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RESEARCH

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Contribution of simulation in paediatric laparoscopic surgery: improving suturing skills before performing a laparoscopic procedure in children

Valeska Bidault-Jourdainne^{1,4,6*}, Jean Breaud², Liza Ali^{3,4}, Isabelle Talon⁵, François Becmeur⁵, Alaa El Ghoneimi^{3,4} and Matthieu Peycelon^{3,4}

Abstract

Introduction Mastering paediatric laparoscopic surgery competency (PLSC) is technically challenging. The present study aimed to determine whether the inter-academic PLSC degree (IAD_PLSC) practical training program enables trainees to improve their skills.

Methods This retrospective study included trainees enrolled in the IAD_PLSC program in 2021 and 2022 which included two separate 12 h-sessions. Trainees practiced to perform intracorporeal laparoscopic knots (ILK) using 5- and 3-mm instruments on a pelvi-trainer simulator; Peg Transfer (PT) was used as a dexterity test; final marks added the adapted Objective Structured Assessment of Technical Skills (OSATS) score (out of 40) and time to complete ILK. ILK was considered a success in case the OSATS score > 27/40.

Results A total of 43 trainees completed the IAD_PLSC program. $N=37$ (86.0%) mastered the ILK (OSATS score > 27/40) using 5-mm instruments at the end of session 1 and $N=33$ (76.7%) at the end of session 2 ($p=0.41$). There was no significant improvement in the median [interquartile range, IQR] OSATS score (32 [30–36] vs. 32 [28–34], $p=0.19$), but the median [IQR] knot completion time improved significantly (184 s [161–268] vs. 166 s [128–218], $p=0.002$). There was a significant correlation between the knot completion time and PT time at the end of session 1 ($\rho=0.58$, 95% confidence interval, CI [0.31;0.76], $p<0.0002$) and session 2 ($\rho=0.78$, 95%CI [0.62;0.87], $p<0.0001$). When using 3-mm instruments, $N=34$ (79.1%) of trainees mastered the ILK at the end of session 2. The median [IQR] OSATS score significantly improved between the end of the two sessions (22 [21–24] vs. 31 [28–33], $p<0.0001$), but there was no significant correlation between OSATS score or knot completion time and PT time, at the end of both sessions.

Conclusion A nation-wide training program in paediatric laparoscopic surgery provides valuable practical training of intracorporeal suturing for residents in pediatric surgery and urology.

Keywords Simulation, Hands-on training, Paediatric surgery, Paediatric urology, Laparoscopy, OSATS, Education

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Introduction

Mastering paediatric laparoscopic surgery competency (PLSC) is a long process, because of the small number of patients for each of the eligible procedures, and the technical challenges of limited workspace in children [1]. Over the last decades, training of laparoscopy for residents in paediatric surgery and urology has shifted from standard companionship in the operating room to a multimodal training including hands-on training on simulators, in line with the goal of “never the first time on the patient” [2–4]. PLSC simulation programs have been developed worldwide, mainly consisting of repeated low- or high-fidelity procedural simulation in dry labs [4–6], which vary in terms of timing and duration [7]. The evaluation of these programs mostly consists of the comparison of residents’ technical skills before and after training, sometimes with an interval for post-event retention [8, 9], but do not explore separately phases of learning and improvement of technical skills.

The inter-academic PLSC degree (IAD_PLSC) was created ten years ago in France with the aim of spreading laparoscopic techniques among residents in paediatric surgery and urology. The structure of practical simulation training over two one-week sessions of 12 h each, five months apart, is original, and corresponds to the medical education concept of deliberate practice: the first session is dedicated to skills acquisition, and the second to skills improvement and maintenance [10, 11]. Since its inception, the IAD_PLSC has trained over 180 trainees, but no evaluation of the results of the practical workshops has yet been carried out.

The aim of the present study was therefore to determine whether the practical training dispensed by the IAD_PLSC enables trainees to improve their skills at the end of the two sessions, and to determine the influence of trainee’s initial dexterity on these results.

Materials and methods

The IAD_PLSC curriculum encompasses theoretical training by experts in PLSC and mentored practical training on pelvitrainers. This retrospective observational study included trainees enrolled in the IAD_PLSC in 2021 and 2022, after giving written consent. Absence to more than two practical training afternoons, as well as absence at the final practical evaluation were exclusion criteria. Study approval was obtained from university ethical committee (IRB 00006477_2023-651ter).

