Journal of Carcinogenesis
Covering Genesis to Therapeutics
Journal of Carcinogenesis, ISSN: 1477-3163
2024; Vol 23: Issue 1, https://carcinogenesis.com/

Role of Lung Ultrasound and Transthoracic Echocardiography for Assessment of Haemodynamics in Patients with Post Partum Sever PET at Intensive Care Unit.

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ABSTRACT

Background: Preeclampsia (PET) is a life-threatening pregnancy disorder where echocardiography and lung ultrasound (LUS) aid in accurate, non-invasive fluid and cardiovascular assessment. **Objective:** The goal of this study was to assess the contribution and clinical utility of lung ultrasonography and transthoracic echocardiography in after operation haemodynamic assessment in individuals with severe PET and was to detect role of lung ultrasonography and transthoracic echocardiogram (TTE) for predicting complications among these individuals.

Methods This cross sectional was executed on 100 female participants in the childbearing period with marked PET hypertension exceeding 160/110 mmHg, proteinuria up to 2 grams, sustained epigastric discomfort, elevated hepatic enzyme levels, thrombocytopenia (<100,000/mm³), visual or neurological impairments, pulmonary edema, and eclampsia. Participants were divided into 61 cases with severe PET and 39 cases with eclampsia and 60 healthy laboring woman as a control group.

Results: Heart rate (HR), LUS score, ejection fraction (EF), and diastolic dysfunction grade all significantly predicted and monitored postoperative complications. HR (>99 bpm) showed the highest sensitivity (94.12%) and strong negative predictive value (NPV 98.2%). LUS score (>9) had the highest specificity (87.95%) and a high NPV (94.8%). EF (>56%) and diastolic dysfunction grade (>1) also demonstrated good predictive value, with high NPVs (92.5% and 95.9%, respectively), supporting their role in early detection of complications.

Conclusions: LUS and transthoracic echocardiography, alongside vital signs, had aided post-delivery monitoring in severe PET by detecting pulmonary congestion, assessing cardiac function, and identifying high-risk women for timely, individualized management.

Keywords: Lung Ultrasound, Transthoracic Echocardiography, Haemodynamics, Preeclampsia

How to Cite: Kareem Abd Elaal Hamed, Tarek Mohamed M. Mansour, AbdElaziz Saeed A. Mohamed, Mohamed Khedrawy, Mahmoud Ahmed A. Elbaset, Mohamed Hassan Mohamed Arafa, Anas Fawzy Khalil, Mohamed R. Elbasyouny, Khaled Eltamawy, Mohy Mohamed Abu Elsoud Ahmed, (2024) Role of Lung Ultrasound and Transthoracic Echocardiography for Assessment of Haemodynamics in Patients with Post Partum Sever PET at Intensive Care Unit... Journal of Carcinogenesis, Vol.23, No.1, 351-359

1. INTRODUCTION

Preeclampsia (PET) is a multifactorial pregnancy disorder that can have significant consequences both maternal and neonatal health outcomes, particularly morbidity and mortality. It is identified by the onset of hypertension accompanied by proteinuria beyond the 20th week of pregnancy, with or without involvement of other organ systems, approximately 2 – 8 % of pregnancies are complicated by PET [1].

The frequency of PET in the United States has risen by approximately 25% over the past two decades. PET remains a leading contributor to maternal and perinatal morbidity and mortality, accounting for approximately 50,000–60,000 deaths worldwide annually [2]. Severe PET is defined by any of the following: systolic blood pressure (SBP) ≥160 mmHg or diastolic blood pressure (DBP) ≥110 mmHg on two recordings obtained at a minimum interval of four hours while the patient is at bed rest; thrombocytopenia defined as a platelet count below 100,000/µl ; hepatic dysfunction, indicated by liver enzyme levels exceeding twofold elevation above the upper limit of the normal range, accompanied by persistent or treatment-resistant epigastric or right upper quadrant pain; progressive renal impairment, defined as a doubling in serum creatinine from baseline within 24 hours, the development of pulmonary edema, or the onset of new visual or neurological impairments [3].

