International Surgery Journal
*Escobar-González A et al. Int Surg J. 2026 Oct;13(10):1848-1854*
https://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20263338

## Original Research Article

# Performance dynamics and learning curve in basic laparoscopic simulation – analysis of 489 participants in a structured training program

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**Received:** 01 September 2026
**Revised:** 19 September 2026
**Accepted:** 21 September 2026

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## ABSTRACT

**Background:** Laparoscopic surgery requires complex psychomotor skills, including bimanual coordination, adaptation to the fulcrum effect, depth perception, and fine instrument control. Dry-lab simulation enables the development of these skills in a safe, reproducible environment without risk to patients.

**Methods:** A retrospective, cross-sectional study with convenience sampling was conducted from March 2024 to January 2026 at the Centro de Formación de Mínima Invasión in Mexico City, Mexico, conducted among residents and attending physicians enrolled in a diploma course on advanced laparoscopy and robotic techniques at a minimally invasive surgery training center in Mexico City. Nonparametric tests included Wilcoxon, Friedman, Kruskal-Wallis, and Mann-Whitney U tests, as well as Spearman correlation, with statistical significance set at p<0.05, using statistical package for the social sciences (SPSS) program.

**Results:** Of 523 initial records, 489 participants were included. Mean age was 30.7±3.7 years; 70.6% were male and 29.4% were female. Most participants belonged to General Surgery (91.0%), followed by Urology (7.0%) and Gynecology (2.0%). Significant improvement was observed in object transfer (35.8%; p<0.001), extracorporeal knot tying (43.5%), and intracorporeal suturing (22.6%; p<0.001). Precision cutting did not show significant improvement: delta +1 second, percentage improvement -0.4%, and p=0.788. Comparisons among tasks demonstrated significant differences (p<0.001).

**Conclusions:** Structured laparoscopic simulation was associated with significant improvement in three basic tasks. The magnitude of improvement varied according to task type and was greatest for extracorporeal knot tying. Precision cutting requires complementary assessment metrics focused on accuracy and technical quality.

**Keywords:** Laparoscopic simulation, Dry lab, Learning curve, Surgical skills, General surgery, Urology, Gynecology

## INTRODUCTION

Laparoscopic surgery has become a central component of modern surgical practice and the standard of care for multiple conditions. Its benefits include less postoperative pain, shorter hospital stays, and earlier functional recovery. However, learning laparoscopy entails specific cognitive and psychomotor demands that differ from those required in open surgery. The operator must perform three-dimensional manoeuvres based on a two-dimensional image, adapt to the fulcrum effect, coordinate both hands under indirect visualization, and compensate for reduced tactile feedback. These demands support educational models that separate the initial acquisition of technical skills from direct clinical practice.[1-6]

The learning curve describes the relationship between task practice and acquired proficiency. According to the Fitts and Posner model, motor learning progresses from a cognitive phase, characterized by high mental workload and frequent errors, to an associative phase in which errors decrease and efficiency improves, ultimately reaching an autonomous phase characterized by fluent performance and lower cognitive load. In laparoscopic simulation, this progression is commonly assessed using task completion time, error rate, and the number of repetitions required to reach a performance plateau.[7-9]

Dry-lab simulation allows modular tasks to be practiced in a controlled, reproducible environment without risk to patients. Box trainers, laparoscopic instruments, and inanimate materials enable deliberate repetition, immediate feedback, and objective assessment at a lower cost than high-fidelity simulators. Although anatomical realism is limited, this modality is useful for developing bimanual coordination, triangulation, cutting, ligation, and suturing skills, and the skills acquired may be associated with better early performance in the operating room.[10-17]

Performance assessment may focus on task outcomes, using time and errors, or on process quality, using global rating scales such as GOALS and kinematic analysis. This distinction is important because time alone does not capture accuracy, instrument stability, or adherence to margins, particularly in tasks such as precision cutting.[18-21]

General Surgery, Gynecology, and Urology all use laparoscopic techniques, but differ in clinical exposure, target anatomy, and technical demands. Familiarity with broad triangulation movements, work within the lesser pelvis, restricted anatomical spaces, and complex reconstructive tasks may influence the rate of skill acquisition. Nevertheless, curriculum standardization and deliberate practice may reduce these differences.[22-30]

In Mexico, limited information is available on performance dynamics in simulation programs that simultaneously compare laparoscopic tasks, surgical specialties, and levels of training. The aim of this study was to compare the magnitude of improvement and the rate of skill acquisition across four basic laparoscopic tasks within a structured simulation program, and to explore the effects of surgical specialty, training level, and age.