Practical training details

The practical sessions took place over two weeks, each time during four consecutive afternoons in February and June, at the I-Lumens simulation laboratory in Paris (Université Paris Cité), France, supervised by consultants with a minimum of four-year experience in (1) laparoscopic

surgery and (2) simulation. During this training, residents were divided into working pairs and alternated between training and observation every 15 min to limit musculoskeletal pain associated with laparoscopic practice on simulators [12, 13]. They repeated practical exercises on a LaparoTrainer® simulator (Fundamentals Of Laparoscopic Surgery™ Trainer Systems, Limbs and Things, Savannah, GA, USA) available on the platform, with 5 mm and 3 mm long-size laparoscopic instruments (one needle holder, one fenestrated grasper and one dissector for each diameter (Karl Storz SE, Tuttlingen, Germany)).

The first session in February was based on the European Basic Laparoscopic Urological Skills [14] and the American Fundamentals of Laparoscopic Surgery (FLS) [15] programs. The practical exercises during the first session consisted of training in basic laparoscopic skills (peg transfer [PT], cord manipulation, and pattern cutting) and ILK acquisition. After repetitions of the three basic skills exercises, trainees practiced ILK on prosthesis, using 5 mm and 3 mm instruments, with 4.0 and 6.0 suture thread respectively, and after initial demonstration by experts. Evaluation of ILK was based on the adapted Objective Structured Assessment of Technical Skills (OSATS) score (see Fig. 1 and below) and time required to complete the exercise.

During the second session in June, training consisted of repeated ILK (evaluated as in the first session), and simulation of standard laparoscopic surgical procedures in paediatric surgery and urology: thoracoscopic oesophageal atresia repair, pyeloplasty, as well as Nissen gastric fundoplication. The models used were low-cost made on-site using rubber balloons, nylon thread, cardboard sheets and staples [16, 17]. These complex procedures were not evaluated regarding trainees’ performances.

Evaluation of practical training

The time to complete PT exercise performed at the beginning of the first session was used herein as a basic evaluation of the trainees’ dexterity, as already described in the literature [7].

Trainees’ laparoscopic skills evaluation was based on performing an ILK, and rated using the OSATS score adapted to this specific procedure (score out of 40; Fig. 1) [18]. Trainees were asked to complete the exercise within 180 s with 5 mm instruments, and 300 s with 3 mm instruments, but there was no time limit. The OSATS score assessed the quality of the suture, including the final appearance of the knot (tightness and length of the various strands), as well as the speed and the fluidity of the various stages of the procedure. The time taken to complete the knot was also expected to affect the final OSATS score.

Trainees were assessed at the end of each session by PLSC experts for both 3 and 5 mm instruments, and the

- A. Tissue handling: score/5: 1 2 3 4 5
 1: rough and repeated handling of tissues with awkward or rough handling of instruments
 3: careful and appropriate handling of tissues and instruments overall, with occasional awkward moves
 5: consistently appropriate and careful handling of instruments and tissues.
- B. Gesture: score/5: 1 2 3 4 5
 1: lots of unnecessary gestures
 3: appropriate gesture with persistence of scarce useless movements
 5: clear saving of movements reaching optimal result.
- C. Instruments handling: score/5: 1 2 3 4 5
 1: awkward and imprecise handling and/or unsuitable use of instruments for the gesture
 3: suitable use of instruments with occasional awkward and/or rough handling
 5: fluid moves and flexible handling of instruments.
- D. Suture achievement: score/5: 1 2 3 4 5
 1: awkward and imprecise, with thread tangle, bad handling of throws and difficulties to maintain tension on threads
 3: precise and slow, majority of knots are correctly positioned with appropriate tension when tied
 5: perfectly controlled realization, with correct position and tying of knots.
- E. Procedure progress: score/5: 1 2 3 4 5
 1: frequent stops, impression of bad knowledge of procedure progression
 3: correct procedure progress with good planning of steps
 5: perfectly well-planned and efficient procedure progress.
- F. Knowledge of procedure: score/5: 1 2 3 4 5
 1: insufficient knowledge, hesitation
 3: overall knowledge of main steps
 5: demonstrate ease and practice for all steps.
- G. Global performance: score/5: 1 2 3 4 5
 1: insufficient
 3: validated skill
 5: superior mastery of skill
- H. Final product quality: score/5: 1 2 3 4 5
 1: insufficient
 3: suitable
 5: perfect.

