

Research Article

Smart Workflow Improves Efficiency in Complex Pelvic Floor Ultrasound: A Preliminary Report

Gita Nurul Hidayah,^{1,2} Fernandi Moegni,^{1,2} Muhammad Syah Nadir Chan¹,
Sri Wahyu Maryuni,³ Edy Fakhrizal,³ Eppy Darmadi Achmad,⁴ Andi Rinaldi,⁴
Tri Hastono^{5,6}, Muhammad Nurhadi Rahman,⁷ Anis Widyasari,⁷ Firda Hanan Bahjah,^{1,2}
Eighty Mardiyani Kurniawati,^{5,6} Budi Iman Santoso.^{1,2}

¹Jakarta Urogynecology Center, YPK Mandiri Hospital, Jakarta

²Division of Urogynecology, Reconstructive Pelvic and Aesthetic Surgery

Department of Obstetrics and Gynecology

Faculty of Medicine Universitas Indonesia

Dr. Cipto Mangunkusumo General Hospital, Jakarta

³Division of Urogynecology, Reconstructive Pelvic and Aesthetic Surgery

Department of Obstetrics and Gynecology

Faculty of Medicine Universitas Riau

Arifin Achmad Regional General Hospital, Pekanbaru

⁴Division of Urogynecology, Reconstructive Pelvic and Aesthetic Surgery

Department of Obstetrics and Gynecology

Faculty of Medicine Universitas Padjadjaran

Hasan Sadikin General Hospital, Bandung

⁵Department of Obstetrics and Gynecology

Faculty of Medicine Universitas Airlangga, Surabaya

⁶Division of Urogynecology, Reconstructive Pelvic and Aesthetic Surgery

Department of Obstetrics and Gynecology,

Dr. Soetomo General Academic Hospital, Surabaya

⁷Division of Urogynecology, Reconstructive Pelvic and Aesthetic Surgery

Department of Obstetrics and Gynecology

Dr. Sardjito General Hospital Public Health and Nursing

Universitas Gadjah Mada, Yogyakarta

Abstract

Objective: To evaluate the effectiveness of an automated smart workflow feature in improving procedural efficiency during complex pelvic floor ultrasound (PFUS) examinations performed by urogynecologists.

Methods: This multicenter prospective cohort study included eight urogynecologists who performed complex PFUS examinations between September 2023 and March 2024. The primary outcome was procedural efficiency, defined as the reduction in examination duration between the baseline and the fifth examination, with the fifth examination representing the early stabilization phase of the learning curve. Learning curves were evaluated using cumulative sum (CUSUM) analysis to assess the achievement of stable procedural performance. User satisfaction was assessed using a Likert scale.

Results: Implementation of the smart workflow feature resulted in a mean improvement in procedural efficiency of 21.93% by the fifth examination. Four of the eight operators (50%) achieved a twofold increase in procedural speed after 4–10 examinations. CUSUM analysis demonstrated that two operators achieved effective and stable procedural performance according to the predefined CUSUM criteria. Participants reported high system usability, with mean satisfaction and convenience scores of 8.63 and 8.50, respectively.

Conclusion: The automated smart workflow significantly improved procedural efficiency during complex PFUS examinations. These improvements may facilitate broader clinical implementation of complex PFUS and support the adoption of standardized workflow optimization in clinical practice.

Keywords: pelvic floor ultrasound, procedural efficiency, smart workflow.

Correspondence author. Gita Nurul Hidayah. Urogynecology, Reconstructive Pelvic and Aesthetic Surgery
Department of Obstetrics and Gynecology, Faculty of Medicine Universitas Indonesia
Dr. Cipto Mangunkusumo General Hospital. Jakarta. Email; nhgita01@ui.ac.id

