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Brief Report

Intraoperative Point of Care Transthoracic Echocardiography: Feasibility and Implications for Education

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Introduction

The American Society of Echocardiography recommends incorporating ultrasound as part of the initial assessment for patients experiencing hemodynamic instability or shock to narrow the differential diagnosis, guide management, and improve outcomes.[1] The American Society of Anesthesiologists has classified "Point of Care Ultrasonography, such as transesophageal or transthoracic echocardiography, for anatomic visualization and hemodynamic assessment" as an area of expertise for practicing anesthesiologists.[2] Consequently, Focused Cardiac Ultrasound (FoCUS) is now included as a core competency in anesthesiology graduate medical education,[3] and graduating residents must demonstrate the ability to interpret FoCUS images as part of the practical component of board certification.[4]

Despite the recent increased emphasis on FoCUS in anesthesiology, barriers continue to hinder its integration into both residency training and routine clinical practice.[5-8] The widespread implementation of FoCUS education requires trained staff to implement ultrasound into routine clinical practice and to teach this skill; however, survey-based studies have indicated that most attending anesthesiologists lack the competence to perform and interpret exams, resulting in inadequate instruction for residents.[5,6,8] In one study, 66% of respondents expected to be somewhat or not proficient at all in FoCUS after anesthesiology residency.[4] Furthermore, in a 2022 survey-based study, nearly 80% of respondents reported inadequate training to perform intraoperative FoCUS, and more than 80% viewed it as infeasible.[8] The authors of this study noted that common training practices, such as live model training or post-anesthesia recovery room training, are unlikely to be effective in encouraging ultrasound integration into clinical practice, given that anesthesiologists primarily work within the operating room.

To promote the integration of ultrasound into routine clinical practice for anesthesiologists, it must first be incorporated into residency training. Previous evidence suggests that specifically implementing intraoperative education may increase resident proficiency in intraoperative FoCUS and reduce the proportion of trainees who mistakenly view it as infeasible.[8] Intraoperative FoCUS has been previously studied and shown to be feasible among experienced attending anesthesiologists[9]; however, the feasibility of intraoperative ultrasound image acquisition among anesthesiology trainees has not yet been studied, and the incorporation of intraoperative FoCUS into residency curricula has not been described. This study describes the introduction of an intraoperative FoCUS component into a preexisting residency ultrasound curriculum and provides insights into the circumstances surrounding successful intraoperative image acquisition.

Materials and Methods

This retrospective observational study was conducted with institutional review board approval at a 650-bed tertiary care teaching facility.

Intraoperative FoCUS Curriculum

Between July 2019 to June 2020, a FoCUS elective was offered to postgraduate year 4 residents (n = 8) in response to internal feedback that residents viewed intraoperative transthoracic image acquisition as infeasible. This elective was implemented into an existing transesophageal echocardiography elective and expanded on the existing previous FoCUS curriculum that included a yearly 1-hour didactic lecture and 1-hour practical classroom session with live models. All 8 eligible residents disclosed that they had no prior echocardiography experience beyond exposure to the program's existing curriculum. The elective required residents to complete 5 proctored post-anesthesia care unit transthoracic exams, 5 proctored intraoperative exams, and 40 independent intraoperative exams.

Independent Examinations

Following demonstration of proficiency on 10 proctored FoCUS examinations, each resident completed 40 independent exams during an ongoing surgery without disrupting the procedure, surgical equipment, or sterility. For each exam,

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the resident logged the surgery type, surgery region, patient position, patient body mass index, and the ability to obtain the following views: parasternal long axis (PLA), parasternal midpapillary short axis (PSA), apical 4-chamber (Ap4), subcostal 4-chamber (SC), and suprasternal (SS). The PLA, PSA, Ap4, and SC views were obtained in accordance with published consensus recommendations,[1] and the SS view was added due to ease of accessibility after surgical draping in most cases, recognizing that this view holds limited clinical utility. Surgery region options included extremity, abdominal (with upper and lower abdomen determined in relation to the umbilicus), thoracic, or cephalad (above the shoulder). Trendelenburg positioning and abdominal insufflation were also logged. Success was documented "Yes" if all structures defining that view were adequately visualized, including endocardium, valves, and major vessels.

