Surgical Endoscopy
https://doi.org/10.1007/s00464-019-07024-1

2019 SAGES ORAL

Minimally invasive tele-mentoring opportunity—the mito project

Jose Quezada[1] · Pablo Achurra[1] · Cristian Jarry[1] · Domenech Asbun[3] · Rodrigo Tejos[1] · Martín Inzunza[1] · Gabriel Ulloa[2] · Andres Neyem[2] · Carlos Martínez[1] · Carlo Marino[1] · Gabriel Escalona[1] · Julian Varas[1]

Received: 16 April 2019 / Accepted: 19 July 2019

Abstract

Background Simulation training is a validated method for acquiring laparoscopic skills. Training sessions may be sporadic or lack continuity in oversight by instructors since traditional programs mandate in-person teaching and evaluation. This study presents the development, implementation, and results of a novel smartphone application that enables remote teacher–student interaction. This interface is used to complete a validated program that provides learner-specific feedback. Outcomes of training via Lapp were compared to outcomes of traditional in-person training.

Methods A web-based and mobile iOS and Android application (Lapp) was developed to enable a remote student–teacher interaction. Instructors use Lapp to assess video recorded training sessions of students at distant locations and guide them through the laparoscopic skill course with specific and personalized feedback. Surgical trainees at two remote training centers were taught using Lapp. A control group was assessed during traditional simulation training at the training facility, with in-person feedback. Pre- and post-training performances were video recorded for each trainee and blindly evaluated by two experts using a global rating scale (GRS) and a specific rating scale (SRS).

Results A total of 30 trainees were trained via Lapp and compared with 25 locally taught. Performance in the Lapp group improved significantly after the course in both GRS and SRS scores, from 15 [6–17] to 23 [20–25], and from 12 [11–15] to 18 [15–20], respectively. The results between both groups were comparable.

Conclusion Laparoscopic simulation training using a mobile app is as effective as in-person instruction in teaching advanced laparoscopic surgical skills. Lapp provides an effective method of teaching through simulation remotely and may allow expansion of robust simulation training curriculums.

Keywords Simulation training · Surgical education technology · Tele-mentoring · Tele-proctoring · Tele-simulation

Laparoscopic surgery is currently the gold standard for many abdominal procedures [1–5]. However, the acquisition of laparoscopic skills presents a learning curve that is specific to laparoscopy. These skills often change with rapid development of new technologies. As such, surgeons are often pressed to learn new techniques in short periods of time [6–8]. Multiple factors, such as extended learning curves and resident work–hour restrictions, have pushed educators to seek more effective methods of teaching advanced surgical skills [6, 9, 10]. Simulation training is an effective learning tool with many benefits. These include reduced learning curves, decrease in training costs, and improving procedure-related outcomes [11–15].

Simulation training is particularly helpful with new surgical trainees, as it provides practice in a controlled environment without risk to patients [16, 17]. It is useful for these trainees to be involved in simulation curricula where trainers provide direct teaching and feedback, and are ideally trained in teaching [11–13]. Feedback clarifies learning objectives, reinforces positive performance, and corrects trainee errors to facilitate the acquisition of skills [16–18]. However, an important limiting factor often becomes inconsistent availability of expert teachers to provide this feedback [19, 20].

✉ Julian Varas
jevaras@uc.cl

1 Experimental Surgery and Simulation Center, Department of Digestive Surgery, Clinic Hospital, School of Medicine, Pontificia Universidad Católica de Chile, Marcoleta 377, Santiago, Chile

2 Computer Science Department, Pontificia Universidad Católica de Chile, Santiago, Chile

3 Department of Surgery, UCSF Fresno, Fresno, CA, USA

Electronic forms of communication have provided platforms for learning and teaching that aim to address these shortcomings. Many of these include crowd source assessments, such as social media interest groups. Other systems employ more private methods of intraoperative video review that provide delayed feedback on surgical technique. [20–23]. Although these systems provide targeted benefits, they are largely intended for surgeons who have completed general training and are looking to expand skills while in practice. Furthermore, the effectiveness of these modalities has not been thoroughly assessed nor compared to traditional in-person feedback [24–26].

A virtual learning platform with web and mobile app-based access was developed. It was named Lapp, for "learning app". Trainees using Lapp undergo a laparoscopic skills curriculum based in simulation training and upload videos of their practice for digital storage. These videos are reviewed remotely by trained experts, who in turn provide specific feedback. The Lapp platform is used to transmit videos and for communication between trainee/trainer, including feedback and associated supplemental materials. This study aimed to determine if trainees undergoing a validated advanced laparoscopy simulation course could acquire equivalent skills when taught remotely via Lapp compared to traditional in-person teaching and feedback.

Methods

Trainees

General surgery residents and general surgeons with access to a simulation lab in Chile were included in the study. The on-site (with in-person feedback) training was performed at the Pontificia Universidad Católica de Chile simulation center (Santiago, Chile), and the remote-site training with no direct, in-person feedback was performed in two regional centers in Chile (cities of Coquimbo and Temuco, 180-750 miles away from Santiago). These two remote simulation centers were equipped with the same hardware (e.g., simulators, energy devices, etc.) and surgical supplies as the Santiago Center.

