

Variability in Focused Assessment with Sonography for Trauma (FAST) Training Outcomes: Identifying Effective and Ineffective Learner Subgroups Among First-Year Resident Physicians

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Abstract

Background

Ultrasound training is an essential part of residency programs during emergency medicine rotations for first-year trainees (postgraduate year 1). The Focused Assessment with Sonography for Trauma (FAST) examination used to assess for internal bleeding in trauma patients is one of the essential skills postgraduate year 1 residents must acquire during the emergency medicine rotation.

Methods

A prospective, longitudinal, observational study of postgraduate year 1 residents during a 2-month long emergency medicine rotation conducted from 1 April 2019 to 31 March 2026. The primary outcome was the mean difference between the hands-on FAST examination scores of the first week of the emergency medicine rotation and the same hands-on FAST examination scores of the final week of the emergency medicine rotation. All postgraduate year 1 residents had open access to the ultrasound machine to practice examining on other postgraduate year 1 residents or could use it on real patients under supervision of emergency medicine physicians.

Results

A total of 311 PGY1 residents completed both assessments. The mean FAST score significantly improved from 8.46 to 15.82 ($p < 0.001$). Multivariable logistic regression revealed that male sex (OR = 0.56, $p = 0.038$), surgical career preference (OR = 0.47, $p = 0.029$), and later rotation months (e.g., December–January: OR = 0.10, $p < 0.001$) were independently associated with lower odds of being a high responder. Conversely, a higher PRACTICE score (OR = 0.86, $p = 0.040$) and positive participation (OR = 0.34, $p = 0.009$) protected against being a low responder, while rotating in August–September critically increased low-responder risk (OR = 9.26, $p = 0.001$).

Conclusion

Professional attitude and proactive clinical participation, rather than baseline technical skills, are the primary drivers of ultrasound training success. Educational interventions should be tailored to mitigate the high risk of training stagnation observed during the mid-year rotation periods (August and September).

Background

Ultrasound training is an essential component of residency programs during emergency medicine (EM) rotations for first-year trainees (postgraduate year 1 [PGY1]).¹ The Focused Assessment with

Sonography for Trauma (FAST) examination, used to detect internal bleeding in trauma patients, is a critical skill that all PGY1 residents must acquire during their EM rotation because of its rapidity and noninvasiveness.²

Although FAST training should ideally be integrated into medical school curricula, the majority of PGY1 residents do not receive formal instruction in ultrasound examination prior to graduation.^{1,3,4} In Japan, since 2004, all physicians have been mandated to complete a 2-year accredited postgraduate clinical training program, which includes rotations in major clinical specialties such as EM, internal medicine, pediatrics, surgery, and community-based practice.^{5,6} The duration of the EM rotation is determined at the discretion of each hospital; at our institution, a mandatory 2-month EM rotation is required for PGY1 residents.

Multiple factors can influence a resident's opportunity to gain hands-on experience with FAST in real-time emergency department (ED) settings, including seasonal fluctuations in patient volume, the fast pace of emergency care, and the number of PGY1 residents assigned to a given rotation.⁷ Given these barriers, PGY1 residents not infrequently complete their EM rotation without acquiring adequate experience on actual patients. To address this, we provided PGY1 residents with unlimited access to ultrasound machines for practice purposes throughout their rotation.¹

The purpose of this study was to evaluate the effectiveness of live patient-based FAST training for PGY1 residents within an established EM rotation and to elucidate the factors that differentiate effective and ineffective learner subgroups.

Methods

Study Design and Setting

A prospective, longitudinal, observational study was conducted to evaluate first-year postgraduate (PGY1) residents during their emergency medicine (EM) rotations at an academic university hospital. The study period spanned from April 1, 2019, to March 31, 2026 (fiscal years 2019–2025). Each clinical rotation lasted two months. To baseline the residents' baseline competency using skills and knowledge acquired during medical school, the initial hands-on Focused Assessment with Sonography for Trauma (FAST) examination was administered without any prior lectures. Following this initial assessment, all participating residents received standardized, interactive verbal feedback during the first week of the rotation to ensure consistency in core teaching points. Although simulation-based training has been shown to yield superior diagnostic ultrasound scanning performance on real patients compared to non-simulation training, PGY1 residents in this study utilized ultrasound machines exclusively on real patients in the clinical setting. The emergency department was equipped with three distinct ultrasound systems (GE Healthcare, Wauwatosa, WI, USA; Fujifilm, Tokyo, Japan; and Canon Medical Systems, Otawara, Japan). PGY1 residents were permitted to utilize these systems on real patients under the strict supervision of attending EM physicians, or to practice on peer residents unsupervised. Supervised FAST