Transthoracic echocardiography (TTE) and lung ultrasonography constitutes a fundamental diagnostic modality for critical care physicians and is progressively being integrated into medical training curricula. Basic TTE is extensively employed by intensivists to assess and monitor cardiovascular function—including myocardial contractility, diastolic performance, and intravascular volume status, consistent with the guidelines of the American Society of Echocardiography [4].

In the intensive care unit (ICU), TTE is a feasible, rapid, non-invasive technique suitable for frequent application. Lung ultrasound (LUS) offers additional advantages, including the earlier detection of clinically significant pulmonary conditions as pulmonary edema, pleural effusion, lung consolidation, and pneumothorax [5].

The precision of diagnosis using focused TTE conducted by non-cardiologists show higher diagnostic performance than clinical evaluation alone. Likewise, LUS demonstrates greater accuracy than physical examination and conventional chest radiography, and may provide diagnostic performance comparable to computed tomography [6].

In critically ill patients, cardiac ultrasound is presently utilized in a goal-oriented approach for indications such as hemodynamic instability or suspected cardiac tamponade, whereas LUS has been utilized to assess extravascular lung water (EVLW) [7].

Systematic reviews have shown that both comprehensive and focused echocardiography consistently impact diagnostic accuracy and clinical decision-making within anesthesia and intensive care settings. Nevertheless, evidence regarding the routine application of combined limited TTE and LUS in critically ill patients remains insufficient [8].

Accurate evaluation of maternal hemodynamic status is essential for optimizing fluid management in patients with severe PET. Inadequate intravascular volume can reduce tissue oxygen delivery and exacerbate organ dysfunction [9].

Excessive fluid administration can precipitate extravasation and pulmonary edema. Women with PET are especially susceptible to over-resuscitation, with PET remaining the primary cause of pregnancy-associated pulmonary edema. Maternal deaths resulting from suboptimal fluid management in PET have likewise been documented [10].

The goal of this study was to evaluate the function and clinical utility of LUS and TTE in after operation hemodynamic surveillance of participants with severe PET, as well as to assess their value in predicting complications in this population.

Patients and Methods:

This cross sectional was executed on 100 female participants in the childbearing period with severe PET blood pressure exceeding 160/110 mmHg, proteinuria up to 2 grams, persistent intense epigastric pain, raised hepatic enzymes, platelet count <100,000/µL, visual or cerebral disturbances, pulmonary edema, and the occurrence of eclampsia.

The study was done after approval from the Research and Ethical Committee of Al-Azhar University Faculty of Medicine, Assiut, Egypt (Code No.: RESEARCH/AZ.AST./AIP029/4/179/10/2023). A documented consent was gathered from the participants or relatives of the participants.

Exclusion criteria were patients with known hypertension, cardiac disease, chronic lung diseases and kidney diseases.

Participants were divided into 61 cases with severe PET and 39 cases with eclampsia and 60 healthy laboring woman as a control group.

All participants underwent a comprehensive history, encompassing gestational age, obstetric history, parity, type of anesthesia, vital signs (pulse and blood pressure), fluid management, proteinuria, and other indicators of severe PET. Subsequent assessments comprised laboratory tests, TTE, and LUS.

Transthoracic echocardiography

With the participant in the left lateral recumbent orientation, TTE was performed using a SONOACE 8000 SE device. The apical four-chamber view was acquired, and pulsed-wave (PW) Doppler was applied with the cursor aligned at the tips of the mitral valve leaflets to assess diastolic function via the E/A ratio. Diastolic dysfunction, if present, was graded as follows: grade 1 (impaired relaxation pattern) E/A <0.8 or E <50 cm/s; grade 2 (pseudonormal) E/A 0.8–2 with E>50 cm/s; and grade 3 (restrictive) E/A>2.