## METHODS

A retrospective, cross-sectional, descriptive, observational study with convenience sampling was conducted from March 2024 to January 2026 at the Centro de Formación de Mínima Invasión in Mexico City, Mexico.

### *Participants and selection criteria*

The study population consisted of residents and board-qualified/attending physicians in General Surgery, Urology, and Gynecology who completed the diploma course in advanced laparoscopy and robotic techniques. Participants were included if they successfully completed the course and had complete records for age, sex, specialty, training level, and initial and final completion times for all four tasks. Completion times were required to be greater than zero and free of extreme values incompatible with the measurement.

Participants who did not complete the diploma course were excluded. For complete-case analysis, records with missing values, initial or final times equal to zero, and evident extreme values, defined as completion times greater than 1,800 seconds, were removed.

### *Study variables*

Demographic, clinical, anatomical, and surgical variables were collected from institutional medical records. Bile duct injuries were classified according to the Strasberg and Bismuth classification systems, as appropriate, based on the anatomical characteristics documented in the operative reports. Variables analysed included sex, age, injury classification, surgical complexity (SG2 or SG3), type of reconstruction performed, presence of postoperative bile leak, and biliary patency during follow-up.

### *Simulation setting and equipment*

Training was performed using box trainers (endotrainers), a high-definition monitor, and a 0° laparoscopic camera. Instruments included Maryland dissectors, laparoscopic scissors, graspers, laparoscopic needle holders, and 3-0 polyglycolic acid and 3-0 silk training sutures. Teaching materials included a plastic peg tower, colored plastic beads, nonwoven fabric, holding clamps, balloons, adhesive, a cork base, and simulated models. A smartphone camera was used for video recording and timing.

### *Tasks evaluated*

The tasks, based on fundamental laparoscopic skills exercises, were as follows.

Object transfer (peg transfer) using Maryland dissectors and a grasper, the participant transferred pieces with a central opening from one hand to the other and placed them on the contralateral side without allowing them to fall outside the visual field. The task assessed bimanual coordination, nondominant-hand coordination, and adaptation to the laparoscopic environment. The time limit was 360 seconds.

Precision cutting using a Maryland dissector and laparoscopic scissors, the participant cut a circular figure marked on nonwoven fabric, remaining within 2 mm outside the line, without detaching or tearing the material and while using both hands. The task assessed fine cutting, angulation, dissection, bimanual coordination, and tissue handling. The time limit was 360 seconds.

Endoscopic ligation or extracorporeal knot tying (ligation loop), in which the participant constructed an extracorporeal knot, introduced it into the trainer, and advanced it with a grasper to a marked line on a simulated appendix. The task assessed technical sequencing, fine coordination, and tissue handling. The time limit was 180 seconds.

Intracorporeal suturing and knot tying, in which the participant performed intracorporeal suturing on a balloon or Penrose drain divided along the midline, placed two stitches at the ends, and constructed a square knot aligned with the marks. The task assessed needle loading and orientation, bimanual coordination, accuracy, and knot construction. The time limit was 560 seconds.

### *Procedure and assessment*

Participants completed a questionnaire on demographic characteristics and background information. The first attempt at each exercise was video-recorded as the baseline assessment, and task completion time was recorded. Subsequently, three attempts at each task were timed, with technical corrections and supervised performance according to the task description and maximum allowed time. Finally, an additional round was performed and video-recorded as the final assessment, with completion time recorded again. Baseline and final videos were uploaded to an online platform as assessment evidence.

### *Variables and outcomes*

The main independent variable was surgical specialty: General Surgery, Gynecology, or Urology. Dependent variables were initial time, final time, time delta, absolute improvement, and percentage improvement for each task. Secondary variables were task type, training level (resident or attending/specialist), age, and sex.