Inclusion criteria for participants were:

1. A certified general surgeon or general surgery resident from a certified program
2. Has successfully completed a basic laparoscopic skills training course (Fundamentals of Laparoscopic Surgery (FLS) based competency) also developed at our institution.

We excluded participants that had previous advanced laparoscopy training or clinical experience in laparoscopic suturing or stapling techniques. The protocol and consent forms were approved by the institutional ethics board for all participants.

Prior to initiating the simulation program, participants took a virtual survey that explored other personal history that may contribute to the ability to learn laparoscopic skills. These included factors such musical instrument training and frequent video games use.

Advanced laparoscopic skills training program and evaluation

All participants underwent a validated simulation program to acquire advanced laparoscopic skills. The skills learned through the simulated program had previously been shown to transfer to the operating room after completing the course. The program also resulted in a shorter learning curve than traditional training with no simulation [27, 28]. Among other components, the course uses a deliberate practice approach as described by Ericsson et al. This presents the trainee with repetitive learning of successively more complex tasks [29].

The program trains novice surgeons for the performance of a laparoscopic hand-sewn jejunojejunostomy (JJ) using an ex vivo simulation model (with bovine bowel). It contains 14 sessions of ascending difficulty in a step by step constructivist fashion [30] (Fig. 1). First, basic simple suturing and bowel handling are trained in 3 sessions. The next three sessions are meant to practice suturing along with creating enterotomies using an ultrasonic energy device. Then, the posterior layer of the anastomosis is taught in a running fashion. Sessions 10 and 12 teach how to close the anterior layer, also with a running suture. Finally, sessions 13 and 14 give the last tips and tricks to optimize operative flow and economy of movement. The focus of evaluation is on technical details, and estimated time goals are suggested in each session.

All participants watched an introductory video of the procedure and performed an initial evaluation of the full JJ. After completing the program, participants underwent a final evaluation. The evaluations were video recorded and assessed by blinded experts, using validated global (GRS) and specific (SRS) rating scales for objective structured assessment of technical skills (OSATS) [27, 31, 32]. Operative time was also assessed at the initial and final evaluation. To pass the final evaluation a minimum of 20 points in the GRS (max 25), 15 points in the SRS (max 20), and a procedural time of fewer than 25 min were required. Further details of the training program and evaluation methods are described elsewhere [27, 28].

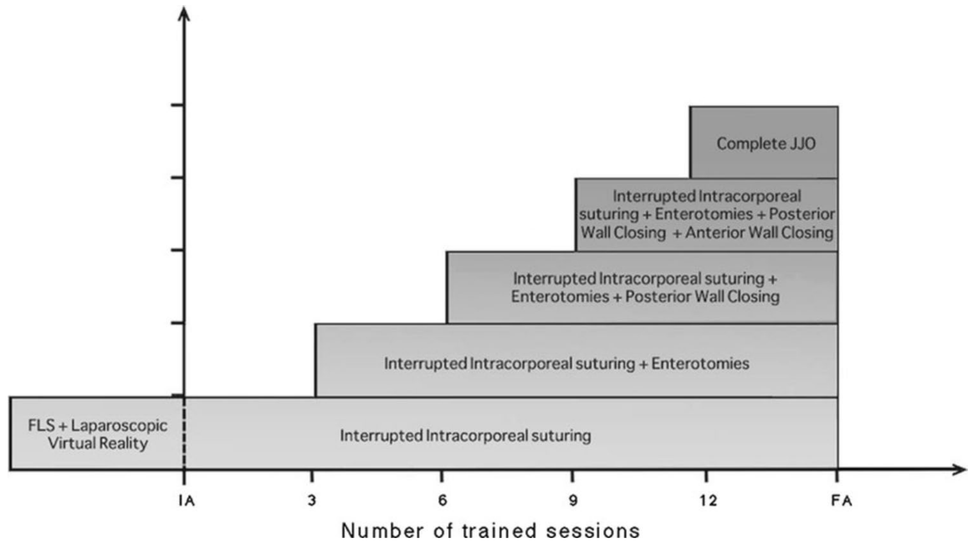

Fig. 1 Advanced laparoscopic simulation program: Includes 14 sequential practice sessions to perform a laparoscopic hand-sewn jejunojejunostomy (JJ). *Image taken from the original paper from surgical endoscopy [27]

Online platform and app (Lapp)

An online platform and mobile iOS/Android application (app) was developed by a multidisciplinary team of surgeons, educators and computer science engineers at our institution. The interface included a tutor and trainee version. In the trainee interface, students can access their videos, feedback, and scores. In the tutor interface, experts can review all trainees assigned to them, give feedback, and review videos and scores. Feedback is provided in the form of written, verbal, and other supplemental materials such as technical videos.

The videos of each session were uploaded by a multimedia expert in each of the regional simulation centers. When a new video was uploaded, a trained expert was assigned to it and notified by the Lapp system. These trainers then reviewed the video and gave text/audio/video feedback through the mobile App or online platform. The experts also assigned evaluation scores (GRS & SRS) and procedural time with the feedback.

The participants then received the feedback, procedural times, and GRS/SRS scores on their smart phones. Further educational videos showcasing the critical aspects and standard errors of each session were included in the online platform. Trainers can use pre-designed videos that showcase a specific technical error or piece of advice. Other modalities of feedback, such as audio recordings, written text, and time-marking a section in the trainees' videos are also possible through Lapp (Fig. 2).