Subsequently, the parasternal long-axis view was acquired in the same orientation, and M-mode echocardiography with the Teichholz method was used to evaluate left ventricular systolic function. EF was documented, with values >55% considered normal.

For inferior vena cava (IVC) assessment, the patient was repositioned supine. The probe was placed in the subcostal region and angled toward the right shoulder to visualize the IVC in its long-axis view. The maximal IVC diameter, typically just before its entry into the right atrium, was measured, with normal values ranging from 1.5 to 2.5 cm.

Lung ultrasonography

LUS was performed using a convex probe (5 MHz) with the participants in the supine orientatio. The chest was divided into 12 zones: four anterior zones (right and left upper and lower anterior), four posterior zones (right and left upper and lower posterior), and four lateral zones (upper and lower right and left lateral).

In each lung zone, elevated EVLW was evaluated by the detection of multiple B-lines, also known as ‘comet-tail’ artifacts. B-lines were defined as discrete, laser-like, vertical hyperechoic reverberation artifacts arising from the pleural line, extending uninterrupted to the lower edge of the imaging screen without attenuation, and moving synchronously with lung sliding. Each lung zone was assigned a score from 0 to 3 according to the observed B-line pattern: 0 indicated fewer than three B-lines; 1 corresponded to multiple distinct B-lines with horizontal spacing of ≤7 mm; 2 represented numerous fused B-lines that were difficult to enumerate, with spacing ≤3 mm, including areas described as ‘white lung’; and 3 denoted pulmonary consolidation, characterized by hyperechoic lung tissue exhibiting dynamic air bronchograms. The scores from all 12 zones were summed to obtain a total score ranging from 0 to 36.

Statistical analysis:

It was performed via SPSS v29 (IBM Inc., Chicago, IL, USA). Quantitative variables were shown as mean and standard deviation (SD) and related among the three groups via ANOVA (F) test with post hoc test (Tukey). Qualitative variables were shown as frequency (%) and were analyzed via the Chi-square test. The area under the curve (AUC) evaluates the overall test performance. A two tailed P value≤0.05 was considered statistically significant. Univariate regression analysis was conducted to assess the association between the dependent variable and a single predictor variable. Multivariate regression was also applied to assess the relationship among a dependent variable and more independent variables.

Results:

Age, weight, height, and body mass index (BMI) were similar across the three groups. Parity and gravidity showed no significant difference among PET group and eclampsia group and were significantly reduced in the PET group and eclampsia than control group (P <0.05). HR was significantly elevated in the PET group and eclampsia than control group (P <0.05) while was significantly elevated in eclampsia group than PET group (P<0.05). SBP and DBP showed no significant difference among PET group and eclampsia group and were significantly elevated in the PET group and eclampsia group than control group (P <0.05). Anesthesia type was significantly different within the three groups (P <0.05). **Table 1**

Table 1: Demographic data and clinical data of the studied groups

		PET group (n=61)	Eclampsia group (n=39)	Control group (n=60)	P	Post hoc test
Age (years)		25.6±5.01	28.1±5.84	26.8±4.95	0.071	---
Weight (kg)		65.1±6.89	65.2±6.77	65±5.12	0.939	---
Height (cm)		165.8±6.4	165.4±6.67	167.3±4.56	0.210	---
BMI (Kg/m²)		23.8±3.2	23.9±3.09	23.2±1.46	0.330	---
Parity		2(2 - 1)	1(1 - 2)	2(1 - 3)	**0.007***	P_1=0.749 **P_2<0.001*** **P_3=0.006***
Gravidity		2(2 - 3)	2(2-2)	3(2-4)	**<0.001***	P_1=0.183 **P_2=0.002*** **P_3=0.049***
HR (beats/min)		94.4±9.56	103.3±12.2	86.1± 3.55	**<0.001***	**P_1<0.001*** **P_2<0.001*** **P_3<0.001***
SBP (mmHg)		178.7±3.01	179.5±12.2	117.3±5.98	**<0.001***	P_1=0.82 **P_2<0.001*** **P_3<0.001***
DBP (mmHg)		100.1±11.8	104±11.74	69±5.42	**<0.001***	P_1=0.138 **P_2<0.001*** **P_3<0.001***
nesthesia type	**Spinal**	52(85.25%)	15(38.46%)	55(91.67%)	**<0.001***	---
	General	9(14.75%)	24(61.54%)	5(8.33%)		

