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Prognostic Value of Subclinical Pulmonary Congestion With Stress Ultrasound of the Lungs in the Development of Heart Failure in Patients With Primary Myocardial Infarction and Percutaneous Coronary Intervention

Aim To determine the clinical and prognostic significance of subclinical pulmonary congestion, as evaluated by stress ultrasound (stress-US) examination of the lungs, in the development of heart failure (HF) during the postinfarction period after acute myocardial infarction (AMI) and percutaneous coronary intervention (PCI).

Material and Methods This prospective observational study included 103 patients with no history of HF and with the first AMI and successful PCI. Standard laboratory tests, including the measurement of NT-proBNP, echocardiography, stress-US of the lungs with a 6-min walk test (6MWT), were performed for all patients. Pulmonary congestion was diagnosed with the total number of B lines ≥2 during stress: mild (2–4 B lines), moderate (5–9 B lines), and severe (≥10 B lines). Subclinical pulmonary congestion implied the absence of clinical signs of congestion in the presence of ultrasonic signs of pulmonary congestion (>2 B lines) during stress. The phenomenon of "wet" lung was identified when the total number of B lines was <2 at rest ("dry" lung) and ≥2 after stress. When the total number of B lines was >2 at rest ("wet" lung at rest) and ≥2 after stress, the phenotype was identified as "very wet" lung. The endpoint was hospitalization for HF during 1.5 years.

Results The study showed a high incidence of subclinical pulmonary congestion as determined by the results of stress-US test of the lungs, mild (18.4%), moderate (37.9%) and severe (42.7%), and of "wet" and "very wet" lung phenotypes (65%). The "wet/very wet" lung phenotypes correlated with the body weight index (R=0.236; p=0.016), troponin concentration upon admission and at 6–12 h (R=0.231; p=0019 and R=0.212; p=0.033, respectively), NT-proBNP concentration (R=0.276; p=0.035), E peak (R=0.241; p=0.019), global longitudinal strain (GLS) (R= –0.208; p=0.034), and left ventricular end-diastolic dimension (R=0.351; p=0.0004). The higher probability of hospitalization for HF during 1.5 years after the discharge from the hospital correlated with a LV EF ≤48% (OR, 4.04; 95% CI: 1.49–10.9; p=0.006), a post-stress total number of B lines ≥10 (OR, 3.10; 95% CI: 1.06–9.52; p=0.038), a pulmonary artery systolic pressure >27 mm Hg (OR, 3.7; 95% CI: 1.42–9.61; p=0.007).

Conclusion Stress-US of the lungs with evaluation of the total number of B lines should be performed for patients after the first AMI and PCI and with no clinical signs of congestion, for stratification of the risk for HF in the postinfarction period.

Keywords Acute myocardial infarction, heart failure, stress-US of the lungs, B lines, subclinical pulmonary congestion, 6-min walk test

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Acute myocardial infarction (AMI) is one of the most common causes of hospitalization in cardiology departments. Advances in treatment methods increased survival after AMI and the prevalence of heart failure (HF) [1, 2]. Percutaneous coronary intervention (PCI) contributes to early survival after AMI [3, 4], but its long-term effects on HF development are under debate. Early detection of subclinical pulmonary congestion in patients after PCI may help improve follow-up management of patients and prevent symptomatic HF. Lung ultrasound evaluating B-lines allows verifying subclinical pulmonary congestion before clinical manifestations [5, 6]. There are data on the use of lung ultrasound during stress echocardiography in various groups of patients to identify subclinical pulmonary congestion [7]. The increase or appearance of B-lines after exercise shows a greater degree of dysfunction and a worse prognosis. The same pattern of B-lines at rest may appear different during exercise and indicate the presence of subclinical congestion in the lungs [7]. At the same time, diagnostic and prognostic significance of subclinical pulmonary congestion diagnosed by the sum of B-lines in lung ultrasound at rest and after exercise has not been previously studied for the purposes of assessing the development of HF in patients with current myocardial infarction (MI) (on days 5–6).

Objective

Determine the prognostic and diagnostic significance of subclinical pulmonary congestion in the development of HF in the postinfarction period in patients with first recognized AMI and PCI using stress lung ultrasound.