examinations were highly interactive; attending physicians provided real-time, immediate feedback, correcting errors in probe placement, angulation, or image optimization as they occurred. All assessment scores were recorded in real time by the instructor. This study was approved by the Institutional Review Board of Osaka Medical and Pharmaceutical University (Approval No. 2767), and written informed consent was obtained from all participants prior to enrollment. All methods were performed in accordance with the relevant guidelines and regulations (such as the Declaration of Helsinki). The study design and reporting followed the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.⁸

Participants and Grouping

The study population consisted of PGY1 rotating residents (n=334) who completed their EM rotation during the specified fiscal years. Based on their identified career preferences and specialty of interest at the time of the rotation, participants were categorized into three distinct groups (Table 1):¹

1. Internal Medicine Group: Cardiology, gastroenterology, respiratory medicine, nephrology, neurology, hematology, and rheumatology.
2. Surgery Group: Cardiovascular surgery, thoracic surgery, gastroenterological surgery, breast and endocrine surgery, orthopedic surgery, neurosurgery, obstetrics and gynecology, urology, and EM.
3. Others Group: Pediatrics, anesthesiology, ophthalmology, otorhinolaryngology, dermatology, plastic surgery, radiology, and psychiatry.

Assessment

PGY1 residents' FAST examination skills were assessed using a previously validated, 18-item hands-on performance checklist (maximum score = 21) (Figure 1).⁹ The assessment was administered individually during the first and final weeks of the EM rotation under the supervision of the principal investigator. Testing took place in a private room without proctor feedback. To ensure test integrity and eliminate potential bias, peers were prohibited from observing the exam or contacting residents who had just finished. During the final week's assessment, residents were also asked to recall the total number of hands-on FAST examinations they had performed during their 2-month rotation. The comprehensive PRACTICE score was defined as the total number of hands-on FAST examinations performed, which included both supervised scans on actual patients and unsupervised practice sessions on peer residents. Following the completion of the EM rotation, each PGY1 resident was evaluated by three third-year EM residents (PGY3) using a three-item survey. This survey assessed the following domains on a 5-point Likert scale (1 = lowest, 5 = highest): Clinical Attitude, Knowledge and Skills in EM, and Positive Participation in EM clinical practice. Specifically, "Clinical Attitude" evaluated professionalism, including patient interactions, appropriate attire, and interpersonal respect. "Knowledge and Skills" reflected medical knowledge and competence in critical procedures (e.g., venipuncture during cardiac arrest). Finally, "Positive Participation" assessed teamwork attributes, evaluating both the execution of assigned EM tasks and proactivity in assisting PGY3 residents and other team members. The survey

characteristics are summarized in Tables 1. The English language version of this survey is available as Supplementary File.

Statistical Analysis

To identify the predictors of high or low responses to training, a two-step statistical approach was employed. First, a hierarchical cluster analysis based on Ward's method was utilized to objectively classify participants into distinct clusters according to their training outcomes (i.e., the trajectory between pre- and post-training FAST scores). Second, multivariable logistic regression analyses were conducted to determine the independent background factors associated with inclusion in the high-responder and low-responder clusters. All statistical analyses were performed using STATA (Version 16.1; StataCorp, College Station, TX, USA), and a two-sided *P*-value < 0.05 was considered statistically significant.