Data is shown as mean ± SD, median (IQR) or frequency (%). *: Statistically significant at P ≤ 0.05. P_1: Compared between PET group and eclampsia group, P_2: Compared between PET group and control group and P_3: compared between eclampsia group and control group.

EF showed no significant difference among PET group and control group and was significantly reduced in eclampsia group than PET group and control group (P <0.05). IVC score was comparable across the three groups. Diastolic dysfunction grades were significantly different among three groups (P <0.001). The LUS score was significantly higher in both the preeclampsia and eclampsia groups compared to the control group (P < 0.05) and was notably greater in the eclampsia group than in the preeclampsia group (P < 0.05).**Table 2**

Table 2: Cardiac function parameters and LUS scores of the studied groups

	PET group (n=61)	Eclampsia group (n=39)	Control group (n=60)	P	Post hoc test

EF (%)		63±6.34	55.9±4.55	65±4.17	**<0.001***	**P_1=0.001*** P_2=0.062 **P_3<0.001***
IVC		1.4(1.3 - 1.5)	1.4(1.2 -1.5)	1.4(1.3 - 1.5)	0.341	---
Diastolic dysfunction	**Normal**	8 (13.11%)	3(7.69%)	52(86.67%)	**<0.001***	---
	Abnormal	53 (86.89%)	36(92.31%)	8(13.33%)		
Diastolic dysfunction	**Normal**	8 (13.11%)	3(7.69%)	52(86.67%)	**<0.001***	---
	Diastolic dysfunction grade 1	31(50.82%)	6(15.38%)	5(8.33%)		
	Diastolic dysfunction grade 2	8(13.11%)	3(7.69%)	52(86.67%)		
	Diastolic dysfunction grade 3	31(50.82%)	6(15.38%)	5(8.33%)		
	Normal	8(13.11%)	3(7.69%)	52(86.67%)		
LUS score		5(3 – 8)	8(3.5 – 13)	2.5(1 – 4)	**<0.001***	**P_1<0.001*** **P_2<0.001*** **P_3=0.041***

Data is shown as mean ± SD, median (IQR) or frequency (%). *: Statistically significant at $P \leq 0.05$. P_1: Compared between PET group and eclampsia group, P_2: compared between PET group and control group and P_3: compared among eclampsia group and control group.

Complications were pulmonary edema in 4 (4%) participants, acute respiratory distress syndrome (ARDS) in 2(2%) participants. Cardiac arrest was observed in 4 (4%) participants, acute respiratory distress syndrome was found in 2 (2%) participants, mild pericardial effusion was found in 2 (2%) participants, SAH and PRESS was found in 1 (1%) participants and peripartum cardiomyopathy and pulmonary embolism was found in 2 (2%) participants. **Table 3**

Table 3: Complications of the studied cases group

	N=100
Pulmonary oedema	4(4%)
Acute respiratory distress syndrome	2(2%)
Cardiac arrest	4(4%)
Acute respiratory distress syndrome	2(2%)
Mild pericardial effusion	2(2%)
SAH and PRESS	1(1%)
Peripartum cardiomyopathy and pulmonary embolism	2(2%)

Data is shown as frequency (%). SAH: Subarachnoid Hemorrhage, PRESS: Posterior Reversible Encephalopathy Syndrome.

