds original information.

Among the studies described, level of user satisfaction with different simulators was only rarely assessed. User satisfaction level was assessed in a previous study done by Maden et al[26] comparing the LTS with the MIST-VR. Eighty-three percent of students chose the LTS when asked to pick only 1 trainer. Measuring this variable as a factor of face validity seemed essential to our study.

Accordingly, user satisfaction was higher with the LTS per visual analog scale. However, considering that the difference was .5 cm on a scale of 10 cm, it is not practically significant. The use of this kind of tool and its reliability in this context was never assessed in the past. Participants evaluated the LTS before having used the MISTELS. It is possible that the results would have been different if the evaluation had been done after the use of both simulators. How can user satisfaction be measured more precisely? A multiple-choice questionnaire would possibly have been able to evaluate user satisfaction more precisely. In general, for the following open question–"Why should your university purchase this simulator?"–the responses were positive for both simulators without favoring one or the other. All participants found both simulators useful. The LTS was often chosen over the MISTELS for its greater number and variety of tasks as well as its autonomous feedback.

Interpretation of the results was rendered difficult by variability in the results according to university and to specialty. Again, the study involved 3 centers, 3 disciplines, and 9 different programs. Participants from the 9 different programs were not equally exposed to laparoscopic simulators. For example, residents in the general surgery program had been exposed more often to simulators for practice and research purposes in their training, ≥10 hours on average in that specialty compared with ≤3 hours in another. In fact, scores were on average higher for that specialty, providing further evidence to support the benefits of simulator training.

To invest in a simulator is a large responsibility for a teaching institution, but to effectively train residents in a surgical domain is a demanding mission. Because increasing constraints are being placed on available operating room time, teaching time is an important consideration when developing teaching curricula for surgery. Surgeons are in a rush. There are increasing fears that medicolegal considerations will result in less surgical experience for residents.[5]

Proficient laparoscopic surgery requires the acquisition of specific surgical skills that are distinct from those of open surgery. Performing as an expert in minimally invasive surgery means being able to integrate 3-dimensional images based on displays in 2 dimensions and using this information to control long instruments moving in 3 dimensions across a fulcrum (trocar).[1] The learning curve of this unique set of skills is abrupt and variable among individuals, which probably explains the wide variability of performance in each academic level and across specialties in our study. The operating room environment is a performance setting, not an environment suitable for deliberate skills acquisition. Novices are unfamiliar with general surgical techniques. When they are trying to learn laparoscopic skills in addition to the other basic skills, it can become an extremely uncomfortable situation and can lead to counterproductive performance anxiety. Unnecessary stress is created in addition to the already usual pressures caused by lack of familiarity with anatomy and by the operating room context.[1] Obviously residents must practice their laparoscopic skills outside of a performance environment with easily available teaching tools, such as simulators. New simulator-based teaching methods have been developed to meet the needs of both practicing surgeons and those in training. The main idea is to provide residents with a practice schedule and to render regular deliberate practice of simple and more complicated tasks easy and compatible with the heavy workload of residency.

The MISTELS has been well validated and is reliable. It is inexpensive and easy to use. Every surgical teaching program can afford at least 1 system. It helps to acquire basic laparoscopic skills. The LTS, like the MISTELS, is a portable and a user-friendly simulator. The LTS can be used in an autonomous fashion, providing objective feedback after completion of each task and a personal log to compile one's own results. The 5 added tasks possibly require different, or more sophisticated, psychometrics abilities. The increased delicacy of certain tasks renders their execution more demanding, and, obviously, the innovative tension test is appealing. The slight difference in user satisfaction and the numerous positive comments are convincing evidence of the appropriateness of such a physical simulator. The integration of a digital system and automatic feedback are now inescapable criteria for new surgical curricula based on simulation and computerized scenarios. LTS technology brings traditional physical simulators a step forward and may help students to acquire not only basic skills but hopefully also advanced skills. However, the added new tasks and the technological improvements, especially the computerization of the system, are onerous and can largely explain the difference in cost. Still, the LTS is more affordable than a virtual-reality simulator and will respond to immediate needed basic skills.

In conclusion, this multicentric and multidisciplinary prospective study confirmed important aspects of the construct and concurrent validity of the LTS2000-ISM60 simulator. The scoring performance of the LTS and the MISTELS are comparable according to laparoscopic experience and academic level. A high level of user satisfaction was found with both simulators but was slightly higher with the LTS. The automatic scoring and performance logging systems are appealing for an evaluation system and university training program. The available budget and the number of simulators needed are both factors in the decision regarding which simulator to purchase. Physical simulators definitely deserve interest and further studies to assess transferability of acquired abilities to the operating room.

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