INTRODUCTION

Pelvic Organ Prolapse (POP) affects up to 40% of women worldwide, with a lifetime risk of requiring surgical intervention ranging from 7% to 19%.^{1–3} In Indonesia, the prevalence of POP is estimated at 26.4% and is frequently associated with urinary and fecal incontinence.⁴ The severity of POP is significantly associated with advancing age and higher parity.⁵ In addition to clinical complications, including vaginal erosion, hemorrhage, and recurrent urinary tract infections, POP imposes a substantial psychosocial burden by impairing social functioning and quality of life.⁶ More than 20% of women with urinary incontinence or POP eventually undergo surgical treatment, which has been shown to improve quality of life.^{7,8} Therefore, early and accurate diagnosis is essential to facilitate timely intervention and potentially reduce long-term healthcare costs.⁷

To improve the early detection of POP, the Indonesian Urogynecological Association conducted a multicenter study on the prediction of pelvic organ prolapse after delivery between September 2023 and March 2024. This initiative was supported by previous evidence emphasizing the importance of early screening and preventive strategies to reduce the progression of POP.⁵ The study incorporated a comprehensive Pelvic Floor Ultrasound (PFUS) protocol to evaluate pelvic floor anatomy and function. PFUS is a valuable diagnostic adjunct because it enables visualization of functional anatomy and occult fascial or muscular defects that may not be detected during physical examination. Furthermore, PFUS allows comprehensive assessment of the anterior, apical, and posterior compartments, including detrusor wall thickness, bladder neck mobility, and levator ani integrity.⁹

The standardized PFUS protocol required acquisition of 17 specific measurements (some assisted by the Smart Pelvic® application), 27 static images, and five video loops, generating up to 42 clinical parameters. Consequently, the examination was classified as a complex pelvic floor ultrasound (complex PFUS) procedure. The complexity of the examination was primarily attributable to the standardized research protocol rather than patient-specific pathological variability. Although all operators completed a standardized training program before study initiation, the comprehensive examination protocol remained time-consuming, requiring

approximately 40–60 minutes per examination. Consequently, there was a need for a workflow optimization tool to improve procedural efficiency.

To address this challenge, an automated smart workflow protocol (iWorks®) was developed to guide operators through the complex image acquisition sequence. The smart workflow automatically provides step-by-step guidance by displaying the next parameter to be acquired and integrates Smart Pelvic®, an artificial intelligence-based application that automatically performs pelvic floor measurements. The present study evaluated the effectiveness of this smart workflow system in improving procedural efficiency during complex PFUS examinations. Demonstrating the utility of workflow optimization technology may facilitate the broader implementation of standardized, high-quality pelvic floor ultrasound in routine clinical practice.

METHODS

This multicenter prospective cohort study was conducted as part of the Prediction of Pelvic Organ Prolapse After Delivery: Multicenter Study between September 2023 and March 2024. The participating centers included Dr. Cipto Mangunkusumo Hospital, YPK Mandiri Hospital, Arifin Achmad Provincial Hospital, Dr. Hasan Sadikin Hospital, Dr. Sardjito Hospital, and Dr. Soetomo Hospital.

The study participants were urogynecologists who performed at least five complex pelvic floor ultrasound (PFUS) examinations during the study period. All examinations were performed in primigravid women with singleton cephalic pregnancies at ≥ 36 weeks of gestation. Because the primary objective was to evaluate individual learning curves using cumulative sum (CUSUM) analysis, a relatively small sample size was considered appropriate. Furthermore, because this study was designed as a preliminary report and the number of clinicians performing PFUS in Indonesia remains limited, a convenience sample of eight urogynecologists was included without a formal *a priori* sample size calculation. Examinations with incomplete data or missing operator information were excluded. Ethical approval was obtained from the Institutional Ethics Committee (No. KET-30/UN2.F1/ETIK/PPM.00.02/2026). The primary outcome of this study was procedural efficiency during complex PFUS rather than diagnostic competence or

diagnostic accuracy. Procedural efficiency was defined as the relative reduction in examination duration between the baseline and the fifth examination. The fifth examination was selected because it represents the early stabilization phase of the learning curve, during which the greatest improvement in procedural efficiency is expected. The predefined accomplishment criterion was an examination duration equal to or less than 50% of each operator's baseline examination time.