Age, HR, diastolic dysfunction grades and LUS scores were significantly higher in complicated groups than no complicated groups (P<0.001). EF was significantly reduced in complicated groups than no complicated groups (P<0.001). BMI, SBP,
DBP and IVC showed no significant difference among the two group. **Table 4**

Table 4: Determinants of Postoperative Complications in the Cases Group

	Complicated (n=17)	No complicated (n=83)	P
Age (years)	29.18±6.3	26.01±5.15	**0.029***
BMI (Kg/m²)	24.24±3.97	23.77±2.97	0.579
HR (beats/min)	110.29±9.94	95.28±10.04	**<0.001***
SBP (mmHg)	179.88±12.54	178.87±6.7	0.633
DBP (mmHg)	97.29±13.2	102.52±11.47	0.099
EF (%)	55.06±6.77	61.33±6.14	**<0.001***
IVC	1.38±0.14	1.4±0.15	0.729
Diastolic dysfunction grade	2(2 - 2)	1(1 - 2)	**<0.001***
LUS score	15(10 – 17)	5(3 – 8)	**<0.001***

Data is shown as mean ± SD, median (IQR) or frequency (%). *: Statistically significant at P ≤ 0.05.

HR can significantly predict and monitor postoperative complications (P<0.001 and AUC = 0.851) at cut-off >99 with 94.12% sensitivity, 66.27% specificity, 36.4% PPV and 98.2% NPV. LUS score can significantly anticipate and monitor postoperative complication (P<0.001 and AUC = 0.824) at the threshold of >9 with 76.47% sensitivity, 87.95% specificity, 56.5% PPV and 94.8% NPV. EF can significantly anticipate and monitor postoperative complications (P=0.001 and AUC = 0.766) at cut-off >56 with 70.59% sensitivity, 74.70% specificity, 36.4%PPV and 92.5% NPV. Diastolic dysfunction grade can be used to reliably predict and monitor postoperative complication (P<0.001 and AUC=0.741) at the threshold of >1 with 88.24% sensitivity, 56.63% specificity, 29.4% PPV and 95.9%NPV. **Figure 1**

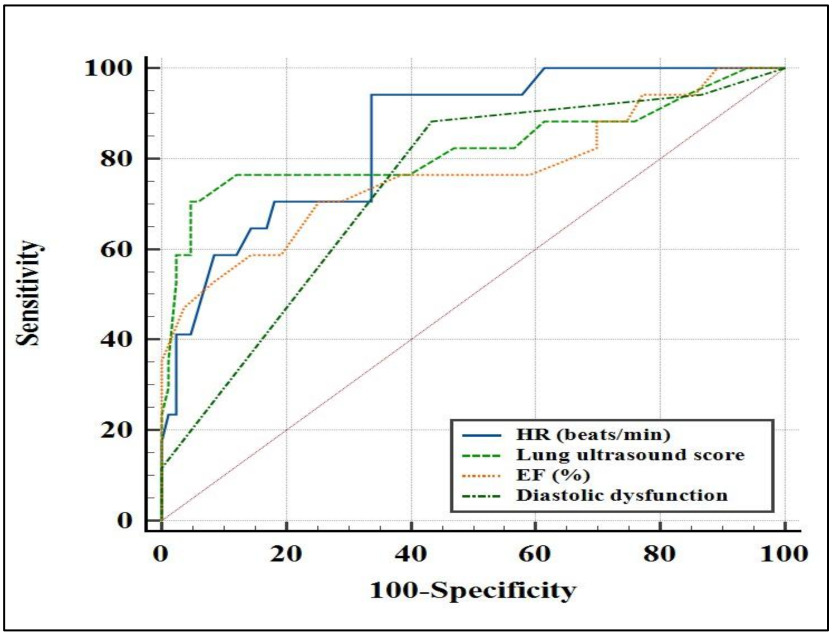

Figure 1: Role of value of lung sonography and transthoracic echocardiography in predicting and monitoring postoperative complication.