Fig. 1 OSATS score adapted for intracorporeal laparoscopic sutures

assessment of the second session served as the final practical evaluation for IAD_PLSC validation. Since none of the participants were likely to have prior experience with 3 mm instruments, knot with these instruments were not timed at the end of the first session. However, as 3 mm instruments are merely used in paediatric laparoscopic procedures in small infants [19], the OSATS score with

3 mm instruments weighted as much as the one with 5 mm instruments for the final rating of the trainees in session #2.

The procedure was considered as acquired if the OSATS score was >20/40 and mastered when the OSATS score was >27/40, whatever the size of the instruments was.

Statistical analysis

Results were analysed using R software© (R Foundation for Statistical Computing, Vienna, Austria). Values were expressed as percentages, median [interquartile range, IQR], and ρ correlation coefficient [95% Confidence Interval, CI]. Comparisons were made using Fisher’s exact test, Student’s t-test for paired samples, and Pearson’s correlation test for paired quantitative data series; differences were considered significant if p -value < 0.05.

Results

A total of 43 trainees completed the IAD_PLSC program over the study period and all were included: 25 in 2021 and 18 in 2022. A total of 28 (65%) trainees (16/25 trainees in 2021 and 12/18 trainees in 2022) followed programs in paediatric surgery outside Europe with no access to PLSC training, the others in France or Europe where they had already completed between two and eight semesters in adult or paediatric visceral surgery (median 4 [3–6]). PT time was similar among European and non-European trainees (45 [40-51.5] versus 47 s [41.75-59], $p=0.07$).

5 mm instruments

With 5 mm instruments, there was no significant difference in the proportion of trainees mastering the ILK at the end of session #1 (86.0%) and the end of session #2 (76.7%) ($p=0.41$), and there was no significant improvement in the median [IQR] OSATS score obtained between the end of session #1 (32 [30–36]) and the end of session #2 (32 [28–34], $p=0.19$). The median [IQR] knot completion time improved significantly between the end of session #1 (184s [161–268]) and the end of session #2 (166s [128–218], $p=0.002$; Table 1).

There was no significant correlation between OSATS score and PT time at the end of session #1 ($\rho=-0.17$, 95%CI [-0.46;0.15], $p=0.29$), but OSATS score at the end of session #2 was significantly and inversely correlated with PT time ($\rho=-0.61$, 95%CI [-0.77; -0.39], $p<10^{-5}$). Interestingly, there was a significant correlation between the knot completion time and PT time both at the end

of session #1 (moderate correlation, $\rho=0.58$, 95%CI [0.31;0.76], $p<0.0002$) and session #2 (strong correlation, $\rho=0.78$, 95%CI [0.62;0.87], $p<10^{-7}$). A strong and significant correlation was also found between the end of sessions #1 and #2 for knot completion times ($\rho=0.77$ [0.59;0.87], $p<10^{-7}$), and significant but mild correlation for OSATS scores ($\rho=0.32$ [0.009 ;0.58], $p=0.045$; Table 2).

3 mm instruments

With 3 mm instruments, the knot was mastered by 79.1% of trainees at the end of session #2. The median [IQR] OSATS score markedly and significantly improved between the end of session #1 (22 [21–24]) and the end of session #2 (31 [28–33], $p<0.0001$); the knot with 3 mm instruments was not timed during the first session precluding comparison with that obtained at the end of session #2 (188s [148;260]; Table 1). There was no significant correlation between OSATS score or knot completion time and PT time, or between OSATS scores at the end of the two sessions (Table 2).

Subgroup analysis with 5 mm instruments

Analysing individual results obtained with 5 mm instruments, two groups of trainees could be defined (*post hoc* analysis): trainees whose OSATS score at the end of session #2 was \leq OSATS score in session #1 (group 1, $n=22$) and trainees whose OSATS score increased between session #1 and session #2 (group 2, $n=21$). In both groups, the median OSATS score remained above the threshold of skill mastery ($>27/40$), was not significantly different between group 1 and group 2 at the end of session #1 (34 [30–37] versus 31 [29;32], $p=0.19$), but was significantly higher in group 2 (34 [33;36]) than in group 1 (30 [27;32], $p=0.0005$) at the end of session #2. The knot completion time was also significantly shorter in group 2 (130s [120;156]) than in group 1 (211s [169;241], $p=0.014$) at the end of session #2, and only group 2 trainees significantly improved their time between both sessions (130s [120;156] vs. 193s [169;247], $p<10^{-5}$). PT time was significantly shorter in group 2 than in group 1 ($p=0.024$).