Delta was calculated as final time minus initial time; a negative value indicated a reduction in completion time and improved performance. Absolute improvement was calculated as initial time minus final time. Percentage improvement was calculated as follows.

$$\text{Percentage improvement} = [(\text{Initial time} - \text{final time})/\text{initial time}] \times 100$$

### *Statistical analysis*

Data were entered into an electronic database and reviewed to identify incomplete records, outliers, and invalid completion times. All times were standardized to seconds. Quantitative variables were described using mean and standard deviation when normally distributed and median and interquartile range when normality criteria were not met. Qualitative variables were summarized as absolute frequencies and percentages.

Normality was assessed using the Shapiro-Wilk test and graphical inspection. Because several measurements were non-normally distributed and extreme values were present, nonparametric tests were prioritized. Initial and final completion times for each task were compared using the Wilcoxon signed-rank test. Overall differences among tasks were analyzed using the Friedman test. Improvement across specialties was compared using the Kruskal-Wallis test, whereas residents and attending physicians/specialists were compared using the Mann-Whitney U test. Associations between quantitative variables were assessed using Spearman's rank correlation. Statistical significance was set at $p<0.05$. Given the imbalance in sample size across specialties, these comparisons were interpreted as exploratory.

## RESULTS

### *Participant selection and characteristics*

A total of 523 records were identified. After applying the data quality criteria, 34 records were excluded due to incomplete information, completion times equal to zero, or extreme values. The final sample comprised 489 participants, representing 93.5% of the original dataset.

The mean age was 30.7±3.7 years, with a median age of 30 years and an interquartile range of 28–32 years. The study included 345 men (70.6%) and 144 women (29.4%). Most participants were from General Surgery (n=445, 91.0%), followed by Urology (n=34, 7.0%) and Gynecology (n=10, 2.0%). Regarding training level, 259 participants were residents (53.0%), whereas 230 were attending physicians or specialists (47.0%) (Table 1).

### *Overall performance by task*

For object transfer, the median initial completion time was 373 seconds and the median final time was 243 seconds. The median delta was -137 seconds and the median percentage improvement was 35.8%. The difference was statistically significant ($p<0.001$).

For precision cutting, the median initial completion time was 270 seconds and the median final time was 268 seconds. The median delta was +1 second and the median percentage improvement was -0.4%. No significant difference was identified between assessments (p=0.788).

For extracorporeal knot tying, the median initial completion time was 138 seconds and the median final time was 71 seconds. The median delta was -49 seconds and the median percentage improvement was 43.5%, with a significant difference (p<0.001).

For intracorporeal suturing, the median initial completion time was 300 seconds and the median final time was 230 seconds. The median delta was -70 seconds and the median percentage improvement was 22.6%, also representing a significant difference (p<0.001) (Table 2). The Friedman test demonstrated statistically significant differences in the magnitude of percentage improvement among the four tasks (p<0.001). The greatest improvement was observed for extracorporeal knot tying (43.5%), followed by object transfer (35.8%), intracorporeal suturing (22.6%), and precision cutting (-0.4%).

***Results by specialty, training level, and age***

For object transfer, median percentage improvement was 36.4% in General Surgery, 25.8% in Gynecology, and 33.8% in Urology. No significant differences were observed among specialties (p=0.546). For precision cutting, median percentage improvement was -2.6% in General Surgery, -31.8% in Gynecology, and 28.9% in Urology. The comparison showed statistically significant differences (p<0.001); however, this finding should be interpreted cautiously because of the small numbers of participants in the Gynecology and Urology groups (Table 3). No statistically significant differences were found between residents and attending physicians/specialists for any task. Likewise, no significant association was observed between age and percentage improvement.

**Table 1: Sample characteristics and participant selection.**

| Variables | N | Result |
|---|---|---|
| **Initial records** | 523 | 100% |
| **Excluded records** | 34 | Incomplete information, completion times equal to zero, or extreme values |
| **Included participants** | 489 | 93.5% of the original database |
| **Age** | 489 | 30.7±3.7 years; median 30; IQR 28-32 |
| **Men** | 345 | 70.6% |
| **Women** | 144 | 29.4% |
| **General Surgery** | 445 | 91.0% |
| **Urology** | 34 | 7.0% |
| **Gynecology** | 10 | 2.0% |
| **Residents** | 259 | 53.0% |
| **Attending physicians/specialists** | 230 | 47.0% |

