

How to minimize the impact of COVID-19 on laparoendoscopic single-site surgery training?

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Key words

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Introduction

The coronavirus disease-2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has spread rapidly worldwide and developed into a pandemic since it first emerged at the end of 2019.^{1,2} Three months after the start of the epidemic, new confirmed COVID-19 cases declined dramatically in China; however, the virus started spreading worldwide.^{3,4} As of May 8, 2021, over 157 505 541 COVID-19 cases were confirmed in over 200 countries and regions, posing an unprecedented and extraordinary disruption for societies and healthcare systems globally.

Abstract

Background: Because of special technical challenges, laparoendoscopic single-site surgery (LESS) has been introduced into surgical practice, with surgeons required to have adequate training. The COVID-19 pandemic has significantly affected every aspect of healthcare systems, including LESS training, which must be modified to minimize the impact of the COVID-19 pandemic.

Methods: A 3-session training programme was designed in 2020 during the epidemic, which was modified in 2019 before the pandemic. Session 1 was an online study on LESS knowledge. Session 2 involved the trainees' self-directed simulator-training. Task performance was evaluated using the fundamentals of laparoscopic surgery (FLS) scoring. Session 3 was practical training, including trainers' live surgical video demonstrations and trainees' surgical video feedback after training. Video feedback performance was evaluated using the modified global rating scale (GRS). Furthermore, trainees completed a general self-efficacy (GSE) instrument. Forty-two gynaecology trainees were allocated into two groups: novices ($n = 32$) and experts ($n = 10$).

Results: Compared with pre-training, FLS scores improved in peg transfer ($P < 0.001$ and $P = 0.01$) and pattern cutting ($P = 0.02$ and $P < 0.001$) for novices and experts, respectively. Participants (81% versus 67%) provided first and second video feedback, respectively. Compared to the first feedback, the GRS scores of both groups improved significantly in the second feedback. All trainees showed an increase in GSE after training ($P < 0.001$).

Conclusion: The modified LESS training programme is a practical and effective option that allows trainees to continue training during the epidemic.

Laparoendoscopic single-site surgery (LESS) has recently evolved rapidly owing to its potential benefits compared with conventional multiport laparoscopy techniques.^{5,6} LESS has been utilized to successfully perform a multitude of gynecologic procedures, including benign and malignant conditions.^{7,8} LESS is technically challenging because the surgeon must pass all the instruments through a single port, which can cause situations including loss of triangulation and crowding of the surgical field. Accordingly, thorough training of the operating surgeon, especially during the implementation phase of the LESS technique, is especially necessary. Before the COVID-19 pandemic, on-site simulation and animal wet training were considered mainstream LESS training.

It is worth noting that the COVID-19 pandemic has had a detrimental impact on 'hands-on' surgical training because of the need to maintain social distance. With the dramatic rise of e-learning globally, web-based remote learning and online virtual training have been suggested, but are unable to provide practical, hands-on experience,⁹ which might potentially affect the outcomes of LESS training. It seems that in the near term, LESS training will not quickly return to normal in the post-COVID-19 era. Thus, a modified LESS surgical training course is needed to help trainees continue training and improve their practical surgical skills during the pandemic.

Accordingly, we propose a LESS training programme for gynaecology given the ongoing COVID-19 pandemic, first aiming to display the changes in training practice compared to that before the COVID-19 pandemic, and second, to investigate the effects and outcomes of a modified LESS training programme during the COVID-19 pandemic.

Materials and methods

Our centre, the Department of Gynaecology at Zhongda Hospital Southeast University (Nanjing, Jiangsu, China), is a qualifying training centre for LESS. Two LESS training programmes were conducted at our centre in September 2019 (before the COVID-19 period) and October 2020 (during the COVID-19 period).

Participants

In September 2019, before the COVID-19 epidemic started, participants from various regions in and outside of Jiangsu province who were willing to sign up for LESS training were recruited for the programme. Finally, 63 gynaecological trainees participated in the programme.

In October 2020, in light of the necessity of social distancing and normalization of epidemic prevention and control, trainees' numbers and origins were limited, despite the city of Nanjing being marked as a low-risk area (no confirmed cases of COVID-19 infection or no new confirmed cases within 14 days). Therefore, 42 gynaecology trainees in Jiangsu province, who tested negative for nucleic acids and possessed a green travel code indicated that they had not been to medium-or high-risk areas (those having confirmed cases of COVID-19 infections) participated in the training programme.