Table 1 Results of first and second sessions of practical training

	Session #1 (n=43)	Session #2 (n=43)	p-value
Trainees with OSATS score > 27/40 using 5 mm instruments, n (%)	37 (86.0)	33 (76.7)	0.41
Median OSATS score using 5 mm instruments, score/40 [IQR]	32 [30–36]	32 [28–34]	0.19
Median time to complete knot using 5 mm instruments, seconds [IQR]	184 [161–268]	168 [128–218]	0.002
Trainees with OSATS score > 27/40 using 3 mm instruments, n (%)	1 (2.3)	34 (79.1)	< 10⁻¹⁰
Median OSATS score using 3 mm instruments, score/40 [IQR]	22 [21–24]	31 [28–33]	< 0.0001
Median time to complete knot using 3 mm instruments, seconds [IQR]	n.a.	188 [148;260]	n.a.
Trainees with OSATS score > 27/40 using 5 and 3 mm instruments, n (%)	1 (2.3)	25 (58.1)	< 10⁻⁸

IQR: Inter-Quartile Range

OSATS: Objective Structured Assessment of Technical Skills

n.a.: not applicable

Table 2 Correlation between OSATS score or time for intracorporeal laparoscopic sutures and time for completing peg transfer

	Correlation with PT time in session #1, ρ [95%CI]	Correlation with PT time in session #2, ρ [95%CI]	Correlation between sessions, ρ [95%CI]
OSATS median score with 5 mm instruments, score/40 [IQR]	-0.17 [-0.46;0.15]	-0.61 [-0.77;-0.39]	0.32 [0.01;0.58]
<i>p</i> -value	0.29	< 0.00001	0.045
Median time to complete knot with 5 mm instruments, seconds [IQR]	0.58 [0.31;0.76]	0.78 [0.62;0.87]	0.77 [0.59;0.87]
<i>p</i> -value	< 0.0002	< 10⁻⁷	< 10⁻⁷
OSATS median score with 3 mm instruments, score/40 [IQR]	0.15 [-0.28;0.53]	0.05 [-0.25;0.35]	0.4 [-0.02;0.70]
<i>p</i> -value	0.50	0.75	0.06
Median time to complete knot with 3 mm instruments, seconds [IQR]	Not applicable	0.02 [-0.28;0.32]	Not applicable
<i>p</i> -value	-	0.91	-

OSATS: Objective Structured Assessment Tool

PT: Peg Transfer

95%CI: 95% confidence interval

p: Pearson's correlation test value

Correlations between PT time and OSATS score or knot completion time were also found in the two subgroups; the strongest correlation with PT time was obtained in group 2 for time to complete the knot at the end of sessions #1 and #2 ($\rho=0.82$ [0.59;0.93], $p < 10^{-4}$, and $\rho=0.86$ [0.68;0.94], $p < 10^{-6}$; Table 3).

Discussion

This study shows that mastering intracorporeal laparoscopic sutures in paediatric surgery simulation is achievable for most trainees, with 5 and 3 mm instruments, through our dedicated training program. The main factor to succeed in suturing is the previous dexterity of trainees (as evaluated by PT time) which influences results with 5 mm but surprisingly not with 3 mm instruments.

OSATS score and time to complete ILK, as used in this study, are widely validated tools for objective assessment of performances in laparoscopic surgery simulation [20, 21]. It was found herein that, with 5 mm instruments, the ILK was mastered by more than two-thirds of the trainees at the end of the IAD_PLSC practical training, but only one session was sufficient to reach this result, which remained stable between session #1 and session #2. Even half of trainees failed to improve their score between the two sessions. However, they became significantly faster at the end of session #2 overall. This was probably related to the use of a basic pelvitrainer (box training), which cannot provide feedback of movement analysis, rather than a virtual reality (VR) laparoscopy simulators with integrated spatial errors analysis. Seemingly, trainees improve their speed because they get used to handle the instruments and struggle against time to complete the knot (lower ILK completion time), but they become more imprecise overall and make more errors in the meantime (stable or lower OSATS score), as it has been suggested by Japanese teams comparing box training and VR training [22, 23]. Another hypothesis to explain the decline in

the OSATS score for half of trainees could be the stress induced by evaluation, as expert evaluation is known to trigger stress and poor performance in laparoscopic surgery simulation [24]. Stress factors are presumably more important in our study at the end of session #2, since this evaluation was the only one encountered for degree validation.