Learning curves were evaluated using cumulative sum (CUSUM) analysis to monitor sequential changes in procedural performance. CUSUM is a statistical process control method that calculates the cumulative deviation of each observed examination duration from a predefined benchmark, thereby enabling sensitive detection of progressive changes in procedural performance while minimizing the influence of random variation.^{10,11}

To quantify sequential changes in procedural performance, the cumulative CUSUM score after the i -th examination was calculated according to the method described by Montgomery¹² as;

$$C_i = \sum_{j=1}^i (\bar{x} - \mu_0)$$

where C_i is the CUSUM after the i -th examination, $\bar{x}$ represents the observed examination duration, μ_0 is the predefined benchmark examination duration, and j denotes the sequential examination number. CUSUM is highly sensitive to small shifts in procedural performance that may not be detected using conventional statistical process control methods.¹²

Two predefined CUSUM outcomes were evaluated. First, operators whose CUSUM curves remained consistently below the predefined benchmark were considered to demonstrate improved procedural efficiency. Second, operators who reached and maintained a stable phase of the learning curve according to the predefined CUSUM interpretation criteria were considered to have achieved **effective and stable procedural performance**. These two outcomes represent different stages of procedural learning. Performing below the benchmark reflects improved procedural efficiency, whereas achieving effective and stable procedural performance reflects sustained stabilization of examination performance over repeated procedures. Because this study focused

exclusively on procedural efficiency, CUSUM analysis was not used to assess diagnostic competence, image quality, or measurement accuracy.^{13,14}

PFUS examinations were performed using the Mindray Nuewa i9® ultrasound system equipped with the Smart Pelvic® application at YPK Mandiri Hospital (Jakarta), Dr. Sardjito Hospital (Yogyakarta), Dr. Hasan Sadikin Hospital (Bandung), and Dr. Soetomo Hospital (Surabaya). Arifin Achmad Provincial Hospital (Pekanbaru) used the Nuewa i9® ultrasound system with the same standardized workflow. The iWorks® Smart Workflow protocol was standardized and identical across all participating centers, regardless of ultrasound system configuration. The workflow provides step-by-step guidance throughout the examination by indicating the next parameter to be acquired and integrates the Smart Pelvic® artificial intelligence application for automated pelvic floor measurements. All participating urogynecologists completed a mandatory standardized training program before study initiation.

Statistical analyses were performed using SPSS version 20 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD), whereas categorical variables are presented as frequencies and percentages. Fisher's exact test was used for categorical variables with expected cell counts of <5 , and the Mann–Whitney U test was applied to continuous variables that were not normally distributed. A two-sided p value of <0.05 was considered statistically significant.

RESULTS

Twelve urogynecologists were screened for eligibility. Four were excluded because they had performed fewer than five complex pelvic floor ultrasound (PFUS) examinations during the study period. Consequently, eight urogynecologists were included in the final analysis. The baseline characteristics of the study participants are presented in table 1.

Table 1. Baseline Characteristics of the Study Participants

Subject characteristics	N (%)	Mean±SD
Age distribution		
≤ 40	2 (25)	53.75 ± 14
> 40	6 (75)	
Age		
Clinical Experience as Urogynecologist		
≤ 2	1 (12.5)	10.75 ± 7.57
2-5	1 (12.5)	
5-10	0 (0)	
> 10	6 (75)	
Clinical Experience as Urogynecologist		
Clinical Experience Performing Pelvic Floor Ultrasound		
≤ 2	6 (75)	5.25 ± 7.82
2-5	0	
5-10	0	
> 10	2 (25)	
Clinical Experience Performing Pelvic Floor Ultrasound		
Regular (at least once/ week) Practice of Pelvic Floor Ultrasound before Research		
No	6 (75)	2 (25)
Yes	2 (25)	
Regular (at least once/ week) Practice of Pelvic Floor Ultrasound during Research		
No	3 (37.5)	5 (62.5)
Yes	5 (62.5)	
Mean of first examination	42 mins 32 sec	
Mean of fifth examination	32 mins 12 sec	
Mean of tenth examination*	18 min 14 secs	
Mean of last examination	28 mins 25 sec	
Rate of Satisfaction in using smart workflow (1-10)		8.63 ± 1.6
Rate of Convenience in using smart workflow (1-10)		8.5 ± 1.20