Result

Of 334 recruited PGY1 residents (211 male, 123 female), 311 (198 male, 113 female) completed both the first- and final-week hands-on FAST assessments (Table 1). Twenty-three participants were lost to follow-up (1 missed the baseline exam; 22 missed the final exam). Resident specialty preferences did not differ significantly by sex, rotation block, or training year (Table 1). Baseline evaluation parameters varied significantly across specialties via ANOVA, except for 'knowledge and skill in EM' (clinical attitude: $p = 0.021$; positive participation: $p = 0.040$; knowledge and skill in EM: $p = 0.085$). Although all residents possessed theoretical awareness of FAST, the vast majority had zero practical scanning experience before the rotation. Overall, the mean FAST score improved significantly from 8.46 (SD = 2.49) in the initial week to 15.82 (SD = 3.13) in the final week (mean difference: 7.37, 95% CI [6.97, 7.76], $p < 0.001$). Subgroup analysis based on career preferences revealed no statistically significant differences in raw FAST performance during either the initial week ($p = 0.073$) or the final week ($p = 0.222$) (Table 2). Regarding individual scanning sites (Table 3), initial-week scores showed negligible to weak correlations with the final total score (p range: 0.14–0.19). Conversely, final-week proficiencies demonstrated robust associations with the final total score; the Left Upper Quadrant ($p = 0.84$, $p < 0.001$) and Right Upper Quadrant ($p = 0.77$, $p < 0.001$) windows displayed exceptionally strong positive correlations, substantially outperforming the Pelvic ($p = 0.50$, $p < 0.001$) and Peristernal Cardiac ($p = 0.46$, $p < 0.001$) windows (Figure 2). Hierarchical cluster analysis successfully partitioned the cohort into three distinct learning phenotypes based on their longitudinal score trajectories: "high responders," "baseline achievers," and "low responders" (Figure 3). Multivariable logistic regression isolated highly divergent predictors for these phenotypes. For the "high responder" phenotype, male sex (OR = 0.56, $p = 0.038$), surgical career preference (OR = 0.47, $p = 0.029$), and later rotation timing (e.g., December–January block: OR = 0.10, $p < 0.001$) were independent negative predictors (Table 4). Conversely, for the "baseline achievers" (Supplemental Table 1), later rotation blocks independently predicted high baseline competence upon entry, peaking in December–January block (OR = 5.59, $p < 0.001$). The odds of being a baseline achiever also surged historically during fiscal years 2021 (OR = 6.64, $p = 0.001$) and 2022 (OR = 3.76, $p = 0.035$).

Notably, individual PRACTICE scores ($p = 0.585$) and behavioral ratings showed no independent association with this phenotype. Finally, regarding the "low responder" stagnation phenotype, higher total practice volume (PRACTICE score: OR = 0.86, $p = 0.040$) and proactive clinical engagement (Positive Participation: OR = 0.34, $p = 0.009$) served as significant protective factors. Temporally, rotating during August and September multiplied the risk of technical stagnation nearly nine-fold (OR = 9.26, $p = 0.001$). Data from fiscal year 2021 perfectly predicted success (zero low responders) and were excluded from the stagnation model (Table 5).

Discussion

Our 7-year institutional experience demonstrates that while unrestricted ultrasound access drives overall proficiency gains in FAST, individual learning trajectories are governed by environmental timing and behavioral commitment rather than baseline technical aptitude.

A central finding is the profound impact of the academic calendar on skill acquisition. Residents rotating later in the year were significantly less likely to be "high responders" than those in the initial April–May block. This is explained by a pedagogical baseline shift. Early-cycle residents enter the emergency department (ED) with virtually no preceding postgraduate exposure, maximizing their margin for measurable growth. Conversely, later-cycle residents have accumulated clinical competence and informal ultrasound exposure during prior rotations. This rationale is strongly supported by our multivariable analysis of the "baseline high-achievers" (Supplemental Table 1). Trainees rotating in June–July, October–November, and especially December–January (OR = 5.59, $p < 0.001$) exhibited significantly higher odds of presenting with high baseline competence from week one. These residents do not demonstrate a steep "high responder" trajectory simply because they are already performing at an advanced level upon entry.

Of greater clinical concern, however, is the severe educational vulnerability identified during late summer. Residents rotating in August and September faced an alarming, nearly nine-fold increased risk of training stagnation (low responders). This mid-year slump reflects a known transitional plateau where the initial adrenaline of residency gives way to clinical burnout and physical fatigue.^{10,11} Notably, neither individual practice volume nor behavioral metrics independently predicted baseline high-achiever status (Supplemental Table 1). This underscores that while individual effort and scanning volume are essential to rescue lagging trainees from stagnation, initial excellence upon entering a rotation is fundamentally a product of aggregate clinical maturity and institutional timing.