Statistical Analysis

Descriptive statistics are presented in frequencies and proportions. Generalized linear mixed effects regression (GLMER) models are used to examine the extent to which the probability of success is associated with the view (PLA, PSA, Ap4, SC, or SS) and anatomic region of the surgery (abdominal, extremity, and thoracic). Model 1 examined the extent to which different views (reference: SC) are associated with success. Model 2 examined the extent to which anatomic surgery region (reference: upper abdominal) is associated with success after controlling for the type of view. A separate GLMER was used to examine the extent to which Trendelenburg position (reference: no) and abdominal insufflation (reference: no) are associated with successful PLA or PSA views in abdominal surgeries. In all models, the resident is included as a random effect to account for within-resident correlations.

All statistical analyses are performed in R 4.3.0.[10]

Results

Because of COVID-19 pandemic restrictions, 4 (50%) residents completed this educational elective, performing a total of 160 examinations (40 per resident).

Most exams (67.5%) were performed during abdominal surgeries, whereas only 11 exams (6.9%) were attempted on thoracic surgeries (Table 1). One exam was excluded, as it was the only procedure of its category (cephalad). Extremity surgeries had the highest image acquisition success (52% for SC to 92.5% for PLA), whereas thoracic surgeries had the lowest (9.1% for SC to 63.6% for PSA).

Compared with the SC view, all other views had a statistically higher probability of success, with the PLA (odds ratio [OR], 16.36) and PSA (OR, 21.98) having the highest success rates (Table 2, Model 1). Post hoc Tukey's honestly significant difference test showed that all pairwise comparisons are statistically significant, except for 3 pairwise comparisons (PSA vs PLA, SS vs PLA, and SS vs PSA). Results from Model 2 showed an additional main effect of surgery type on the probability of success. Compared with upper abdominal location, success rates were higher for lower abdominal and extremity (OR, 2.21 and 6.59, respectively), but lower for thoracic surgeries (OR, 0.49).

For abdominal surgeries, success rates were higher for Trendelenburg positioning with PLA or PSA views (OR, 3.58; 95% confidence interval [CI], 1.4-9.11), whereas there was no main effect of abdominal insufflation on success rates for PLA or PSA view (OR, 1.91; 95% CI, 0.91-4.01).

Discussion

This study highlights the successful integration of an intraoperative FoCUS training curriculum into a previously out-of-operating room curriculum. The final curriculum consisted of minimal didactic instruction and only 10 proctored examinations. Following these interventions, a small cohort of senior residents was able to independently perform intraoperative FoCUS examinations with self-reported success rates comparable to those of experienced anesthesiologists in previous research. In a study by Kratz et al,[9] 5 anesthesiologists performed 222 intraoperative FoCUS examinations, achieving an overall image success rate of 91%, with 78% success in abdominal surgeries. Our abdominal surgery success rates of 76.9% (PLA) and 81.5% (PSA) closely mirror these results. Our demonstrated integration of FoCUS training during the intraoperative period, combined with evidence of effective skill acquisition, may serve as a valuable model for perioperative educators seeking to teach FoCUS in time- and resource-constrained clinical environments.

In addition, our study identified the views (PLA, PSA, and SS) and surgical regions (lower abdominal and extremity) with the highest image acquisition success and suggested that Trendelenburg positioning may enhance image acquisition. After controlling for Trendelenburg positioning, abdominal insufflation was associated with ~91% increased success rate, although the CIs were very large (OR, 1.91; 95% CI, 0.91-4.01), suggesting this finding may not be reliable. This information may be valuable for educators in guiding curriculum development when integrating an intraoperative component into existing FoCUS training. Specifically, FoCUS educators should consider emphasizing parasternal views for all surgeries, note that extremity or lower abdominal surgeries offer the best odds of completing a full FoCUS exam, and consider Trendelenburg positioning to assist in examinations when needed.

Limitations of this study include its retrospective single-center design, small representative sample of residents and exams due to disruption from the COVID-19 pandemic, resident self-rating of exam success, and resident self-selecting exam subjects. This last limitation of resident self-selection of subjects may be evident with only 11 thoracic surgical cases attempted. Despite these significant limitations, our results add to existing knowledge by demonstrating intraoperative FoCUS educational curriculum feasibility with resident physicians and identifying the views, surgery locations, and position maneuvers that optimize image acquisition.