A baseline questionnaire, especially before laparoscopic experience, was filled out by each participant. Subsequently, trainees were allocated into two categories depending on their previous LESS experience: the 'novice' group without any LESS experience, and the 'expert' group with LESS of being an assistant. None had performed LESS surgery by themselves, and none had received training in basic LESS skills.

LESS training programmes

Two separate 3-day LESS training programmes were conducted before and during the COVID-19 epidemic and were composed of three training sessions. Session 1 was centred on theoretical instruction, Session 2 included training in the LESS box-trainers, and Session 3 included practical training. A summary of the programme training features before and during the pandemic is provided in Table 1.

Training session 1: theoretical training

On the first day, theoretical training regarding the LESS technique was available to all trainees in the form of on-site, offline classroom teaching in 2019 before the epidemic. In 2020, during the pandemic, web-based online teaching was made free for trainees from across China, boosting the number of trainees to a maximum of 40 000.

Training session 2-Simulator training

The second day was the simulator-training session, which was performed on semi-elliptical box-trainers covered by a transparent membrane (Hangzhou Kangji Medical Instruments Co., Hangzhou, China). Additionally, a proprietary multilumen single-trocar port system (Olympus) was deployed in the training box. Two 5-mm common straight laparoscopic graspers (Olympus), straight scissors (Olympus), and a standard needle holder were employed.

After signing the informed consent form, all participants received a training programme comprising three tasks on a laparoscopic box-trainer. These tasks include peg transfer, pattern cutting, and intracorporeal suturing, each of which is based on the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS).¹⁰

In 2019, before the COVID-19 epidemic, all trainees conducted simulator-training sessions simultaneously with ten adjacent box-

Table 1 Comparison of the training program features before and during the epidemic

Parameters	2019 before the epidemic	2020 during the epidemic	Reason and possible impact
Participants	All gynaecological trainees (63)	Nucleic acid negative, travel code green, gynaecological trainees (42)	Protect the trainee from being infected by other trainees
Theoretical training	On-site teaching	Web-based online teaching	Minimization of face-to-face instruction of the trainees
Simulator training			
Spacing distance	No distance gap	Spatial social-distancing protocols	Keep social distance
Instruction	Trainers' on-site instruction	Trainees' video-based self-directed practice	Keep social distance and minimize face-to-face contact
Practical training	Trainees' wet skills training	Trainers' live surgical video demonstration Trainees' surgical video feedback	Closure of the animal laboratory

trainers and received continual standardized instructions from the trainer in each session.

In 2020, during the COVID-19 pandemic, each participant was first shown a pre-recorded instructional video demonstrating the equipment available and how each of these tasks should be completed. A baseline test was then conducted for all trainees without further instruction.

After the baseline test, participants took training sessions one by one in a sequential manner on the same simulation box-trainer. However, given the relatively sufficient space in our training centre, it was acceptable that multiple participants practiced the tasks simultaneously using different box-trainers. It is worth noting that social distance strictly requires trainees to keep a distance of 6 ft apart from each other, and a keep-clear zone was marked on the floor where the simulation was occurring.

The training was mainly instructed by the standardized video previously mentioned, and video-based self-directed feedback was proposed with reflective pauses between sets of repetitions. All trainees were post-tested objectively based on the validated fundamentals of laparoscopic surgery (FLS) scoring method.¹¹

Training session 3-Practical training

In 2019, animal lab training was conducted on the third day. Trainees practiced their surgical skills by performing LESS hysterectomy on a live anaesthetised pig.

In 2020, however, due to the closure of the animal laboratory at Southeast University, wet training could not be carried out, but instead the LESS hysterectomy through live surgery operated by the trainers. After the training, every trainee was encouraged to upload a video of the LESS procedure on actual patients in their institution to a secure platform, only allowed to be accessed by the trainers. Within a week, trainers evaluated operative performance and provided personalized feedback guidance to the trainees, encouraging them to continue to learn. Within one month, trainees were equally encouraged to perform the second video feedback session (Fig. 1). Operative performance was evaluated using a modified global rating scale (GRS), an observational rating tool widely accepted to assess surgical skills,^{12,13} including five domains of surgical competence: respect for tissue, time and motion, instrument handling, the flow of operation, and knowledge of specific procedures. All videos uploaded by the trainees were approved by the

patients, and informed consent forms were signed by them. The LESS and video recordings were approved by the ethics committee of the trainee's hospital.

Meanwhile, participants completed the general self-efficacy (GSE) instrument presented in Table 2 and a satisfaction questionnaire.