Prior to use by trainees, Lapp was tested by 15 volunteers for user experience using the *lean* methodology to test software [33, 34]. These volunteers were from our institution and had general knowledge about surgery and surgical technique. Their comments were used to fix technical software problems and maximizing user friendliness before the beginning of the study.

Training methods (Fig. 3)

The expert trainers had all undergone training specific to teaching the laparoscopic skills program. They all had at least 5 years of experience in teaching via surgical simulation. The details regarding their training have been published elsewhere [27, 28]. These instructors furthermore underwent a month-long course on how to use Lapp for evaluating video and delivering feedback.

Participants were assigned to one of two training programs: in-person evaluation and feedback (control group) or remote evaluation and feedback via the Lapp interface (Lapp group). Due to logistical necessity, these assignments were based on where the trainees lived and thus which training center they had access to. The Lapp group was made up of participants from the two regional centers described above. As opposed to the control group, the Lapp group trainees did not receive direct, in-person instruction by local instructors. The Lapp group trainees watched videos to learn the new techniques, and later uploaded video of themselves training (when specified in a training session) to the online platform. The videos were then reviewed by the same tutors who assessed the control group. Once a video was uploaded to the Lapp cloud, trainees received feedback within 72 h. The Lapp trainees thus received remote feedback from instructors only through the Lapp platform.

Statistical analysis

The comparative analysis between before and after a training session was performed with the Wilcoxon test. The comparison between the different groups was conducted with

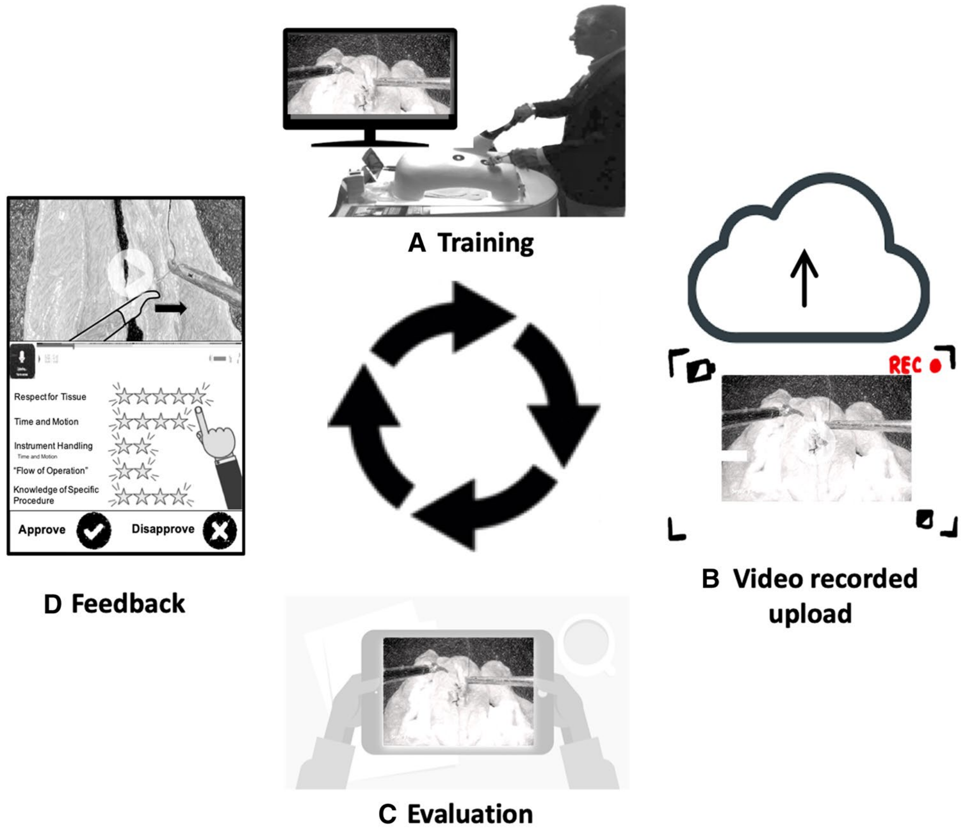

Fig. 2 Deferred remote feedback. Lapp Group received remote feedback from instructors only through the Lapp platform. **A** Trainees practice on simulator and record video of session. **B** Video is uploaded to the on-line platform. **C** Expert mentors assess the sessions and **D** Provide feedback through the app/learning plataform

the Kruskal–Wallis test and Mann–Whitney as appropriate. p value <0.05 was considered statistically significant.

It was calculated that a minimum sample size of 23 subjects was needed for each group to properly power the study. This accounted for the use of a paired, two-tailed t-test with alpha set at 0.05 and a power of 80%. The test was designed to be sensitive to variance between the groups and thus a significant difference in GRS was set as 1.0 points (out of 25.0 total).

Results

A total of 55 participants were included in the study: 25 received on-site feedback, and 30 received remote feedback through Lapp. These trainees undertook the laparoscopic skills course during the same time period. Demographic and training characteristics of the participants are in Table 1. There were no significant differences in age, training stage, or basic laparoscopic experience between groups. Other aspects of social history that may influence dexterity were also similar between groups.