OSATS score with 5 mm instruments at the end of session #2 seemed to be inversely correlated with PT time: the lower the PT time, the higher the OSATS score. Time to complete the knot was also strongly correlated with PT time, at the end of the two sessions, and in both overall and subgroup analyses. In addition, subgroup analysis found that trainees improving their OSATS score between the end of the two sessions (group 2) also significantly improved their knot completion time, contrary to trainees with stable or decreasing OSATS score (group 1). These trainees in group 2 had a significantly lower median PT time compared to the other trainees of group 1. Taken together, these results suggest that trainees with better initial dexterity (as evaluated by PT time) complete knots better (OSATS score and knot completion time) at the end of session #2. These results are in line with other published studies demonstrating that practicing basic skills improves laparoscopic suturing skills, especially for operators with various previous exposure to laparoscopic procedures [6–9, 25]. Some teams even advocate that basic laparoscopic skills training like ours should be used as training module to harmonise trainees' skills before performing more complex tasks [9, 26]. Similarly, as operator stress is reported to influence performance in laparoscopic simulation, especially in young surgeons with less laparoscopic surgery experience like our trainees [27, 28], this may contribute to the results discussed above.

With 3 mm instruments, mastering laparoscopic sutures was slower, as the proportion of trainees with

Table 3 Comparison of results of intracorporeal laparoscopic knot tying with 5 mm instruments, based on individual OSATS score evolution

	Group 1: OSATS score at the end of session 2 ≤ OSATS score at the end of session #1 (n = 22)	Group 2: OSATS score at the end of session 2 > OSATS score at the end of session #1 (n = 21)	p value group 1/ group 2
PT completion median time, seconds [IQR]	54 [44–67]	44 [40–47]	0.024
Trainees with OSATS score using 5 mm instruments > 27/40 at the end of session #1, n (%)	21 (95.5)	16 (76.2)	0.09
Trainees with OSATS score using 5 mm instruments > 27/40 at the end of session #2, n (%)	13 (59.1)	20 (95.2)	0.009
p-value session #1/#2	0.009	0.18	
OSATS median score with 5 mm instruments at the end of session #1, score/40 [IQR]	34 [31.5–37.5]	31 [29–32]	0.19
OSATS median score with 5 mm instruments at the end of session #2, score/40 [IQR]	31 [29–32]	33.5 [33–36]	< 10⁻³
p-value session #1/#2	< 10 ⁻⁷	< 10 ⁻⁴	
Correlation between OSATS median score and PT time, ρ [95%CI]			
- session #1	-0.33 [-0.66;0.10] p = 0.13	-0.36 [-0.68;0.09] p = 0.11	
- session #2	-0.46 [-0.74;-0.04] p = 0.033	-0.67 [-0.86;-0.34] p < 10 ⁻³	
Correlation between OSATS median scores at the end of session #1 and session #2, ρ [95%CI]	0.79 [0.53;0.92] p < 10 ⁻⁴	0.76 [0.49;0.90] p < 10 ⁻⁴	
Median time to complete knot with 5 mm instruments at the end of session #1, seconds [IQR]	184 [158–276]	193 [169–247]	0.58
Median time to complete knot with 5 mm instruments at the end session #2, seconds [IQR]	211 [169–241]	130 [120–156]	0.014
p-value session #1/#2	0.75	< 10 ⁻⁵	
Correlation between time to complete knot and PT time, ρ [95%CI]			
- session #1	0.52 [0.08;0.79] p = 0.023	0.82 [0.59;0.93] p < 10 ⁻⁴	
- session #2	0.69 [0.38;0.86] p < 10 ⁻³	0.86 [0.68;0.94] p < 10 ⁻⁶	
Correlation between times to complete the knot at the end of session #1 and session #2, ρ [95%CI]	0.73 [0.45;0.88] p < 10 ⁻³	0.89 [0.74;0.96] p < 10 ⁻⁶	

OSATS: Objective Structured Assessment of Technical Skills

PT: Peg Transfer

IQR: Inter-Quartile Range

95%CI: 95% Confidence Interval

OSATS score > 27 increased significantly between the end of the two sessions. This is in line with the objective of deliberate practice: [11] skill acquisition in session #1 and skill improvement in session #2. The ILK with 3 mm instruments represents a higher level of technical difficulty for beginners than the knot with 5 mm instruments, since it requires finer surgical technique [19, 29], and in this case the IAD_PLSC program is the first program proved to provide effective training.