Our analysis also captured a stark drop in high responders during fiscal year 2022 (OR = 0.13, $p = 0.004$), which aligns precisely with our relocation to a newly constructed hospital wing and the launch of our comprehensive Emergency and Critical Care Center in July 2022. While this transition modernized our infrastructure, the logistical friction of navigating a reorganized environment temporarily disrupted established educational workflows and spontaneous access to hardware.¹² Conversely, fiscal years 2021 and 2022 saw a significant surge in baseline high-achievers (Supplemental Table 1), likely

reflecting late-COVID-19 era undergraduate curriculum adaptations, such as accelerated simulation-based training.¹³

Finally, while baseline knowledge bore no predictive value on training responsiveness, "Positive Participation" served as a powerful independent shield against stagnation. This reinforces that proactivity and teamwork are the primary vehicles for psychomotor mastery. The lower odds of high responsiveness observed among male residents and surgical aspirants warrant further qualitative inquiry, but may stem from baseline overconfidence or a narrow focus on intraoperative imaging rather than rapid triage protocols.

Limitations

This study has several limitations. First, centered at a single Japanese academic medical center, our results may not fully generalize to institutions with different rotation lengths or equipment constraints. Second, our learner phenotypes were derived via statistical clustering rather than pre-established clinical proficiency thresholds. However, a bootstrap resampling simulation with 100 replications demonstrated high stability of the mean post-training scores across matrices, confirming that these clusters represent reliable, reproducible learner behaviors. Third, our clinical metrics were adapted from national PG-EPOC rubrics, which may not map perfectly to international milestone indices.¹⁴ Lastly, the peer-to-peer component of the PRACTICE score relied on retrospective self-reporting, introducing potential recall variance. Nonetheless, the depth and duration of this dataset offer robust evidence for optimizing training logistics.

Conclusion

Providing open access to ultrasound machinery during an EM rotation yields excellent overall growth in FAST proficiency among PGY1 residents. However, beneath cohort averages lie highly variable learning phenotypes. Active clinical engagement buffers against failure, whereas rotating during the mid-year slump (August–September) or amidst major institutional relocations threatens skill mastery. Conversely, later-stage rotations naturally yield higher baseline performers. Postgraduate programs should utilize these temporal insights to structure targeted mentorship and reduce equipment access friction during predictable periods of risk.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Osaka Medical and Pharmaceutical University (Approval No. 2767), and written informed consent was obtained from all participants prior to enrollment.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Author Contributions

KoO conceived and designed the study, oversaw data collection and ethical approvals, performed the hierarchical cluster analysis and multivariable logistic regression modeling, interpreted the results, and drafted the original manuscript. SM contributed to the design of the hands-on performance assessment metrics, assisted in data collection and tracking across the seven-year study period, and substantively revised the manuscript for critical intellectual content. KaO participated in data validation, assisted with the literature review, managed the structural classification of resident specialties, and contributed to drafting the discussion section. All authors read, critically reviewed, and approved the final submitted version of the manuscript, and agree to be personally accountable for their respective contributions.

Acknowledgement

Not applicable.

Dual publication

The results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration by another publisher.

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Tables

Tables 1 to 5 are available in the Supplementary Files section.

Figures

Focused Assessment with Sonography for Trauma score sheet

	Yes (1)	No (0)
Peristernal Cardiac (4 points)		
Correct probe orientation(indicator to right shoulder)	1	0
Image anatomy		
Heart Identified	1	0
Pericardial sac identified	1	0
Aorta identified	1	0
Right Upper Quadrant (5 points)		
Correct probe orientation (indicator towards head)	1	0
Image anatomy		
Diaphragm identified	1	0
Morrison's Pouch identified	1	0
Tip of Liver identified	1	0
Inferior pole of right kidney identified	1	0
Left Upper Quadrant (5 points)		
Correct probe orientation (indicator towards head)	1	0
Image anatomy		
Diaphragm identified	1	
Subphrenic space identified	1	0
Splenorenal recess identified	1	0
Inferior pole of right kidney identified	1	0
Pelvic (4 points)		
Correct probe orientation for transverse (indicator to right)	1	0
Correct probe orientation for sagittal (indicator towards head)	1	0
Image anatomy		
Bladder identified	1	0
Pouch of Douglas identified (Rectouterine, Retrovescicular)	1	0
 Total time 0:00-2:00 (3 points)	 3	
Total time 2:01-4:00 (2 points)	2	
Total time 4:01-6:00 (1 point)	1	
Total time >6:00 (0 point)	0	
 Total points (0-21 points)		

Figure 1

Focused Assessment with Sonography for Trauma score sheet.