IQR: interquartile range

**Table 2: Overall results by laparoscopic task.**

| Tasks | Median initial time (seconds) | Median final time (seconds) | Median delta* (seconds) | Median percentage improvement | P value | Interpretation |
|---|---|---|---|---|---|---|
| **Object transfer** | 373 | 243 | -137 | 35.8 | <0.001 | Significant improvement |
| **Precision cutting** | 270 | 268 | +1 | -0.4 | 0.788 | No significant improvement |
| **Extracorporeal knot tying** | 138 | 71 | -49 | 43.5 | <0.001 | Significant improvement |
| **Sutura intracorpórea** | 300 | 230 | -70 | 22.6 | <0.001 | Significant improvement |

*Delta=final time - initial time. A negative delta indicates reduced completion time and improved performance. The overall comparison among tasks using the Friedman test was significant (p<0.001)

**Table 3: Median percentage improvement in selected tasks by specialty.**

| Tasks | General surgery | Gynecology | Urology |
|---|---|---|---|
| **Object transfer** | 36.4% | 25.8% | 33.8% |
| **Precision cutting** | -2.6% | -31.8% | 28.9% |

Object transfer: Kruskal-Wallis p=0.546. Precision cutting: Kruskal-Wallis p<0.001. Specialty-specific results are exploratory because of the imbalance in sample size

## DISCUSSION

This study evaluated performance dynamics across four fundamental dry-lab laparoscopic simulation tasks. Paired comparisons demonstrated significant improvement in object transfer, extracorporeal knot tying, and intracorporeal suturing, whereas precision cutting showed no significant change in completion time. Overall, these findings indicate that skill acquisition is not uniform and that the response to training depends on the psychomotor demands of each task.

The greatest gains were observed in extracorporeal knot tying and object transfer, with improvements of 43.5% and 35.8%, respectively. Both tasks rely on structured, repetitive motor sequences that may facilitate early consolidation of psychomotor patterns. This behavior is consistent with progression from the cognitive to the associative phase of learning, particularly when deliberate practice, supervised repetition, and immediate feedback are provided.[7-9,12]

Object transfer showed a median reduction of 137 seconds. This task requires bimanual coordination, control of the nondominant hand, adaptation to the fulcrum effect, and basic visuospatial orientation. Early improvement may be related to the rapid consolidation of simple motor patterns and a progressive reduction in initial cognitive load.[14,22]

Extracorporeal knot tying was the task with the greatest percentage improvement. Its fixed sequence—knot construction, introduction, and controlled advancement—allows clearly defined repetitive steps to be internalized. From an educational perspective, this responsiveness to deliberate practice suggests that the task may serve as an early indicator of progress in basic laparoscopic skills.[7,23]

Intracorporeal suturing showed significant improvement, although of a smaller magnitude. This finding is consistent with its greater technical complexity, as the task requires integration of depth perception, advanced bimanual coordination, fine needle control, economy of motion, and knot construction within the laparoscopic field. The combination of these demands increases cognitive load and may prolong the transition toward more efficient stages of performance.[26,30]

Precision cutting did not show a significant reduction in completion time. This finding does not necessarily indicate an absence of learning; rather, it highlights the limitation of time as a standalone performance metric. Cutting quality depends on path accuracy, force control, instrument stability, adherence to margins, and fine bimanual coordination.

Some participants may have prioritized accuracy over speed. Therefore, assessment of this task should be complemented by technical-quality metrics, global rating scales such as GOALS, or kinematic analysis.[18,20]

The overall differences among tasks support the hypothesis that skills with a clearly defined sequential structure may demonstrate greater learning efficiency than those that depend on fine motor control and technical judgment. This finding has curricular implications: tasks should not necessarily receive identical training time, and proficiency criteria should be adapted to the nature of each exercise.