In univariate regression, HR, EF, diastolic dysfunction grade, and LUS score were standalone predictors of postoperative adverse events (P<0.001). In Multivariate regression, HR, EF, and LUS score were standalone predictors of postoperative complication (P<0.001) while diastolic dysfunction grade was not. Table 5

Table 5: Univariate and multivariate regression of lung sonography and transthoracic echocardiography versus postoperative complication

	Univariate			Multivariate		
	Odds ratio	**95% CI**	**P**	**Odds ratio**	**95% CI**	**P**
HR (beats/min)	1.1581	1.07 - 1.24	**<0.001***	1.19	1.05 -1.35	**0.005***
EF (%)	0.8227	0.73 - 0.92	**0.001***	0.73	0.58 -0.92	**0.009***
Diastolic dysfunction grade	6.0724	1.82 - 20.24	**0.003***	1.07	0.22 -5.01	0.929
LUS score	1.3713	1.19 - 1.57	**<0.001***	1.47	1.16 -1.86	**0.001***

Data is shown as frequency (%). *Significant as P≤0.05, CI: Confidence interval.

2. DISCUSSION:

The key observation from this research was that higher LUS scores (reflecting pulmonary congestion), elevated HR, reduced left ventricular EF, and higher grades of diastolic dysfunction (E/A ratio) had been strongly associated with eclampsia and postoperative complications. We had found that postoperative haemodynamic complications had been predicted by simple, bedside measures: HR had predicted complications with P<0.001, AUC = 0.851, at the threshold of >99 beats/min giving 94.12% sensitivity, 66.27% specificity, 36.4% PPV and 98.2% NPV; LUS had predicted complications with P<0.001, AUC = 0.824, at the threshold of >9 giving 76.47% sensitivity, 87.95% specificity, 56.5% PPV and 94.8% NPV; left ventricular EF had predicted complications with P = 0.001, AUC = 0.766, at a cut-off >56 giving 70.59% sensitivity, 74.70% specificity, 36.4% PPV and 92.5% NPV; and diastolic dysfunction grade had predicted complications with P<0.001, AUC = 0.741, at a cut-off >1 giving 88.24% sensitivity, 56.63% specificity, 29.4% PPV and 95.9% NPV.

In multivariate regression, only HR, EF, and LUS scores remained independent predictors of complications.

Several pathophysiological mechanisms could have explained our findings. Pregnancy itself had increased blood volumeand alters vascular permeability, predisposing women to pulmonary edema. In PET, endothelial dysfunction further disrupts fluid homeostasis, resulting in reduced intravascular oncotic pressure and increased capillary leak, so that relatively small fluid shifts may lead to pulmonary congestion. Sciscione et al. [11] highlighted these mechanisms as major contributors to pulmonary edema during pregnancy.

Ambrožič et al. [12] emphasized that PET had encompassed two hemodynamic phenotypes; one with high output/hypervolemia and one with low output/hypovolemia, implying that some patients had been prone to fluid overload if over-resuscitated. In this context, LUS had noninvasively quantified EVLW: multiple “B-lines” on ultrasound had represented alveolar-interstitial syndrome and rising lung water. Indeed, Martins et al. [11] noted that point-of-care LUS had been able to detect early pulmonary edema (even before overt symptoms) and exhibited an elevated accuracy than chest X-ray in this setting.

In our study, higher LUS scores have likely reflected increased extravascular lung fluid in severe cases. Similarly, echocardiographic diastolic dysfunction (prolonged relaxation) had been expected in severe PET due to hypertensive afterload and endothelial dysfunction; we had observed diastolic dysfunction in most cases. The association between diastolic dysfunction and pulmonary edema had been well-known: patients with impaired relaxation had tended to have elevated filling pressures and fluid back-up into the lungs.

This is confirmed by Yagani et al. [13] who reported that >50% of women with severe PET had lung interstitial syndrome on LUS, and that the LUS B-line score correlated strongly (r=0.848) with the mitral E/e′ ratio (a diastolic index). Moreover, Dennis and Solnordal [14] remarked that normal pregnancy changes, including increased cardiac output and reduced colloid oncotic pressure, may predispose women to pulmonary edema, and these physiological adaptations can be exacerbated by the endothelial dysfunction characteristic of PET.