An 18-item, hands-on performance test (total score = 21) was developed to test medical students' skills on the FAST exam.

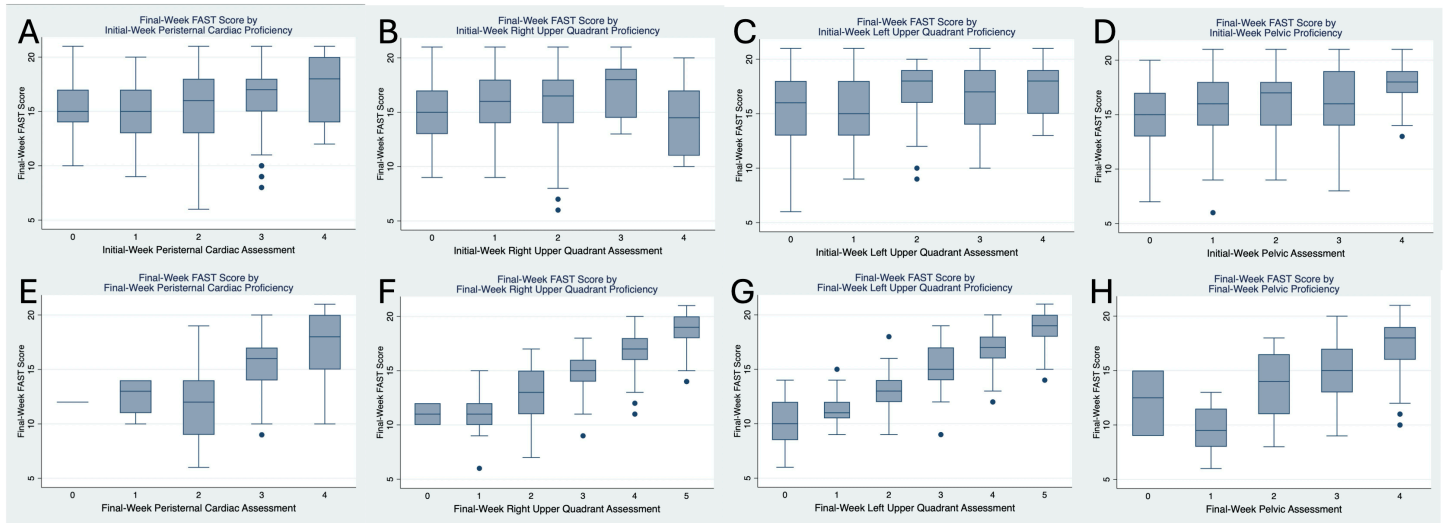


Figure 2

Distribution of final-week FAST comprehensive examination scores stratified by initial- and final-week proficiencies at individual scanning sites.

The upper panels show the final-week FAST scores stratified by initial-week proficiencies for (A) peristernal cardiac, (B) right upper quadrant, (C) left upper quadrant, and (D) pelvic (bladder) assessments. The lower panels show the final-week FAST scores stratified by corresponding final-week proficiencies for (E) peristernal cardiac, (F) right upper quadrant, (G) left upper quadrant, and (H) pelvic assessments. Each box plot represents the median (horizontal line within the box), interquartile range (bounds of the box), and adjacent values (whiskers), with dots indicating outliers. Note the markedly stronger, distinct upward trajectories associated with final-week scanning proficiencies compared to the modest baseline associations observed in the initial week.