All participants completed the program with a GRS score > 20 and in less than 25 min by the time of the final evaluation. Nobody failed the program and the mean total performances score increased in both groups from pre-test assessment, 15 (6-19), to post-test assessment, 24 (20–25), $p < 0.05$.

In the Lapp group, participants significantly improved their laparoscopic skills (Table 2). GRS, SRS, and task completion times were significantly improved in the final evaluation when compared to the initial evaluation, from 15 [6–17] to 23 [20–25] points, 12 [11–15] to 18 [15–20] points, and 40 [SD 10.5] to 23 min [SD 3.4], respectively.

In the control group, all participants significantly improved their OSATS scores and task completion times, as had been shown in previous studies [27, 28].

When comparing the Lapp group with the control group, no differences were identified in their overall progress, median 10 points [1–14] and 9 points [6–10] respectively, $p = 0.768$. Their times to complete a task were comparable, at 23 min. [SD 3.4] and 23 min. [SD 3.3]. And the Lapp and in-person feedback groups had similar GRS scores in the initial and final evaluation (Fig. 4).

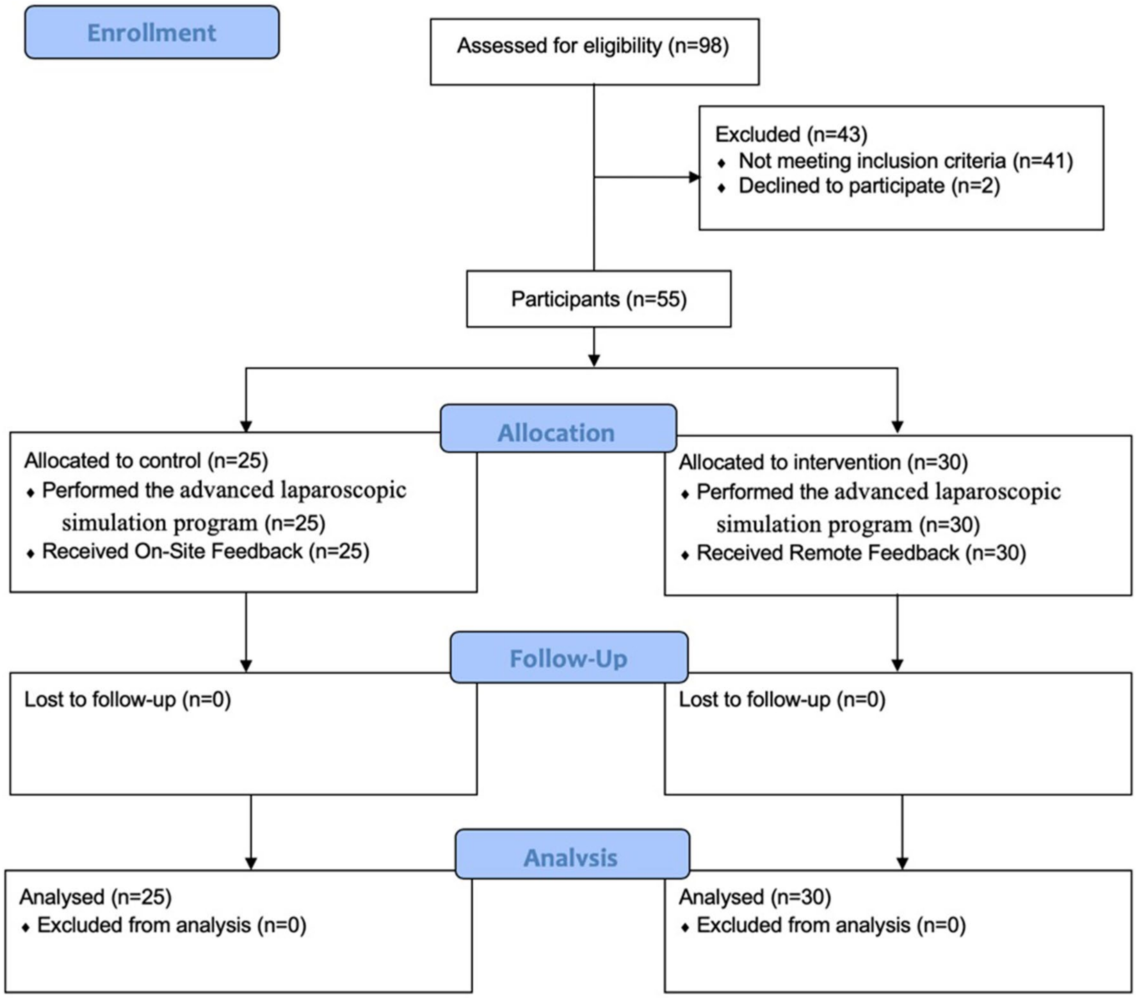

Fig. 3 Flow diagram

Discussion

This study found that remote teaching and learning of complex laparoscopic skills through the Lapp platform was as effective as in-person feedback. Fifty-five trainees were trained at the same time using the same group of instructors.