*Only 3 subjects examined ≥10 cases

The examination duration demonstrated a clear learning curve, with progressively shorter times as operators gained experience, although a slight increase was observed in the final stage, reflecting individual variability. The consistently high satisfaction and convenience

scores highlight that the smart workflow not only enhanced technical efficiency but also provided a more positive working experience for the operators. The examination durations and procedural efficiency of each operator are summarized in Table 2.

Table 2. Examination Duration and Procedural Efficiency during Complex Pelvic Floor Ultrasound

Subject Number	Duration of first examination	Duration of fifth examination	Efficiency of examination duration on fifth examination	Number of Cases to Reach Twice Faster Examination (Accomplishment)
1	00.40.21	00.45.05	-12.50*	>6
2	00.42.24	00.19.38	54.76	5
3	00.34.41	00.17.04	48.57	5
4	00.47.18	00.37.08	21.74	>8
5	00.19.16	00.17.50	5.26	>14
6	00.36.54	00.29.28	18.92	4
7	00.48.12	00.42.57	10.42	>7
8	00.52.40	00.36.45	28.30	10
Mean	00.40.13	00.30.44	21.93	

*Negative values indicate longer examination times.

The mean examination duration decreased from 40 minutes 13 seconds during the first examination to 30 minutes 44 seconds during the fifth examination, corresponding to an overall improvement in procedural efficiency of 21.93%. Four of the eight operators (50%) achieved a twofold increase in examination speed after 4–10 examinations, whereas the remaining operators required additional examinations to reach the predefined performance target or had not achieved it during the study period. The individual learning curves derived from cumulative sum (CUSUM) analysis are presented in figure 1.

CUSUM analysis demonstrated two distinct learning outcomes. First, four operators exhibited examination durations that remained consistently below the predefined benchmark, indicating improved procedural efficiency relative to the benchmark. Second, only two operators (Subjects 4 and 8) achieved effective and stable procedural performance according to the predefined CUSUM interpretation criteria. Subject 4 reached stable procedural performance after four examinations, whereas Subject 8 achieved stable performance after eight examinations and subsequently maintained this level throughout the remaining examinations.

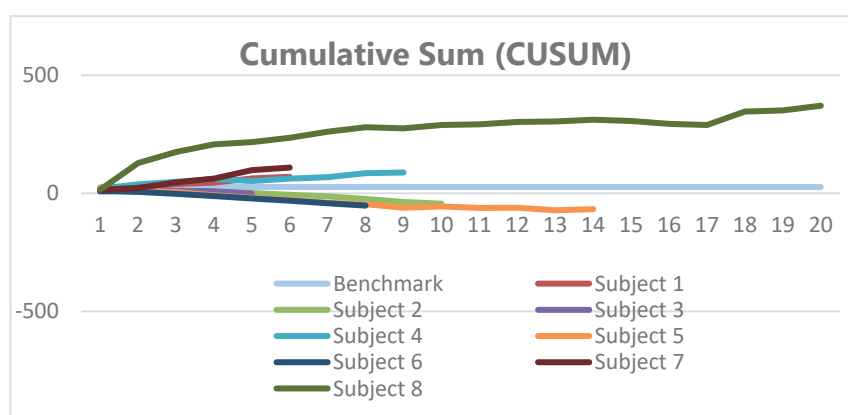


Figure 1. CUSUM of Examination Duration among Urogynecologists

Although four operators demonstrated examination durations below the benchmark, only two operators fulfilled the criteria for effective and stable examination performance. These findings indicate that improvement in procedural speed

does not necessarily correspond to stabilization of procedural performance. The characteristics of urogynecologists who achieved effective and stable examination time are summarized in Table 3.