Material and Methods

The prospective study included 103 patients with the diagnosis of acute AMI hospitalized in the cardiological intensive care unit of State Clinical Hospital named after V. V. Vinogradov (Table 1).

Inclusion criteria: new-onset AMI diagnosed following the fourth universal definition of MI [8]; successful primary PCI in patients with ST-segment elevation myocardial infarction (STEMI), early PCI (within 24 h) in patients with non-ST-segment elevation myocardial infarction (NSTEMI), that is achievement of TIMI III blood flow in the involved vessel; no history of HF, shortness of breath at admission, Killip I.

Exclusion criteria: intravenous diuretics and vasopressors; primary lung pathology (pneumonia), lung cancer; complications of AMI (ventricular septal rupture, papillary muscle displacement); severe rhythm and conduction disorders.

The study was approved by the ethics committee of the Institute of Medicine of Peoples' Friendship University of Russia and State Clinical Hospital named after V. V. Vinogradov. All subjects signed the informed consent.

Medical history was collected, and standard physical examination, electrocardiography (ECG), chest X-ray, PCI were carried out in all patients included in the study. All hemodynamically significant lesions were treated

Table 1. Clinical and demographic characteristics of patients (n=103)

Parameter	Value
Age, years	62.1 ± 11.8
Male, n (%)	69 (66.9)
Body mass index, kg/m^2	27.4 [25.3; 32.0]
Smoking, n (%)	35 (33.9)
SBP/DBP, mm Hg	136 [125; 150]/80 [72; 87]
History of atrial fibrillation	11 (10.7 %)
Diabetes mellitus type 2	23 (22.3 %)
Dyslipidemia	54 (52.4 %)
STEMI/NSTEMI	75 (72.8%)/28 (27.2%)
Single-vessel disease	33 (32 %)
Two-/three-vessel disease	28 (27.2%)/42 (40.8%)
TIMI score	4 [3; 5]
CRUSADE score	27 [20; 36]
SYNTAX score	21 [14; 28]

The data are expressed as the absolute values and percentages or the medians with the 25th and 75th percentiles or as the means ± standard deviations. STEMI, ST-segment elevation myocardial infarction; NSTEMI, non-ST-segment elevation myocardial infarction; TIMI, thrombolysis in myocardial infarction score; CRUSADE, the score of bleeding risk during hospital stay in patients with non-ST-segment elevation ACS; SYNTAX, the score assessing the severity of coronary artery disease in various strategies of myocardial revascularization in patients with multivessel coronary artery disease.

Table 2. Laboratory findings at admission (n=103)

Parameter	Value
Creatinine, μmol/L	91 [78; 107]
GFR (CKD EPI), mL/min/1.73 m^2	70.49 [60.4; 82.7]
Glucose, mmol/L	7.1 [6.0; 9.8]
Sodium, mmol/L	138.5 ± 5.4
Potassium, mmol/L	4.2 ± 0.6
TC, mmol/L	5.9 ± 1.31
LDL cholesterol, mmol/L	3.6 [2.8; 4.7]
HDL cholesterol, mmol/L	1.1 [0.9; 1.2]
Triglycerides, mmol/L	1.7 [1.1; 2.5]
Hemoglobin, g/L	142 ± 17
NT-proBNP, pg/mL	677.2 [227.5; 1775.7]
< 125 pg/mL	15 (14.6 %)
125–600 pg/mL	35 (33.9 %)
> 600 pg/mL	53 (51.5 %)
Troponin-1, ng/mL	0.24 [0.05; 1.22]
Troponin-2, ng/mL	22.8 [4.21; 56.63]

The data are expressed as the absolute values and percentages or the medians with the 25th and 75th percentiles or as the means ± standard deviations. GFR (CKD EPI), glomerular filtration rate calculated using the CKD-EPI formula; NT-proBNP, N-terminal pro-brain natriuretic peptide (< 125 pg/mL – HF is unlikely, 125–600 pg/mL – gray zone, > 600 – HF is likely [9]); troponin-1 is estimated at admission to the intensive care unit; troponin-2 is estimated in 6–12 hours after hospitalization.