Conclusion

Intraoperative FoCUS is a clinical skill that can be effectively taught to resident trainees and feasibly implemented into an existing ultrasound curriculum. When implementing such a curriculum, educators should consider that the parasternal views are the most accessible, positioning can

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augment image acquisition, and surgery type can affect image acquisition success.

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Abstract

Background: Incorporating intraoperative ultrasound education into anesthesiology graduate medical training may benefit both trainees and the field of anesthesiology.

Methods: This study describes the successful integration of intraoperative ultrasound training into an existing Focused Cardiac Ultrasound (FoCUS) curriculum. A retrospective analysis of educational logs from 4 postgraduate year 4 anesthesiology residents (exam n = 160) was conducted to determine the most accessible intraoperative FoCUS views, success rates of image acquisition by surgical region, and impact of abdominal insufflation and Trendelenburg positioning on success rates.

Results: Parasternal views had the highest probability of successful image acquisition (parasternal long axis [PLA] odds ratio [OR] = 16.36 and parasternal midpapillary short axis [PSA] OR = 21.98 compared with subcostal 4-chamber [SC]). Extremity surgeries offered the highest success rates (52% for SC to 92.5% for PLA), whereas thoracic surgery had the lowest (9.1% for SC to 63.6% for PSA). Trendelenburg positioning increased the odds of successful image acquisition in PLA or PSA views (OR, 3.58; 95% confidence interval, 1.4-9.11).

Conclusions: Integrating intraoperative ultrasound education into existing FoCUS curricula is feasible. Educators should consider emphasizing parasternal views, which are the most accessible to anesthesia clinicians, consider the higher success rates in extremity surgeries for complete examinations, and recognize that Trendelenburg positioning may enhance image optimization.

Keywords: FoCUS education; FoCUS; POCUS education; POCUS; FoCUS curriculum; intraoperative hemodynamic monitoring

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Tables

Table 1. *Frequencies (n) and Proportions (%) of Success by View and Anatomical Region of Surgery*[a]

	All Surgeries	Abdominal (n = 108)	Lower Abdominal (n = 38)	Upper Abdominal (n = 70)	Extremity (n = 40)	Thoracic (n = 11)
Ap4	69 (43.1)	37 (34.3)	19 (50)	18 (25.7)	29 (72.5)	2 (18.2)
PLA	127 (79.4)	83 (76.9)	31 (81.6)	52 (74.3)	37 (92.5)	6 (54.5)
PSA	134 (83.8)	88 (81.5)	32 (84.2)	56 (80)	38 (95)	7 (63.6)
SC	31 (19.4)	9 (8.3)	6 (15.8)	3 (4.3)	21 (52.5)	1 (9.1)
SS	125 (78.1)	85 (77.8)	33 (86.8)	51 (72.9)	35 (87.5)	6 (54.5)

Abbreviations: Ap4, apical 4-chamber; PLA, parasternal long axis; PSA, parasternal short axis; SC, subcostal; SS, suprasternal.

[a] Abdominal surgery was also categorized into lower/upper abdominal surgeries. One case documented as neurology surgery was excluded in this study because of the small sample size.

Table 2. *Results From Generalized Mixed Effects Linear Regression Models Estimating the Effect of View and Surgery on the Probability of Success*[a]

	Model 1			Model 2		
	OR	**95% CI**	***P***	**OR**	**95% CI**	***P***
View						
Ap4	3.13	1.89-5.19	<.001	3.76	2.17-6.53	<.001
PLA	16.36	9.40-28.47	<.001	24.40	13.23-45.03	<.001
PSA	21.98	12.30-39.27	<.001	33.49	17.68-63.44	<.001
SS	15.75	9.08-27.32	<.001	23.41	12.73-43.08	<.001
Surgery						
Lower abdominal				2.21	1.40-3.47	.001
Extremity				6.59	3.93-11.04	<.001
Thoracic				0.49	0.25-0.97	.040
R^2	0.311			0.441		

Abbreviations: 95% CI, 95% confidence interval; Ap4, apical 4-chamber; OR, odds ratio; PLA, parasternal long axis; PSA, parasternal short axis; R^2, proportion of variance of success explained by independent predictors in the model; SS, suprasternal.

[a] Subcostal view is used as the reference, and upper abdominal surgery is used as the reference. Residents were included as random effects to take into account within-resident correlations.