Interestingly, performances with 3 mm instruments improved between session #1 and session #2 even with a period without access to the simulator and variable access to laparoscopy in trainees' respective departments (unknown in our study). This has been reported but with a shorter period [9, 30], and reinforces the validity of the IAD_PLSC training model in two separated

sessions. With 3 mm instruments there was no correlation between initial PT time and OSATS score or time to complete the knot, which may suggest that the increase in score observed between sessions #1 and #2 is mainly related to training during the practical sessions. This absence of correlation between performances and dexterity may also result from the fact that 3 mm instruments require precise motions in a restricted space, in which gross dexterity does not play a major role, compared to 5 mm instruments. Indeed, Azzie et al. demonstrated that surgeons initially performed better on an adult FLS simulators than on an adapted PLS simulator, regardless of their dexterity, especially for ILK [6].

These 3 mm instruments, known as “mini-laparoscopy” instruments, are the hallmark of paediatric mini-invasive surgery, mostly used in small infants where working

volumes are extremely restrained [19, 31]. Thus, being able to perform procedures with such instruments is of great value for paediatric surgery residents. We only offered trainees one adult size of pelvi-trainer box, and only one length of 3 mm instruments, which is the standard length used in most paediatric surgery departments, but it is reported that the best length for 3 mm instruments depends on the ratio between their intracorporeal and extracorporeal parts [32]. Thus, in clinical practice, several different lengths of instrument may be made available to fit closely to the wide range of intracorporeal workspaces in paediatric surgery [31], and it may therefore be of interest to offer a similar range for simulators as well as for instruments in the IAD_PLSC program [6].

Overall, these various results indicate that IAD_PLSC training program is effective to assess laparoscopic suturing performance using 5 mm instruments and to improve performance with 3 mm instruments, i.e. a level 2 contribution on Kirkpatrick's learning scale (technical skill improvement) [33], but above all indicate that skill assessment should be based on ILK with 3 mm instruments only to reflect the training of this program. However, it may be of interest to widen the assessment of skills acquisition to the more complex tasks performed in IAD_PLSC training program as it is reported that simulator-based exercises may lead to perform complex simulated procedures, even by young residents with limited laparoscopic surgery experience [34]. We thus plan to integrate evaluation of running sutures during pyeloplasty or oesophageal anastomosis simulation, on low fidelity "home-made" models [16, 17], in future sessions with an adapted OSATS score that has yet to be validated.

The present study has certain limitations. It a retrospective cohort study, so there are data that were not collected; the most important being the assessment of skills prior to the training, the number of attended laparoscopic procedures for each trainee between the two practical sessions and the evaluation of trainee's stress that could have negatively influenced performance during procedures. A control group of trainees with only theoretical and video learning would have been also of great interest, although impossible to provide in this context. However, this study reports the results from the only national simulation program available in PLSC in France. We hope that it will spread among Europe and help implement paediatric surgery resident's training with more laparoscopy simulation sessions all along their residency.

In conclusion, IAD_PLSC, with this specific and dedicated training program, provides interesting and valid practical training of basic laparoscopic skills, particularly with 3 mm instruments. It allows more than 75% of our trainees to master intracorporeal laparoscopic knot procedure, whatever their previous laparoscopic surgical

experience. Dexterity of the participants, as evaluated in this study by Peg Transfer time at the beginning of the training, is the main determinant of performances with 5 mm instruments at the end of both sessions, but has no influence on performances with 3 mm paediatric instruments. As laparoscopic intracorporeal sutures using 5 mm instruments appear now to be insufficient to assess the program, the next step is to modify the evaluation by integrating more complex procedures such as running sutures and performing oesophageal atresia or ureteropelvic junction obstruction repairs in 3D-printed models.