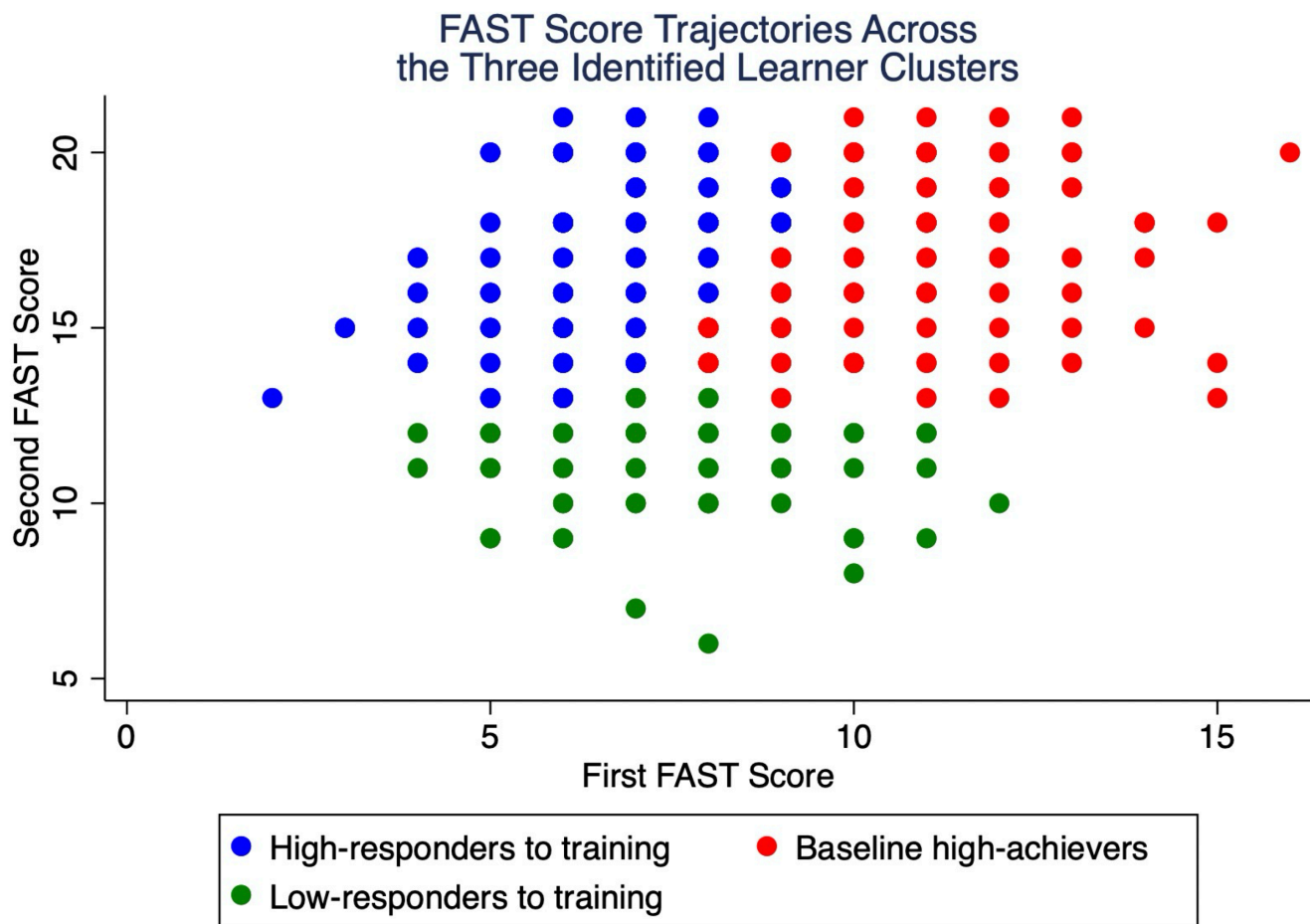


Figure 3

Scatter plot of hands-on FAST examination score trajectories across the three identified learner clusters.

The trajectories illustrate the clinical proficiency gains from the initial week (First FAST Score, X-axis) to the final week of the emergency medicine rotation (Second FAST Score, Y-axis). Trainees are color-coded by their statistically clustered training responsiveness: blue circles represent "High-responders to training" (low baseline with substantial psychomotor improvement); red circles denote "Baseline high-achievers" (consistently elevated performance maintained throughout the rotation); and green circles indicate "Low-responders to training" (persistently low performance reflecting training stagnation). Both axes represent the objective 18-item structured assessment scores (maximum possible score = 21).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [TablesFAST.docx](#)
- [SupplementalTable1FAST.docx](#)

- [IntegratingPGEPOCinto3itemsurvey.docx](#)