There is increasing interest in simulation as a means of teaching surgical skills. Simulation in surgery has been shown to reduce the learning curves, training costs, and complications associated with medical procedures [11–14]. This training in simulated environments has been shown to improve the surgical skills of residents, and these skills are transferred to the OR [16, 17, 22, 32, 35–37].

Our institution had previously developed an advanced laparoscopic skills course based on the completion of a laparoscopic hand-sewn jejuno-jejunostomy, with 14 training sessions. This curriculum has been studied and shows program validity and transfer of skills to the OR [27, 28]. Our institute has an international presence in Latin America and other surgical training programs have shown interest in replicating the curriculum. However, a major setback to expanding the program elsewhere has been the need for frequent feedback from trained instructors throughout the length of the course. This asks for a relatively robust staff that has to be physically available to give the precise feedback necessary during training. As a result, over 100 surgeons and surgical trainees travel to our simulation lab yearly to complete the advanced laparoscopic skills course.

In our first approach to remote simulation-based teaching, we developed a smartphone application in 2013 with standardized tutorial videos. These detailed videos provided step by step instructions on how to learn advanced laparoscopic skills and effectively complete the training program. Also included were videos of the most common errors and how to correct them. However, this app lacked a bidirectional student–teacher interaction, and thus there was no personalized feedback. We therefore developed a new learning platform via Lapp that solves these issues. The students upload

Table 1 Demographics

Demographic	LAPP group $N=30$ (%)	Control group $N=25$ (%)	*p* value
Age, median (range)	36 (23–65)	33 (28–45)	0.359
Gender			0.123
Male	28 (93)	19 (76)	
Female	2 (7)	6 (24)	
Training stage			0.474
PGY1	4 (13)	1 (4)	
PGY2	3 (10)	5 (20)	
PGY3	6 (20)	4 (16)	
Surgeon	17 (57)	15 (60)	
Hand dominance			0.218
Right	26 (87)	23 (92)	
Left	4 (13)	2 (8)	
Basic laparoscopic experience[a]			0.388
< 20 cases	4 (13)	2 (8)	
20–50 cases	6 (20)	9 (36)	
> 50 cases	20 (67)	14 (56)	
Play musical instrument	8 (27)	4 (16)	0.340
Play video game (> 3 h/wk)	12 (40)	8 (32)	0.539

PGY: postgraduate year

[a]Self-reported experience with laparoscopic cholecystectomy or appendectomy

their training videos so expert trainers can personalize their assessment and feedback. The benefits of simulated training are preserved and made widely more accessible.

Training remotely through Lapp not only removed the need for on-site trainers, but also provided much convenience to the instructor and learner in regards to training schedule. Trainees were able to practice whenever their schedule allowed, which is a welcome benefit for surgical residents.

A potential for bias can be seen in the fact that the cohorts were not randomized. Unfortunately this was logistically too difficult, given the physical distance between the cohorts and their selection based on the training available. However, intuitively this would likely bias results in favor of the control group. The control group was from the same institution that had designed Lapp. It is thus conceivable that they are more readily exposed to the techniques and standards upheld by the designers of Lapp. The results did not reflect this influence on outcomes.

Some groups have used tele-mentoring as a way of teaching surgical skills at a distance, often transcontinental. For example, FLS proctors at the University of Toronto were able to successfully teach FLS skills to a group of learners in Botswana. FLS skills were also taught successfully between remote locations in Colombia via tele-mentoring [19, 38]. The limitation, even in these cases of remote interactions, is again the need for immediate and simultaneous availability of both the trainer and the trainee. In our experience, teaching advanced laparoscopic skills increases the need for trainer feedback and further strains training programs. The Lapp platform allowed for both the trainer and the trainee to continue the student–teacher relationship at a distance during an advance skills course.

The ability to teach surgical skills through simulation is becoming an important part of surgical education. Surgical residency training in the United States is subject to increasingly stringent regulations that restrict the amount of time and autonomy residents experience in the operating room [39–42]. Coupled with the advent of surgical technology that demands new and complex skill-sets, there is a widening gap between the technical skills expected of general surgeons in practice and those that are being successfully mastered during a general surgery residency [6, 43, 44]. Laparoscopic skills are nonetheless an essential aspect of general surgery training and advanced laparoscopic skills are often associated with a steep learning curve [45, 46].

Our findings indicate that remote simulation training through Lapp was as effective as on-site evaluation during a validated training program. It is designed to teach new trainees and is effective to this end within our study. This remote training may assist in improving some of the above issues by increasing accessibility and scalability to laparoscopic simulation training.