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Author contributions

All authors have made substantial contributions to this article: AEG and FB and JB were responsible for the conception AND design of the work. VB and LA and IT and MP did the acquisition of data. VB and LA and MP performed analysis of data. VB and JB and MP performed interpretation of data and have drafted the work. All authors substantively revised it. AND all authors have approved the submitted version (and any substantially modified version that involves the author's contribution to the study); AND all authors have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All participants consent to participate and study approval was obtained from university ethical committee (IRB 00006477_2023-651ter).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- Markel M, Lacher M, Hall NJ, et al. Training in minimally invasive surgery: experience of paediatric surgery trainees in Europe. *Br J Surg* Published Online August. 2023;1:znad245. <https://doi.org/10.1093/bjs/znad245>
- Fraser SA, Klassen DR, Feldman LS, Ghitulescu GA, Stanbridge D, Fried GM. Evaluating laparoscopic skills. *Surg Endosc Interv Tech*. 2003;17(6):964–7. <https://doi.org/10.1007/s00464-002-8828-4>
- Sarker SK, Patel B. Simulation and surgical training. *Int J Clin Pract*. 2007;61(12):2120–5. <https://doi.org/10.1111/j.1742-1241.2007.01435.x>
- Buléon C, Mattatia L, Minehart RD, et al. Simulation-based summative assessment in healthcare: an overview of key principles for practice. *Adv Simul*. 2022;7(1):42. <https://doi.org/10.1186/s41077-022-00238-9>
- Diao M, Cheng W, Tam PKH, Li L. Development of pediatric minimally invasive surgery in mainland China. *J Pediatr Surg*. 2019;54(2):229–33. <https://doi.org/10.1016/j.jpedsurg.2018.10.077>
- Azzie G, Gerstle JT, Nasr A, et al. Development and validation of a pediatric laparoscopic surgery simulator. *J Pediatr Surg*. 2011;46(5):897–903. <https://doi.org/10.1016/j.jpedsurg.2011.02.026>
- Yokoyama S, Mizunuma K, Kurashima Y, et al. Evaluation methods and impact of simulation-based training in pediatric surgery: a systematic review. *Pediatr Surg Int*. 2019;35(10):1085–94. <https://doi.org/10.1007/s00383-019-04539-5>
- Shepherd G, Von Delft D, Truck J, Kubiak R, Ashour K, Grant H. A simple scoring system to train surgeons in basic laparoscopic skills. *Pediatr Surg Int*. 2016;32(3):245–52. <https://doi.org/10.1007/s00383-015-3841-6>
- Kolozsvari NO, Kaneva P, Brace C, et al. Mastery versus the standard proficiency target for basic laparoscopic skill training: effect on skill transfer and retention. *Surg Endosc*. 2011;25(7):2063–70. <https://doi.org/10.1007/s00464-011-1743-9>
- Widder A, Backhaus J, Wierlemann A, et al. Optimizing laparoscopic training efficacy by 'deconstruction into key steps': a randomized controlled trial with novice medical students. *Surg Endosc*. 2022;36(12):8726–36. <https://doi.org/10.1007/s00464-022-09408-2>
- Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in health-care education: a best evidence practical guide. *AMEE Guide 82 Med Teach*. 2013;35(10):e1511–30. <https://doi.org/10.3109/0142159X.2013.818632>
- Gözen AS, Tokas T, Tschada A, Jalal A, Klein J, Rassweiler J. Direct comparison of the different conventional laparoscopic positions with the ethos surgical platform in a laparoscopic pelvic surgery simulation setting. *J Endourol*. 2015;29(1):95–9. <https://doi.org/10.1089/end.2014.0051>
- Stomberg MW, Tronstad SE, Hedberg K, et al. Work-related musculoskeletal disorders when performing laparoscopic surgery. *Surg Laparosc Endosc Percutan Tech*. 2010;20(1):49–53. <https://doi.org/10.1097/SLE.0b013e3181cde d54>
- Brinkman WM, Tjiam IM, Schout BMA, et al. Results of the European Basic Laparoscopic Urological skills examination. *Eur Urol*. 2014;65(2):490–6. <https://doi.org/10.1016/j.eururo.2013.10.036>
- Zendejas B, Ruparel RK, Cook DA. Validity evidence for the fundamentals of laparoscopic surgery (FLS) program as an assessment tool: a systematic review. *Surg Endosc*. 2016;30(2):512–20. <https://doi.org/10.1007/s00464-015-4233-7>
- Breud J, Talon I, Fourcade L, et al. The National Pediatric Surgery Simulation Program in France: a tool to develop resident training in pediatric surgery. *J Pediatr Surg*. 2019;54(3):582–6. <https://doi.org/10.1016/j.jpedsurg.2018.09.003>