No consistent differences were observed among General Surgery, Urology, and Gynecology. This suggests that a standardized program may promote comparable acquisition of basic skills across specialties. The difference observed in precision cutting should be regarded as exploratory because of the imbalance among groups. Studies cited in the source manuscript likewise suggest that interspecialty differences may diminish when training is structured around deliberate practice and common performance criteria.[22,25]

Training level and age were not associated with the magnitude of improvement. This finding suggests that the benefits of structured, repetitive exposure may extend to both residents and specialists and may not depend exclusively on previous surgical experience.[12,15]

Strengths of this study include its sample size, the assessment of several standardized tasks, and paired analysis of baseline and final measurements. Limitations include the retrospective design, convenience sampling, marked imbalance among specialties, predominant use of completion time as the performance metric, and absence of a formal assessment of technical quality. These limitations restrict interpretation of comparisons among specialties and support the incorporation of complementary metrics in future assessments.

These findings provide information relevant to surgical education in Mexico and support the design of competency-based curricula. Prioritizing tasks according to their learning curves, extending training exposure for intracorporeal suturing, and incorporating accuracy metrics for cutting may contribute to assessments that better reflect the characteristics of each skill.

## CONCLUSION

Structured dry-lab laparoscopic simulation was associated with significant improvement in completion time for object transfer, extracorporeal knot tying, and intracorporeal suturing. The magnitude of improvement differed among tasks and was greatest for extracorporeal knot tying. Precision cutting showed no significant change when assessed solely by completion time, indicating the need for complementary measures of accuracy and technical quality.

No consistent differences were identified according to surgical specialty or training level, and age was not associated with improvement. The research hypothesis was partially supported: variability was observed according to task type, but overall differences attributable to specialty or training level were not confirmed.

These results support simulation as a tool to standardize learning, assess technical performance, and promote competency acquisition before skills are applied in real patients.

## ACKNOWLEDGEMENTS

The authors would like to thank the Laparoscopic Center.

*Funding: No funding sources*
*Conflict of interest: None declared*
*Ethical approval: The study was approved by the Institutional Ethics Committee*

## REFERENCES

1. Instituto Mexicano del Seguro Social [IMSS]. Cirugía de mínima invasión: Evaluación de la dificultad técnica y curvas de aprendizaje en el residente. Colección DPM. Tomo 13. Ciudad de México, México; 2024.
2. Chen Y, Li T, Wang J, Zhang H. Application of a highly simulated and adaptable training system in the laparoscopic training course for surgical residents. Adv Med Educ Pract. 2023;14:215-25.
3. Müller C, Weber S, Krause T. Laparoscopy training of novices with complex curved instruments using 2D- and 3D-visualization. Surg Endosc. 2024;38(5):2541-9.
4. Ahmed K, Hussein M, Dasgupta P. Simulation-based education in urology - an update. BJU Int. 2024;131(2):145-55.
5. Holguín-Montes EJ. Evaluación de la efectividad del entrenamiento FLS modificado por Holguín en simuladores laparoscópicos en residentes de Cirugía General [Tesis de Especialidad Médica]. Chihuahua, México: Universidad Autónoma de Chihuahua; 2024.
6. Al-Farsi M, El-Haddad R, Jabbar A. Mastering the retroperitoneal angle: A dry lab learning curve analysis for urology residents in continuous intracorporeal suturing. Int J Urol Simulat. 2026;14(1):55-63.
7. López H, Martínez E, Silva R. Learning Curves in Laparoscopic Training: Comparative Analysis of Two Training Models. J Laparoendosc Adv Surg Techniq. 2026;36(2):134-41.
8. Nielsen AB, Jensen P, Kristensen M. Motor learning theories applied to laparoscopic box training: A systematic review of the cognitive and associative phases. Med Educ Online. 2026;31(1):2135099.
9. Patel N, Desai M, Shah S. The role of deliberate practice in mitigating the laparoscopic learning curve: A systematic review. Int J Surg. 2025;111(8):2410-8.
10. Kwon Y, Park S, Choi H. Deconstructing surgical proficiency: The enduring relevance of dry lab simulation in the era of advanced robotics. J Surg Educ. 2024;81(1):110-8.
11. Ramírez-Martínez J, López H. Simulación de baja fidelidad versus alta fidelidad en la enseñanza de la sutura urológica reconstructiva: Una revisión sistemática en el entorno latinoamericano. Revista Mexicana de Urología. 2025;85(1):45-53.
12. Torres J, Ramírez E. Transferability of simulation-acquired laparoscopic skills to the operating room: A cohort study. World J Surg. 2023;47(10):2405-12.
13. Müller C, Schmidt T. Correlation between dry lab plateau achievement and early clinical performance in laparoscopic appendectomies. World J Surg. 2024;48(4):845-52.
14. O'Connor P, Murphy E, Ryan S. Cross-specialty analysis of psychomotor skills acquisition in laparoscopic simulation. Am J Surg. 2023;226(6):840-6.
15. Hansen L, Jensen K, Kristensen J. Training Laparoscopic Surgeons: Assessing Workload and Skill Using NASA-TLX. Surgery. 2026;179(3):610-8.
16. Gómez RA, Silva MT. Taller de simulación laparoscópica: Adquisición de habilidades básicas y avanzadas en residentes de cirugía general. Revista de la Facultad de Medicina UNAM. 2023;66(2):18-26.
17. Castillón-Vela I, Pozo-Jiménez G, Prieto-Matienzo L, Galante-Romo I, Cogorno-Wassylkowski L. Programa modular de formación en laparoscopia con modelos de simulación 3D low-cost. Libro de Resúmenes de la XLIII Confederación Americana de Urología (CAU). 2024;1(1):112-4.
18. Gómez-Ruiz M, Sánchez-García C, Pérez-Díaz L. Assessment tools for minimally invasive surgery simulation programmes: a narrative review. Ann Laparosc Endosc Surg. 2024;9:12-20.
19. Morales AR. Evaluación de la destreza quirúrgica entre residentes de distinto grado académico mediante simulador laparoscópico y escala GOALS [Tesis de Especialidad]. San Luis Potosí, México: Universidad Autónoma de San Luis Potosí; 2026.
20. Harrison J, Lee SK. Automated kinematic analysis in dry lab laparoscopic simulation: Moving beyond time and error metrics. Surg Innov. 2025;32(2):140-9.
21. Johnson M, Smith L. Objective metrics in simulation training: A comparative study of surgical specialties. Surg Endosc. 2025;39(4):1120-8.
22. Silva-Ramírez H, Gómez-Ayala C, Mendoza L. Cross-specialty analysis of psychomotor skills acquisition: Do general surgery residents learn faster in a dry lab setting? Am J Surg. 2025;230(3):415-22.
23. Chang L, Davies K, Patel N. Early intensive dry lab training and its impact on the general surgery residency learning curve: A multi-institutional study. Surg Endosc. 2023;37(8):5890-8.