Table 2 Trainees' results obtained through the laparoscopic trianing programs

	LAPP group ($N=30$)			Control group ($N=25$)		
	Pre-test	Post-test	*p* value	Pre-test	Post-test	*p* value
GRS (5–25)	15 (6–17)	23 (20–25)	< 0.05	15 (10–19)	24 (22–25)	< 0.05
SRS (4–20)	12 (11–15)	18 (15–20)	< 0.05	12 (8–15)	19 (16–20)	< 0.05
Operative time (m)	39 (10.47)	22 (3.37)	< 0.05	42 (12.58)	22 (3.35)	< 0.05

GRS global rating score, *SRS* specific rating score

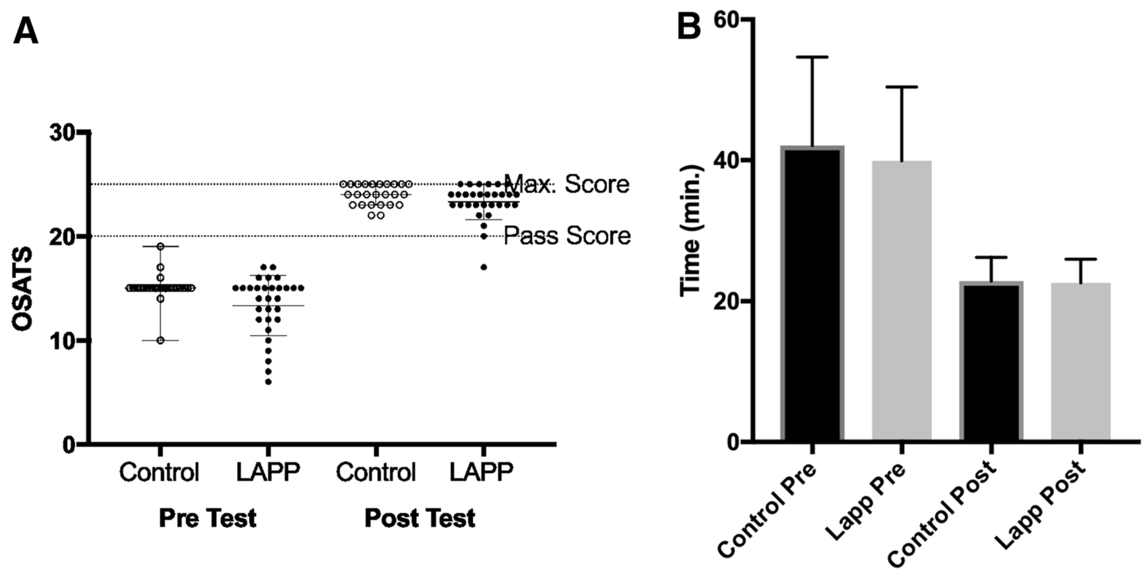

Fig. 4 Comparison of both groups, **A** OSATS global rating scale on initial and final evaluation for on-site feedback (control) and remote deferred feedback (Lapp group). **B** Procedure time at the initial evaluation (Pre) and final evaluation (post) on both groups

Compliance with ethical standards

Disclosure Drs. Jose Quezada Pablo Achurra, Cristian Jarry, Domenech Asbun, Rodrigo Tejos, Martín Inzunza, Gabriel Ulloa, Andres Neyem, Carlos Martínez, Carlo Marino, Gabriel Escalona and Julian Varas for this study were financed and supported by a 2017 SAGES Research Grant and a Chilean Research Grant FONDECYT REG. 11170108 from CONICYT and by the Department of Digestive Surgery, Faculty of Medicine, Pontificia Universidad Católica de Chile. Dr Julian Varas is a cofounder of the company T&C, which manufactured the surgical simulators used in this study.

References

1. Hutter MM, Randall S, Khuri SF, Henderson WG, Abbott WM, Warshaw AL (2006) Laparoscopic versus open gastric bypass for morbid obesity: a multicenter, prospective, risk-adjusted analysis from the National Surgical Quality Improvement Program. Ann Surg 243:657–662. https://doi.org/10.1097/01.sla.0000216784.05951.0b
2. Zou Z-H, Zhao L-Y, Mou T-Y, Hu Y-F, Yu J, Liu H, Chen H, Wu J-M, An S-L, Li G-X (2014) Laparoscopic vs open D2 gastrectomy for locally advanced gastric cancer: a meta-analysis. World J Gastroenterol 20:16750–16764. https://doi.org/10.3748/wjg.v20.i44.16750
3. Velanovich V (2000) Laparoscopic vs open surgery. Surg Endosc 14:16–21. https://doi.org/10.1007/s004649900003
4. Stefan S, Maren W, Brigitte H, Seiler M, Marc CM (2011) Laparoscopic versus open surgical techniques for ventral or incisional hernia repair. Cochrane Database Syst Rev 3:CD007781
5. Pattillo JC, Kusanovic R, Salas P, Reyes J, García-huidobro I, Sanhueza M, Palma A, Báez S, Viñuela E, Friant O, Galaz I, Silberman M, Arrese M, Martínez J (2004) Colecistectomía laparoscópica ambulatoria: Una experiencia factible en un hospital público chileno Juan. Rev Méd Chile 132:429–436
6. Mattar S, Alseidi A, Jones D, Jeyarajah D et al (2013) General surgery residency inadequately prepares trainees for fellowship. Ann Surg 258:440–449. https://doi.org/10.1097/SLA.0b013e3182a191ca
7. de Educación Comité, de la Academia Superior, de Medicina Chilena (2009) Situación actual de la Educación Médica en Chile. Rev Med Chil 137:709–712
8. Nácul MP, Cavazzola LT, de Melo MC (2015) Current status of residency training in laparoscopic. ABCD Arq Bras Cir Dig (São Paulo) 28:81–85
9. Peets A, Ayas NT (2012) Restricting resident work hours: the good, the bad, and the ugly. Crit Care Med 40:960–966. https://doi.org/10.1097/CCM.0b013e3182413bc5
10. Fletcher KE, Underwood W 3rd, Davis SQ, Mangrulkar RS, McMahon LF Jr, Saint S (2005) Effects of work hour reduction on residents' lives: a systematic review. JAMA 294:1088–1100. https://doi.org/10.1001/jama.294.9.1088
11. Kolozsvari NO, Feldman LS, Vassiliou MC, Demyttenaere S, Hoover ML (2011) Sim one, do one, teach one: considerations in designing training curricula for surgical simulation. J Surg Educ 68:421–427. https://doi.org/10.1016/j.jsurg.2011.03.010
12. Aggarwal R, Darzi A (2011) Simulation to enhance patient safety: why aren't we there yet? Chest 140:854–858. https://doi.org/10.1378/chest.11-0728
13. Aggarwal R, Grantcharov T, Moorthy K, Milland T, Papasavas P, Dosis A, Bello F, Darzi A (2007) An evaluation of the feasibility, validity, and reliability of laparoscopic skills assessment in the operating room. Ann Surg 245:992–999. https://doi.org/10.1097/01.sla.0000262780.17950.e5
14. Zevin B, Aggarwal R, Grantcharov TP (2014) Surgical simulation in 2013: why is it still not the standard in surgical training? J Am Coll Surg. https://doi.org/10.1016/j.jamcollsurg.2013.09.016
15. Dehabadi M, Fernando B, Berlingieri P (2014) The use of simulation in the acquisition of laparoscopic suturing skills. Int J Surg 12:258–268. https://doi.org/10.1016/j.ijsu.2014.01.022
16. Beyer-Berjot L, Palter V, Grantcharov T, Aggarwal R (2014) Advanced training in laparoscopic abdominal surgery: a systematic review. Surg (United States) 156:676–688. https://doi.org/10.1016/j.surg.2014.04.044