- Rod J, Marret JB, Kohaut J, et al. Low-cost Training Simulator for Open Dismembered Pyeloplasty: development and face validation. *J Surg Educ*. 2018;75(1):188–94. <https://doi.org/10.1016/j.jsurg.2017.06.010>
- Chang OH, King LP, Modest AM, Hur HC. Developing an Objective Structured Assessment of Technical Skills for laparoscopic suturing and Intracorporeal Knot Tying. *J Surg Educ*. 2016;73(2):258–63. <https://doi.org/10.1016/j.jsurg.2015.10.006>
- Lobe TE, Panait L, Dapri G, et al. A SAGES technology and value assessment and pediatric committee evaluation of mini-laparoscopic instrumentation. *Surg Endosc*. 2022;36(10):7077–91. <https://doi.org/10.1007/s00464-022-0946 7-5>
- Martin JA, Regehr G, Reznick R, et al. Objective structured assessment of technical skill (OSATS) for surgical residents: objective structured assessment of technical skill. *Br J Surg*. 1997;84(2):273–8. <https://doi.org/10.1046/j.1365-2 168.1997.02502.x>
- Leiri S, Nakatsuji T, Tesfay ST, Pimentel EA, Nagji A, Fried GM. Certification pass rate of 100% for fundamentals of laparoscopic surgery skills after proficiency-based training. *Surg Endosc*. 2008;22(8):1887–93. <https://doi.org/10.1007/s00 464-008-9745-y>
- Leiri S, Nakatsuji T, Higashi M, et al. Effectiveness of basic endoscopic surgical skill training for pediatric surgeons. *Pediatr Surg Int*. 2010;26(10):947–54. <https://doi.org/10.1007/s00383-010-2665-7>
- Tanoue K, Leiri S, Konishi K, et al. Effectiveness of endoscopic surgery training for medical students using a virtual reality simulator versus a box trainer: a randomized controlled trial. *Surg Endosc*. 2008;22(4):985–90. <https://doi.org/ 10.1007/s00464-007-9554-8>
- Andreatta PB, Hillard M, Krain LP. The impact of stress factors in simulation-based laparoscopic training. *Surgery*. 2010;147(5):631–9. <https://doi.org/10.10 16/j.surg.2009.10.071>
- Stefanidis D, Hope WW, Korndorffer JR, Markley S, Scott DJ. Initial laparoscopic basic skills training shortens the learning curve of laparoscopic suturing and is cost-effective. *J Am Coll Surg*. 2010;210(4):436–40. <https://doi.org/1 0.1016/j.jamcollsurg.2009.12.015>
- Nakajima K, Wasa M, Takiguchi S, et al. A modular laparoscopic training program for Pediatric surgeons. *J Soc Laparoendosc Surg*. 2003;7:33–7.
- Arora S, Sevdalis N, Aggarwal R, Sirimanna P, Darzi A, Kneebone R. Stress impairs psychomotor performance in novice laparoscopic surgeons. *Surg Endosc*. 2010;24(10):2588–93. <https://doi.org/10.1007/s00464-010-1013-2>
- Maddox MM, Lopez A, Mandava SH, et al. Electroencephalographic monitoring of Brain Wave Activity during Laparoscopic Surgical Simulation to measure surgeon concentration and stress: can the student become the Master? *J Endourol*. 2015;29(12):1329–33. <https://doi.org/10.1089/end.2015.0239>
- Trudeau MO, Carrillo B, Nasr A, Gerstle JT, Azzie G. Comparison of Adult and Pediatric surgeons: insight into Simulation-based Tools that May improve expertise among experts. *J Laparoendosc Adv Surg Tech A*. 2018;28(5):599–605. <https://doi.org/10.1089/lap.2017.0214>
- Van Bruwaene S, De Win G, Miserez M. How much do we need experts during laparoscopic suturing training? *Surg Endosc*. 2009;23(12):2755–61. <https://doi.org/10.1007/s00464-009-0498-z>
- Lee ACH, Haddad MJ, Hanna GB. Influence of instrument size on endoscopic task performance in pediatric intracorporeal knot tying. *Surg Endosc*. 2007;21(11):2086–90. <https://doi.org/10.1007/s00464-007-9311-z>
- Emam TA, Hanna GB, Kimber C, Dunkley P, Cuschieri A. Effect of intracorporeal-extracorporeal instrument length ratio on endoscopic Task performance and surgeon movements. *Arch Surg*. 2000;135(1):62–5. <https://doi.org/10.100 1/archsurg.135.1.62>
- Westwood E, Malla B, Ward J, Lal R, Aryal K. The impact of a laparoscopic surgery training course in a developing country. *World J Surg*. 2020;44(10):3284–9. <https://doi.org/10.1007/s00268-020-05606-y>
- Schmitt F, Mariani A, Eyssartier E, Granry JC, Podevin G. Skills improvement after observation or direct practice of a simulated laparoscopic intervention. *J Gynecol Obstet Hum Reprod*. 2018;47(3):101–6. <https://doi.org/10.1016/j.jog h.2017.12.004>

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