Table 3. The Characteristics of Urogynecologists Who Achieve Effective and Stable Examination According to CUSUM

Parameters	Subject 4	Subject 8
Age	69	54
Clinical Experience Performing Pelvic Floor Ultrasound	0 (≤ 2 years)	0 (≤ 2 years)
Regularity Pelvic Floor USG prior the study	No	No
Regularity Pelvic Floor USG during the study	No	Yes
Initial Duration of Pelvic Floor USG (first exam)	00.47.18	00.52.40
Fifth Examination Duration	00.37.08	00.36.45
Number of Cases Needed to Reaching Effective and Stable Examination Time	4 cases	8 cases

DISCUSSION

This multicenter prospective cohort study evaluated the implementation of an automated smart workflow system for complex pelvic floor ultrasound (PFUS) examinations among eight urogynecologists. Although 75% of the participants had more than 10 years of subspecialty experience, most had limited

experience performing PFUS, with 75% reporting no routine PFUS practice before the study. Most participants began performing PFUS regularly only after joining the multicenter study *Prediction of Pelvic Organ Prolapse After Delivery*, indicating that they were still in the early phase of procedural skill acquisition.

Training is fundamental to the development of competency in gynecological ultrasound.¹⁵

In the present study, examination duration decreased substantially during the early phase of repeated practice. This finding is consistent with the power law of practice, which proposes that the greatest improvements in procedural efficiency occur during the initial stages of skill acquisition, followed by progressively smaller gains with continued practice.^{10,16,17}

Implementation of the smart workflow was associated with a marked improvement in procedural efficiency. Examination duration decreased by an average of 21.93% by the fifth examination compared with baseline, and 50% of the operators achieved a twofold increase in examination speed after only 4–10 examinations. These findings suggest that the smart workflow facilitates the acquisition of technical workflow efficiency during complex PFUS by providing structured guidance throughout image acquisition. Consequently, operators may perform the examination more efficiently with fewer repetitions. However, these improvements reflect procedural efficiency only and should not be interpreted as evidence of improved diagnostic competence, image quality, or measurement accuracy.

Previous studies have demonstrated that the steepest improvement in procedural performance generally occurs during the first 10–15 repetitions before reaching a performance plateau.¹⁸ The present findings suggest that the smart workflow may shorten this learning period, allowing operators to achieve substantial procedural efficiency after only 4–10 examinations. This observation is consistent with simulation-based ultrasound training studies in which novice operators achieved expert-level technical performance after a median of five practice sessions.¹⁹ In contrast, more technically demanding ultrasound examinations, such as first-trimester fetal anatomy assessment in obese patients, may require approximately 30 examinations before satisfactory procedural performance is achieved.²⁰

Several analytical approaches have been used to evaluate learning curves, including graphical inspection, split-group analysis, regression modelling, and cumulative sum (CUSUM) analysis.^{10,16} Among these methods, CUSUM provides continuous monitoring of sequential procedural performance and is particularly sensitive to small performance changes that may not be detected using conventional statistical approaches.^{11,21} Consequently, CUSUM has

become an established method for evaluating procedural learning curves in medical education and ultrasound training.^{22–24}

CUSUM analysis in the present study demonstrated two distinct learning outcomes. Four operators consistently performed examinations below the predefined benchmark, indicating improved procedural efficiency relative to the benchmark. However, only two operators (Subjects 4 and 8) fulfilled the predefined CUSUM criteria for effective and stable procedural performance. These findings demonstrate that improved procedural efficiency and stabilization of procedural performance represent different stages of the learning process. An operator may achieve faster examination times without yet demonstrating consistent procedural stability over repeated examinations.

Subject 4 achieved effective and stable procedural performance after four examinations, whereas Subject 8 reached this milestone after eight examinations and subsequently maintained stable performance throughout the remaining examinations. In contrast, Subjects 1 and 7 continued to demonstrate upward learning trajectories, suggesting that additional examinations may be required before stable procedural performance is achieved. Therefore, although four operators demonstrated procedural efficiency exceeding the predefined benchmark, only two achieved sustained stabilization during the study period.