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Table 3. Phenotypes of subclinical pulmonary congestion

Changes in phenotypes during exercise	Dry lung	Wet lung during exercise	Wet lung at rest
Lung at rest	Dry	Dry	Wet
Lung during exercise	Dry	Wet	Very wet
B-lines at rest	No	No	Yes
B-lines during exercise	No	Yes	Yes
Risk of developing HF	Low	Intermediate	High

endovascularly during index hospitalization in patients with multivessel coronary artery involvement. Laboratory tests were performed in accordance with the standards of medical care (total blood count and biochemical test, including troponin and N-terminal pro-brain natriuretic peptide (NT-proBNP) hormone; Table 2).

Echocardiography was performed under the standard protocol using a Vivid iq device before discharge from the hospital. Wall motion systolic index (WMSI), left ventricular ejection fraction (LVEF) using the Simpson's method, global longitudinal strain (GLS), ratio of peak transmitral flow velocity to mitral annular velocity (E/e'), LV end-diastolic dimension (LVEDD), LV end-diastolic volume (LVEDV) using the Simpson's method, and pulmonary artery systolic pressure (PASP) were evaluated [10].

Stress lung ultrasound was performed using a VIVID iq portable ultrasound scanner on days 5–6 of hospital stay before discharge. An abdominal probe was used to scan the anterior and lateral surfaces of the chest in the third intercostal space between the midclavicular and anterior axillary lines, and the anterior and middle axillary regions on both sides. Examination was performed before the beginning of the exercise and within 1–2 minutes after the completion [7]. Pulmonary congestion was diagnosed with the sum of 2 or more B-lines: mild (2–4 B-lines), moderate (5–9 B-lines), and severe (≥10 B-lines) [7, 11, 12]. Subclinical pulmonary congestion was understood as the absence of clinical signs of congestion in the presence of ultrasound signs of pulmonary congestion (2 and more B-lines) in stress lung ultrasound during exercise by the time of discharge from the hospital [7]. The technique of stress lung ultrasound with the calculation of B-lines in four zones is shown in Figure 1 (adapted from [7]).

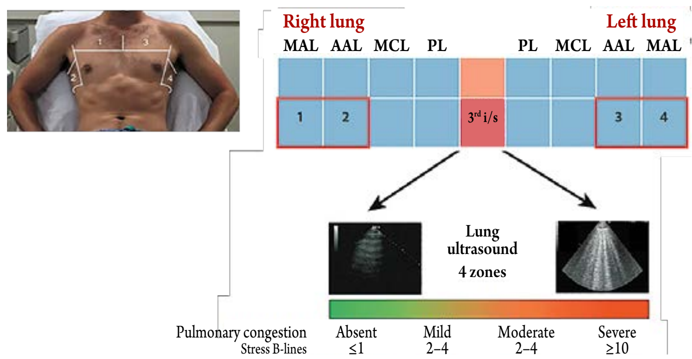
Six minute walking test (6MWT) test was performed as an alternative to the treadmill test, given known significant correlation between 6MWD and maximum exercise load in some patient groups [13].

Stress lung ultrasound evaluated phenotypes of subclinical pulmonary congestion that determined the risk of developing HF [11] (Table 3).

Assessment of outcome

The follow-up period was 1.5 years. The study endpoint was hospitalization for HF during the follow-up period.

Figure 1. Stress lung ultrasound technique



i/s, intercostal space; PL, parasternal line; AAL, anterior axillary line; MCL, midclavicular line; MAL, midaxillary line.

Statistical analysis

Statistica version 8.0 (Statsoft) and SPSS version 22.0 were used for the statistical processing of data. The distributions were tested using the Kolmogorov-Smirnov test. Normally distributed quantitative variables were described as the arithmetic means (M) and standard deviations (SD), and asymmetrically distributed quantitative variables were presented as the medians (Me) and interquartile ranges (IQR). The Mann-Whitney U-test was used to evaluate the significance of differences in quantitative variables between two groups. The intragroup differences were assessed at different points using the Wilcoxon W-test. The categorical variables were expressed as the absolute values (n) and percentages (%). The correlation analysis was performed using the Spearman's rank correlation coefficient. Pearson's χ^2 test was used to compare the groups by the frequency rates of qualitative variables. Prognostic significance was estimated in a ROC analysis with the calculation of the area under the ROC curve (AUC). The probability of survival was assessed using Kaplan-Meier survival curves and log-rank comparisons. The effect of subclinical pulmonary congestion on the risk of hospitalization for HF was assessed by univariate and multivariate Cox regression analysis. The differences were statistically significant with $p < 0.05$.