Statistical analysis

Statistical analyses were performed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test showed a normal distribution of the data ($P > 0.05$). Normally and non-normally distributed data were expressed as mean \pm standard deviation (SD) and median with interquartile range, respectively. For paired data, the Wilcoxon matched-pairs sign-rank test was used for operative performance comparisons and the paired *t*-test for task performance outcome and GSE. A *P*-value < 0.05 indicated a statistical significance.

Results

A total of 42 trainees completed the LESS training during the COVID-19 crisis in 2020, comprising 32 novices and 10 experts. For FLS scores in box-trainer task performance, pre- to post-training within-group improvement was found in peg transfer ($P < 0.001$ and $P = 0.01$) and pattern cutting ($P = 0.02$ and $P < 0.001$) for novices and experts, respectively. Besides, a significant improvement was found in intracorporeal suturing for experts ($P = 0.02$) but not for novices ($P = 0.12$) (Table 3).

As shown in Figure 2, 34 trainees (81%), including 26 novices (76%) and eight experts (24%), provided the first video feedback. Subsequently, 28 trainees (67%) received the second feedback, including 20 novices (71%) and 8 experts (29%). For novices, the LESS techniques involved salpingectomy (35% versus 32%), ovariectomy (26% versus 25%), and myomectomy (15% versus 14%). For experts, LESS was performed for salpingectomy (9% versus 14%), ovariectomy (6% versus 4%), myomectomy (6% versus 7%), and hysterectomy (3% versus 4%). The proportions shown were

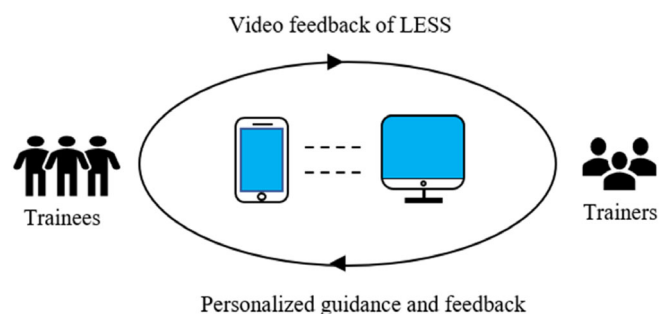


Fig. 1. Graphical representation of the surgical video feedbacks between trainees and trainers.

Table 2 General self-efficacy scale (GSE)

1	I can always manage to solve difficult problems if I try hard enough.
2	If someone opposes me, I can find the means and ways to get what I want.
3	It is easy for me to stick to my aims and accomplish my goals.
4	I am confident that I could deal efficiently with unexpected events.
5	Thanks to my resourcefulness, I know how to handle unforeseen situations.
6	I can solve most problems if I invest the necessary effort.
7	I can remain calm when facing difficulties because I can rely on my coping abilities.
8	When I am confronted with a problem, I can usually find several solutions.
9	If I am in trouble, I can usually think of a solution.
10	I can usually handle whatever comes my way.

Note: Responses: 1 = Not at all true; 2 = Hardly true; 3 = Moderately true; 4 = Exactly true.

Table 3 Box-trainer task performance differences between pre- and post-training based on the fundamentals of laparoscopic surgery (FLS) scoring

Group	Parameter	N	Pre M (SD)	Post M (SD)	95% CI (L/H)	<i>P</i> *
Novices	Peg transferring	32	112.4 (10.6)	129.4 (6.4)	13.9/20.0	0.00
	Pattern cutting	32	117.3 (9.4)	122.0 (7.9)	1.0/8.4	0.02
	Intracorporeal suturing	32	8.6 (3.3)	9.2 (3.4)	-0.1/1.3	0.12
Experts	Peg transferring	10	110.7 (15.9)	129.5 (10.1)	5.6/32	0.01
	Pattern cutting	10	107.2 (12.4)	135.5 (7.0)	16.2/40.4	0.00
	Intracorporeal suturing	10	11.8 (3.7)	13.9 (2.5)	0.4/3.8	0.02

Abbreviations: CI, confidence interval; M, mean value; SD, standard deviation.

*Paired *t* test.

Bold values: statistically significant changes.

calculated from the first to second feedback. Additionally, 81.25% of novices (26/32) provided the first video feedback, and this proportion decreased to 62.5% (20/32) for the second feedback, while 80% of experts (8/10) provided two feedbacks.