User acceptance of the smart workflow was high. The mean satisfaction score was 8.63, with 87.5% of participants reporting satisfaction scores of 8 or higher. Similarly, the mean convenience score was 8.50, and 75% of participants rated the system's ease of use as 8 or higher. These findings indicate that the smart workflow was well accepted by users and may facilitate the implementation of complex PFUS examinations in routine clinical practice.

The present study provides a preliminary evaluation of an automated workflow optimization tool for pelvic floor ultrasound. Its principal strength lies in focusing on procedural workflow efficiency rather than diagnostic performance. By demonstrating a reduction in examination duration and favorable user acceptance, this study provides preliminary evidence that smart workflow technology may improve the efficiency of complex PFUS examinations and support broader implementation of standardized pelvic floor ultrasound in clinical practice.

Several limitations should be acknowledged. First, this study evaluated procedural efficiency only and did not assess diagnostic accuracy, image quality, or measurement precision. Therefore, improved examination speed should not be interpreted as improved diagnostic performance. Second, only two operators achieved effective and stable procedural performance during the study period, whereas other operators may require additional examinations before reaching performance stabilization. Third, the relatively small sample size precluded determination of the precise number of examinations required to achieve stable procedural performance. Nevertheless, the multicenter design reflects real-world clinical practice and enhances the generalizability of the findings. In addition, sequential analysis of repeated examinations within individual operators provides valuable insight into procedural learning trajectories.

CONCLUSION

The automated smart workflow significantly improved procedural efficiency during complex pelvic floor ultrasound examinations, with substantial reductions in examination duration achieved during the early learning phase. Together with its high user acceptability, these findings suggest that workflow automation may facilitate the broader implementation of standardized PFUS while improving the efficiency of clinical practice.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Indonesian Urogynecological Association (HUGI) and all participating hospitals for their supports in this study. And to Ayyada Khairunnisa, MD for reviewing this manuscript.

REFERENCES

- Hullfish KL, Trowbridge ER, Stukenborg GJ. Treatment strategies for pelvic organ prolapse: a cost-effectiveness analysis. *Int Urogynecol J*. 2011;22(5):507-15. doi: 10.1007/s00192-010-1306-0
- Slade E, Daly C, Mavranetzouli I, et al. Primary surgical management of anterior pelvic organ prolapse: a systematic review, network meta-analysis and cost-effectiveness analysis. *BJOG*. 2020;127(2):18-26. doi: 10.1111/1471-0528.15938
- Myoga M, Sho T, Aoki H, Ishizuka T, Nakajima D, Yoshimura K. Cost analysis of four types of surgeries for pelvic organ prolapse in a Japanese population. *J Obstet Gynaecol Res*. 2021;47(4):1567-71. doi: 10.1111/jog.14660
- Santoso B, Fauziah NR. Prevalence and characteristics of pelvic floor dysfunction in a tertiary care center in Indonesia. *Indones J Obstet Gynecol*. 2017;5(3):168-72. doi: 10.32771/inajog.v5i3.546
- Djusad S, Hakim S, Meutia AP, et al. Clinical characteristics of pelvic organ prolapse at a nationally referred general hospital: a retrospective study (2023-2024). *Indones J Obstet Gynecol*. 2025;13(4):285-9. doi: 10.32771/inajog.v13i4.2145
- Svihrova V, Svihra J, Luptak J, Swift S, Digesu GA. Disability-adjusted life years (DALYs) in general population with pelvic organ prolapse: a study based on the prolapse quality-of-life questionnaire (P-QOL). *Eur J Obstet Gynecol Reprod Biol*. 2014;182:22-6. doi: 10.1016/j.ejogrb.2014.08.019
- Dieter AA, Wilkins MF, Wu JM. Epidemiological trends and future care needs for pelvic floor disorders. *Curr Opin Obstet Gynecol*. 2015;27(5):380-4. doi: 10.1097/GCO.0000000000000204
- Hakim S, Maharani CR. Changes in quality of life score of patients with pelvic organ prolapse after vaginal surgery measured by Pelvic Floor Distress Inventory (PFDI-20) and Pelvic Floor Impact Questionnaire (PFIQ-7) questionnaires. *Indones J Obstet Gynecol*. 2017;5(3):164-7. doi: 10.32771/inajog.v5i3.545
- Dietz HP. Pelvic floor ultrasound: a review. *Am J Obstet Gynecol*. 2010;202(4):321-34. doi: 10.1016/j.ajog.2009.08.014
- Lin PL, Zheng F, Shin M, Liu X, Oh D, D'Attilio D. CUSUM learning curves: what they can and can't tell us. *Surg Endosc*. 2023;37(10):7991-8001. doi: 10.1007/s00464-023-10294-x
- Lim TO, Soraya A, Ding LM, Morad Z. Assessing doctors' competence: application of CUSUM technique in monitoring doctors' performance. *Int J Qual Health Care*. 2002;14(3):251-8. doi: 10.1093/intqhc/14.3.251
- Montgomery DC. Statistical quality control. 7th ed. New York: John Wiley & Sons. 2012.
- Wu CJ, Huang KJ, Chang WC, Li YX, Wei LH, Sheu BC. Analyzing the learning curve of vaginal pelvic reconstruction surgery with and without mesh by the cumulative summation test (CUSUM). *Sci Rep*. 2022;12(1):7025. doi: 10.1038/s41598-022-11107-1
- Novoa NM, Varela G. Monitoring surgical quality: the cumulative sum (CUSUM) approach. *Mediastinum*. 2020;4:4. doi: 10.21037/med.2019.11.01
- Guerriero S, Pascual MA, Ajossa S, et al. Learning curve for ultrasonographic diagnosis of deep infiltrating endometriosis using structured offline training program. *Ultrasound Obstet Gynecol*. 2019;54(2):262-9. doi: 10.1002/uog.20176
- Valsamis EM, Chouari T, O'Dowd-Booth C, Rogers B, Ricketts D. Learning curves in surgery: variables, analysis and applications. *Postgrad Med J*. 2018;94(1115):525-30. doi: 10.1136/postgradmedj-2018-135880
- Pusic MV, Boutis K, Hatala R, Cook DA. Learning curves in health professions education. *Acad Med*. 2015;90(8):1034-42. doi: 10.1097/ACM.0000000000000681