17. Beyer L, De Troyer J, Mancini J, Bladou F, Berdah SV, Karsenty G (2011) Impact of laparoscopy simulator training on the technical skills of future surgeons in the operating room: a prospective study. Am J Surg 202:265–272. https://doi.org/10.1016/j.amjsurg.2010.11.008
18. Hattie J, Timperley H (2008) Referaat the power of feedback. Tijdschr voor Med Onderwijs 27:5051. https://doi.org/10.3102/003465430298487
19. Henao O, Escallon J, Green J, Farcas M, Sierra JM, Sanchez W, Okrainec A (2013) Fundamentals of laparoscopic surgery in Colombia using telesimulation: an effective educational tool for distance learning. Biomedica 33:107–114. https://doi.org/10.1590/S0120-41572013000100013
20. Sebajang H, Trudeau P, Dougall A, Hegge S, McKinley C, Anvari M (2005) Telementoring: an important enabling tool for the community surgeon. Surg Innov 12:327–331. https://doi.org/10.1177/155335060501200407
21. Rosser JC, Wood M, Payne JH, Fullum TM, Lisehora GB, Rosser LE, Barcia PJ, Savalgi RS (1997) Telementoring. A practical option in surgical training. Surg Endosc 11:852–855. https://doi.org/10.1007/s004649900471
22. Tavakol M, Mohagheghi MA, Dennick R (2008) Assessing the skills of surgical residents using simulation. J Surg Educ 65:77–83. https://doi.org/10.1016/j.jsurg.2007.11.003
23. Muysoms F, Jacob B (2018) International hernia collaboration consensus on nomenclature of abdominal wall hernia repair. World J Surg 42:302–304. https://doi.org/10.1007/s00268-017-4115-3
24. Shippey SH, Chen TL, Chou B, Knoepp LR, Bowen CW, Handa VL (2011) Teaching subcuticular suturing to medical students: video versus expert instructor feedback. J Surg Educ 68:397–402. https://doi.org/10.1016/j.jsurg.2011.04.006
25. Nesbitt CI, Phillips AW, Searle RF, Stansby G (2015) Randomized trial to assess the effect of supervised and unsupervised video feedback on teaching practical skills. J Surg Educ 72:697–703. https://doi.org/10.1016/j.jsurg.2014.12.013
26. Backstein D, Agnidis Z, Sadhu R, Macrae H (2005) Effectiveness of repeated video feedback in the acquisition of a surgical technical skill. Can J Surg 48:195–200
27. Varas J, Mejía R, Riquelme A, Maluenda F, Buckel E, Salinas J, Martínez J, Aggarwal R, Jarufe N, Boza C (2012) Significant transfer of surgical skills obtained with an advanced laparoscopic training program to a laparoscopic jejunojejunostomy in a live porcine model: Feasibility of learning advanced laparoscopy in a general surgery residency. Surg Endosc 26:3486–3494. https://doi.org/10.1007/s00464-012-2391-4
28. Boza C, León F, Buckel E, Riquelme A, Crovari F, Martínez J, Aggarwal R, Grantcharov T, Jarufe N, Varas J (2017) Simulation-trained junior residents perform better than general surgeons on advanced laparoscopic cases. Surg Endosc 31:135–141. https://doi.org/10.1007/s00464-016-4942-6
29. Ericsson KA, Krampe RT, Tesch-Romer C (1993) The role of deliberate practice in the acquisition of expert performance. Psychol Rev 100:363–406
30. Hirsch ED (1993) The core knowledge curriculum: what's behind its success? Educ Leadersh 50:23–30
31. Martin JA, Regehr G, Reznick R, Macrae H, Murnaghan J, Hutchison C, Brown M (1997) Objective structured assessment of technical skill (OSATS) for surgical residents. Br J Surg 84:273–278. https://doi.org/10.1002/bjs.1800840237
32. León Ferrufino F, Varas Cohen J, Buckel Schaffner E, Crovari Eulufi F, Pimentel Müller F, Martínez Castillo J, Jarufe Cassis N, Boza Wilson C (2015) Simulation in laparoscopic surgery. Cirugía Española. https://doi.org/10.1016/j.cireng.2014.02.022