We found a striking tachycardia in complicated cases. While not a direct cardiac imaging finding, elevated HR had likely reflected sympathetic activation and hemodynamic stress in severe PET; its strong predictive value (AUC 0.851) may have stemmed from HR being an integrated marker of cardiovascular strain.

Our data had been consistent with expert recommendations to use combined POCUS modalities (LUS and TTE) for hemodynamic monitoring.

Ambrožič et al. [12] argued that echo plus LUS yields comprehensive information on cardiac function, lung congestion, and volume status, helped to identify high-risk women.

Our findings agreed with and extended previous literature. In PET cohorts without acute complications, systolic function is generally preserved.

Valensise et al. [15] demonstrated that women with preeclampsia exhibit distinct hemodynamic patterns and evidence of cardiovascular adaptation, supporting the concept that maternal cardiac function is altered in preeclamptic pregnancies.

Likewise, we observed that EF remained normal in the PET group (63±6%) and only dropped in the eclampsia group. In contrast, we found widespread diastolic dysfunction; this matches reports that severe PET is often accompanied by impaired relaxation.

In contrast, Sayed et al. [16] documented that severe PET was linked with 29% occurrence of diastolic dysfunction postpartum, versus 15% in mild cases. Our rates were even higher, likely because our definition was broader, and all patients had severe features.

Point-of-care ultrasound studies likewise support our results. Ayoub et al. [17] found that 67% of severe late PET patients had any ultrasound abnormality (including pulmonary edema in 24%, diastolic dysfunction in 33%). Yagani et al. [13] similarly detected interstitial edema in over half of severe cases.

In our research, the higher LUS scores in eclamptic patients likely reflect more severe lung fluid accumulation, analogous to the trends noted in those studies. Consistent with this observation, Vaught et al. [18] demonstrated that women with severe preeclampsia exhibit cardiovascular changes associated with elevated filling pressures and an increased risk of pulmonary congestion.

Also, Bajwa's meta-analysis [19] found that LUS and echocardiographic parameters correlate with volume status and can serve as early fluid markers in severe PET. This supports our finding that LUS score and echo indices (EF, E/A ratio) predict complications.

Consistent with our findings, Zieleskiewicz et al. [20] noted that Echo Comet Score >25 predicted increased filling pressures (E/E′ > 9.5) with sensitivity 1.00 (95% CI, 0.69–1.00) and specificity 0.82 (95% CI, 0.66–0.92).

Also, Bobot et al. [21] stated that the Echo Comet Score showed sensitivity 80%, specificity 58%, PPV 26% and NPV 94% for detecting overload compared with transthoracic echocardiography.

Additionally, Wang et al. [22] reported an overall sensitivity 97% (95% CI 96%–98%) and specificity 98% (95% CI 97%–99%) for LUS to diagnose acute pulmonary edema across included studies.

The study was limited by its cross-sectional, monocentric design and the focus on only severe cases. No preoperative ultrasound baseline had been obtained. Fluid management had not been protocolized. The relatively small sample size may not have captured less frequent complications, and operator variability in ultrasound interpretation was possible. We had lacked a pre-delivery baseline ultrasound to compare with postoperative changes, and anesthesia type (spinal vs general) had differed across groups, which could have influenced hemodynamics. Ultrasound assessments had been performed by experienced operators, but LUS and TTE interpretation had inherent observer dependency. We had only included severe PET/eclampsia cases (no mild cases), so results might not have applied to less severe disease.

3. CONCLUSION:

LUS and transthoracic echocardiography had complemented each other for post-delivery monitoring in severe PET; together with simple vital signs they had helped detect occult pulmonary congestion, assess cardiac performance, and identify women at higher risk of complications, supporting earlier and tailored control.

Financial support and sponsorship: Nil **Conflict of Interest:** Nil

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