18. Zuo SW, Chen CC, Chen A, Wu H, Lerner V. Learning curves of OBGYN residents preparing for the FLS manual skills exam. *J Surg Educ.* 2024;81(1):115-21. doi: 10.1016/j.j Surg.2023.08.016
19. Madsen ME, Konge L, Nørgaard LN, et al. Assessment of performance measures and learning curves for use of a virtual-reality ultrasound simulator in transvaginal ultrasound examination. *Ultrasound Obstet Gynecol.* 2014;44(6):693-9. doi: 10.1002/uog.13400
20. Choi J, Buskmiller C, Toates S, et al. EP08.06: A learning curve for first trimester anatomy ultrasound in obese patients. *Ultrasound Obstet Gynecol.* 2023;62(S1):142. doi: 10.1002/uog.26736
21. Biau DJ, Williams SM, Schlup MM, Nizard RS, Porcher R. Quantitative and individualized assessment of the learning curve using LC-CUSUM. *Br J Surg.* 2008;95(7):925-9. doi: 10.1002/bjs.6056
22. Norris A, McCahon R. Cumulative sum (CUSUM) assessment and medical education: a square peg in a round hole. *Anaesthesia.* 2011;66(4):250-4. doi: 10.1111/j.1365-2044.2011.06692.x
23. Xholli A, Londero AP, Jakimovska M, et al. An implementation of the learning curve cumulative summation test to evaluate a practicum for endometrial cancer ultrasound staging. *Ultrasonography.* 2023;42(1):147-55. doi: 10.14366/usg.22055
24. Pascual MA, Alcazar JL, Graupera B, et al. Training performance in diagnosis of congenital uterine anomalies with 3-dimensional sonography: a learning curve cumulative summation analysis. *J Ultrasound Med.* 2016;35(12):2589-94. doi: 10.7863/ultra.15.12061