The operative performance results are shown in Figure 3. Compared to the first feedback, GRS scores improved regarding tissue ($P = 0.03$ and $P = 0.02$), time and motion ($P = 0.02$, $P = 0.03$),

instrument handling ($P = 0.03$, $P = 0.02$), flow of operation ($P = 0.03$, $P = 0.02$), and knowledge of specific procedures ($P < 0.001$ and $P = 0.01$) for novices and experts in the second feedback, respectively.

Figure 4 shows comparisons of each trainee's GSE confidence index before and after training. Surprisingly, the GSE confidence index of all trainees increased. Specifically, a significant difference was observed between pre-and post-training (17.69 ± 3.95 versus 24.55 ± 3.62 , respectively; $P < 0.001$).

Table 4 summarizes the results of the training satisfaction questionnaire. All trainees (97.62%) considered that the guidance was appropriate during the pandemic, and the majority (83.33%) felt safe and well protected. Regarding training sessions, web-based online teaching, simulation-based training, and surgical video feedback were considered effective training tools (85.71%, 95.24%, and 80.95%, respectively).

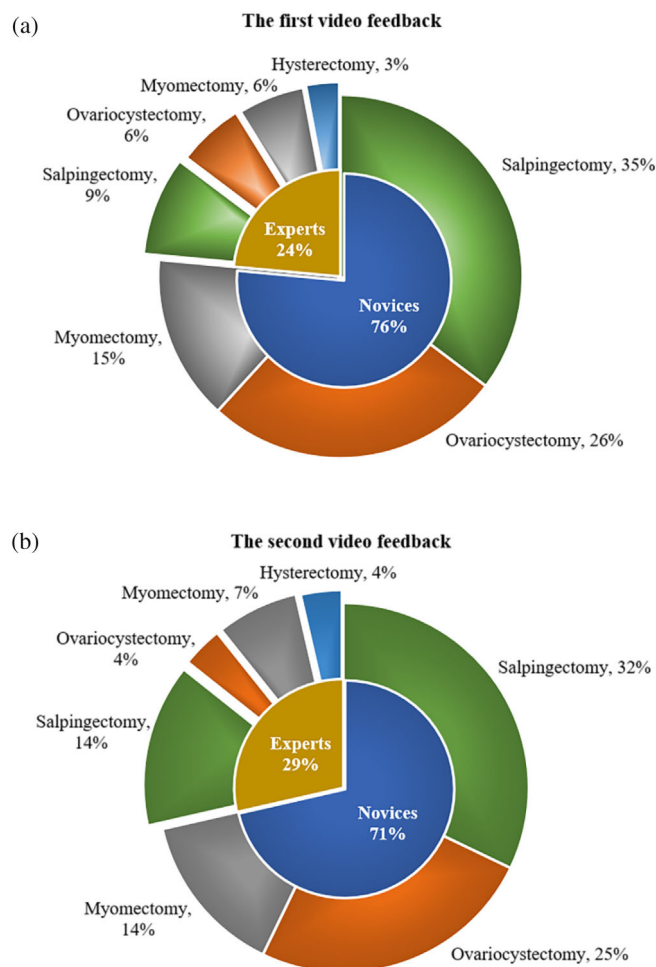


Fig. 2. Chart showing types and proportion of the surgical video feedback during the first (a) and the second feedback (b).

Discussion

The global COVID-19 pandemic has brought many practical difficulties to LESS surgical training; however, little LESS training practice during COVID-19 has yet been published. In this study, we evaluated the effect of a modified LESS training practice in 2020 during the pandemic, an optimized training programme characterized by a combination of web-based online teaching, self-directed simulator-training, and trainees' surgical video feedback. Improved performance in both the box-trainer task and video feedback was observed following the implementation of this programme. Moreover, an increase in the GSE confidence index for all trainees was noted. Overall, our LESS training programme is a practical and effective option that enables trainees to continue training during the epidemic.