24. Schmidt A, Fischer K, Wagner M. Developing a Realistic and Cost-Effective Training Model (MaiSurge) for Laparoscopic Hysterectomies. JMIR Med Educ. 2026;12(1):e66369.
25. Valdés CE, Fernández ML, Soto P. Superando la falta de casuística clínica: El impacto del endotrainer en la curva de aprendizaje de residentes de Ginecología y Obstetricia. Ginecología y Obstetricia de México. 2025;93(4):210-9.
26. Watanabe T, Tanaka Y, Sato M. The steep learning curve of reconstructive urological laparoscopy: Is dry lab training sufficient before operating room exposure? BJU Int. 2023;132(5):580-8.
27. Kim S, Park J, Lee H. Novices' learning curve in single-port surgery using three surgical training programs. J Minim Invas Gynecol. 2024;31(2):150-7.
28. Rossi E, Bianchi L. Overcoming spatial constraints in gynecological laparoscopy: Efficacy of angled dry lab models for vaginal cuff closure training. J Minim Invas Gynecol. 2024;31(6):720-8.
29. Rodríguez C, Jiménez A, Flores M. Ergonomics and cognitive load in early laparoscopic training across gynecology and general surgery. Gynecol Surg. 2025;22(1):45-53.
30. Fernández A, Gómez M. Self-Designed Simulation-Based Laparoscopic Training Program for Urology Residents: Results After 6 Years of Experience. Urology. 2024;185:23-9.

**Cite this article as:** Escobar-González A, Saavedra-Flores DR, Sarmiento-Alvarado VA, Mercado-Pérez EF, Gil-Hurtado E, Barragán-Padilla M, et al. Performance dynamics and learning curve in basic laparoscopic simulation – analysis of 489 participants in a structured training program. Int Surg J 2026;13:1848-54.