33. Brhel M, Meth H, Maedche A, Werder K (2015) Exploring principles of user-centered agile software development: a literature review. Inf Softw Technol 61:163–181. https://doi.org/10.1016/J.INFSOF.2015.01.004
34. Poppendieck M, Poppendieck TD (2007) Implementing lean software development : from concept to cash. Addison-Wesley, Boston
35. Rodríguez-Sanjuán JC, Manuel-Palazuelos C, Fernández-Díez MJ, Gutiérrez-Cabezas JM, Alonso-Martín J, Redondo-Figuero C, Herrera-Noreña LA, Gómez-Fleitas M (2010) Assessment of resident training in laparoscopic surgery based on a digestive system anastomosis model in the laboratory. Cirugía española 87:20–25. https://doi.org/10.1016/j.ciresp.2009.08.003
36. Orzech N, Palter VN, Reznick RK, Aggarwal R, Grantcharov TP (2012) A comparison of 2 ex vivo training curricula for advanced laparoscopic skills: a randomized controlled trial. Ann Surg 255:833–839. https://doi.org/10.1097/SLA.0b013e31824aca09
37. Grantcharov TP, Funch-Jensen P (2009) Can everyone achieve proficiency with the laparoscopic technique? Learning curve patterns in technical skills acquisition. Am J Surg 197:447–449. https://doi.org/10.1016/j.amjsurg.2008.01.024
38. Okrainec A, Henao O, Azzie G (2010) Telesimulation: an effective method for teaching the fundamentals of laparoscopic surgery in resource-restricted countries. Surg Endosc 24:417–422. https://doi.org/10.1007/s00464-009-0572-6
39. Ahmed N, Devitt KS, Keshet I, Spicer J, Imrie K, Feldman L, Cools-Lartigue J, Kayssi A, Lipsman N, Elmi M, Kulkarni AV, Parshuram C, Mainprize T, Warren RJ, Fata P, Gorman MS, Feinberg S, Rutka J (2014) A systematic review of the effects of resident duty hour restrictions in surgery: impact on resident wellness, training, and patient outcomes. Ann Surg 259:1041–1053. https://doi.org/10.1097/SLA.0000000000000595
40. Damadi A, Davis AT, Saxe A, Apelgren K (2007) ACGME duty-hour restrictions decrease resident operative volume: a 5-year comparison at an ACGME-accredited university general surgery residency. J Surg Educ 64:256–259. https://doi.org/10.1016/j.jsurg.2007.07.008
41. Teman NR, Gauger PG, Mullan PB, Tarpley JL, Minter RM (2014) Entrustment of general surgery residents in the operating room: factors contributing to provision of resident autonomy. J Am Coll Surg 219:778–787. https://doi.org/10.1016/j.jamcollsurg.2014.04.019
42. Stride HP, George BC, Williams RG, Bohnen JT, Eaton MJ, Schuller MC, Zhao L, Yang A, Meyerson SL, Scully R, Dunnington GL, Torbeck L, Mullen JT, Mandell SP, Choti M, Foley E, Are C, Auyang E, Chipman J, Choi J, Meier A, Smink D, Terhune KP, Wise P, DaRosa D, Soper N, Zwischenberger JB, Lillemoe K, Fryer JP (2017) Relationship of procedural numbers with meaningful procedural autonomy in general surgery residents. Surg (United States) 163:488–494. https://doi.org/10.1016/j.surg.2017.10.011
43. Coleman JJ, Esposito TJ, Rozycki GS, Feliciano DV (2013) Early subspecialization and perceived competence in surgical training: are residents ready? J Am Coll Surg 216:764–773. https://doi.org/10.1016/j.jamcollsurg.2012.12.045
44. Park A, Kavic SM, Lee TH, Heniford BT, Baltimore C (2007) Minimally invasive surgery: the evolution of fellowship. Surgery 142:505–511. https://doi.org/10.1016/j.surg.2007.07.009
45. Tekkis PP, Senagore AJ, Delaney CP, Fazio VW (2005) Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. Ann Surg 242:83–91. https://doi.org/10.1097/01.SLA.0000167857.14690.68
46. Cologne KG, Zehetner J, Liwanag L, Cash C, Senagore AJ, Lipham JC (2015) Three-dimensional laparoscopy: does improved visualization decrease the learning curve among trainees in advanced procedures? Surg Laparosc Endosc Percutaneous Tech 25:321–323. https://doi.org/10.1097/SLE.0000000000000168