During the implementation phase of a new operative technique, thorough education and training are essential for surgeons. The LESS-dedicated technique—characterized by unique challenges such as loss of instrument triangulation and crowding of the surgical field,¹⁴ is no exception. With the global COVID-19 healthcare crisis at hand, the duration and magnitude of which are still unknown, the training programme is in a period of flux, and most of the trainees felt that the lockdown adversely affected their learning progress.¹⁵ Thus, an optimized training programme is

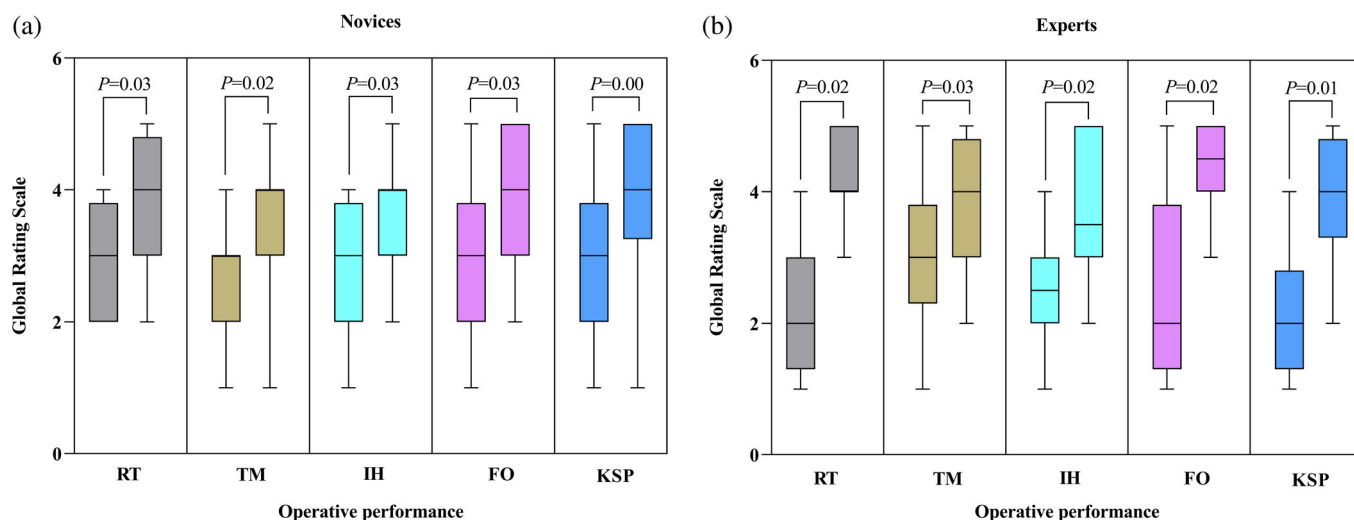


Fig. 3. Box plots of within-group differences for operative performance assessment between the first and the second video feedback among the novices (a) and experts (b), respectively, based on the global rating scale (GRS). FO, flow of operation; IH, instrument handling; KSP, knowledge of specific procedure; RT, respect for tissue; TM, time and motion.

necessary, not only to overcome the current COVID-19-related restrictions but also to break through any further restrictions.

Conferences are a traditional component of medical training. Owing to social distance requirements, virtual meetings that transform from physical ones are preferred and more effective during the pandemic.¹⁶ Our web-based online classes offer a unique opportunity to allow maximum trainee participation without geographical limitations. More importantly, it allows trainees to focus on what they are interested in through repeated replay during their fragmented time to achieve more efficient, extensive, and persistent learning compared to offline classes.

LESS training, which only applies to online classes, is challenging, considering that it is a course in which surgical skills are acquired using instruments. Fortunately, simulations have been widely accepted in teaching surgical skills and have opened new

avenues in training.^{17,18} During the pandemic, several categories of simulation resources were available in the surgical training curricula. The addition of virtual reality simulation has already been shown to improve the performance of minimally invasive surgery. However, because of the lack of haptic feedback, increasing the learning curve and reducing the realism have been noted.¹⁹ Likewise, homemade simulation models allow trainees to improve their surgical skills. However, limitations remain, including the difficult acquisition of homemade tools²⁰ and the difficulty of operating these models without facilitators.²¹ Box-trainer simulations are effective and useful resources for developing surgical curricula.²² Unfortunately, the main limitation of a purchased box-trainer is its high cost, making it less feasible for individual training during a pandemic.²³ Accordingly, during the COVID-19 crisis, our simulator-training session was performed in a specific training institution. However, the challenge is to strike a balance between high-quality surgical training and trainees' protection. Thus, in light of the need for social distance and the minimisation of face-to-face instruction of trainees, in the present study, a video-based self-directed practice could be a convenient and effective solution to avoid crowded on-site mentoring. Meanwhile, it is associated with the significantly improved simulator-training task performance in a majority of trainees for both groups, 'novices' and 'experts,' suggesting that simulator-training self-directed has certainly played an outstanding role in improving surgical skills, irrespective of previous LESS experience. However, the performance for a relatively complicated procedure, such as intracorporeal suturing, was only improved in the expert trainees' group. This result reminds us to train hierarchically in future simulator-training so that 'novices' can receive separate and additional training in a relatively complex operation.

Generally, a training programme should not only improve the basic operating skills of trainees but also improve their performance in clinical practice. However, to date, it has not yet been determined whether basic skills acquired through simulator-training courses can

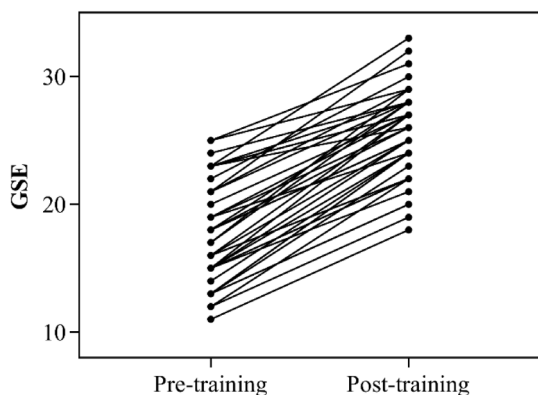


Fig. 4. Change in GSE confidence index between pre- and post-training during the epidemic. All trainees had increases in GSE confidence index, and none decreased.

Table 4 Trainees' perception regarding the training program during the pandemic

Question	Trainees n (%)
Do you think that our institution has provided you appropriate guidance on training during the pandemic?	
Yes	41 (97.62)
No	1 (2.38)
Do you believe that web-based online teaching could be effective for theoretical training?	
Yes	36 (85.71)
No	6 (14.29)
Do you believe that a simulator-training may help you to retain and/or improve your surgical skills?	
Yes	40 (95.24)
No	2 (4.76)
The adding of surgical video feedback mechanisms could be helpful to your practical training?	
Yes	34 (80.95)
No	8 (19.05)
Do you feel safe and well protected against COVID-19 pandemic the measures taken by our institution in the training?	
Yes	35 (83.33)
No	7 (16.67)

improve clinical practice. Animal lab training is a common method for evaluating the outcomes of training courses.²⁴ During the epidemic, however, trainers used live surgical video demonstrations rather than animal experiments, expecting to facilitate the transfer of skills effectively. Specifically, the demonstration of surgical procedures through live surgery has been widely reported as a helpful tool for training, as it is known that the acquisition of both motor and cognitive skills can be achieved through observation.²⁵ More importantly, the surgical video feedback mechanism, a closed-loop circular learning platform connecting trainees and trainers, is a very effective approach for guiding trainees to continue practicing. As John Wiley reported, feedback, particularly web-based, is a critical tool for trainees.²⁶ In our study, the LESS procedure for benign diseases, especially salpingectomy, was the most common form of video feedback in both groups. Our study indicates that the video feedback mechanism significantly improves operative performance and keeps them in training, which may lead to substantial long-term improvement in surgical skills. Other factors might also affect the improvement in operative performance, such as the subjective initiative of the trainees and the time window between the two feedbacks.

This study has limitations. First, because of the restrictions of the COVID-19 epidemic, the sample size is limited, especially that of the 'experts' group. Second, the modified LESS training programme was not compared with the traditional LESS training programme before the COVID-19 pandemic because the baseline conditions of the trainees were not comparable. Third, the LESS experience of trainees is different, and a hierarchical approach in future simulator-training might be better. Therefore, the modified training programme warrants further improvement. Further comparative studies with larger sample sizes are needed to confirm this effect.

Conclusion

In conclusion, in response to COVID-19-related restrictions, appropriate optimisation of LESS training practices is required. We propose a training programme that enables trainees to continue training during the epidemic and provides confidence and satisfaction for the trainees. The results are encouraging, and because of their practicality and effectiveness, such practices will soon become part of our long-term surgical training.

Conflict of interest

None declared.

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Informed consent

Written informed consent was obtained from all participants.

Author contributions

Jingyun Xu: Conceptualization; data curation; formal analysis; investigation; writing – original draft. **Zhihao Zhou:** Investigation; methodology; writing – review and editing. **Kai Chen:** Conceptualization; data curation; project administration; writing – review and editing. **Yue Ding:** Conceptualization; data curation; investigation; resources. **Yue Hua:** Data curation; formal analysis; investigation. **Mulan Ren:** Project administration; supervision; writing – review and editing. **Yang Shen:** Conceptualization; data curation; project administration; supervision; writing – review and editing.

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