Results

All patients included in the study had no clinical signs of pulmonary congestion at discharge.

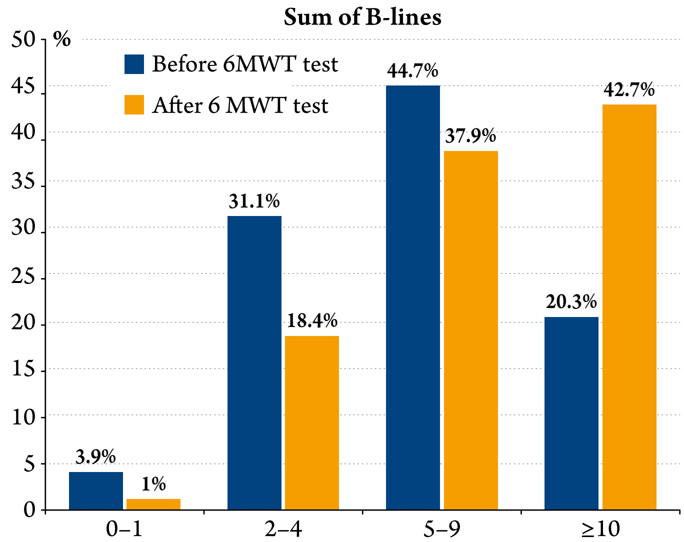
During lung ultrasound at rest, 3.9% (n = 4) of patients of the general group the sum of B-lines in the four zones of <2, and 96.1% (n=99) of patients had the sum of ≥2 B-lines. Stress lung stress ultrasound with 6MWD test detected mild, moderate, and severe subclinical pulmonary congestion in 18.4% (n=19), 37.9% (n=39), and 42.7% (n = 44) of patients, respectively (Figure 2). Subclinical pulmonary congestion was defined as the appearance or increase of B-lines ≥ 2 during exercise. Median sum of B-lines increased from 5 [4; 8] to 8 [5; 12] (p=0.001).

Phenotypes were determined during the study of subclinical pulmonary congestion only in comparison of the numbers of B-lines at rest and during exercise. The following phenotypes were detected: dry lung in 0.9%, wet lung in 2.9%, and very wet lung in 62.1% of patients. The number of B-lines did not increase during exercise in 34.1% of cases. Compared to patients without changes in the number of B-lines, patients with wet/very wet lung phenotype had significantly higher body mass index (BMI), risk of bleeding according to the CRUSADE score, levels of troponins and NT-proBNP, and more pronounced cardiac morphofunctional changes (Table 4).

Two subgroups were additionally identified to study the severity and phenotypes of subclinical pulmonary congestion: patients with STEMI (n=75) and patients NSTEMI (n=28). According to stress lung ultrasound findings, patients of these subgroups did not have statistically significant differences in the prevalence of mild, moderate, and severe subclinical pulmonary congestion. The analysis of the general group was conducted consequently.

Increased number of B-lines in stress lung ultrasound correlated with NT-proBNP (R = 0.312; p = 0.017), LVEF (R = –0.299; p = 0.022), GLS (R = 0.286; p = 0.004), E/e' (R = 0.283; p = 0.032), LVEDD (R = 0.312; p = 0.017), and WMA index (R = 0.361; p = 0.005).

Figure 2. Distribution of patients with AMI (n=103) depending on the sum of B-lines before and after 6MWD test



AMI, acute myocardial infarction;
6MWD, 6 minute walking distance.

Predictors of an increase in the degree of subclinical pulmonary congestion during stress lung ultrasound were established in the multivariate logistic regression analysis: LVEF <50%, WMA index >2, and a history of atrial fibrillation (AF) (Table 5).

The wet/very wet lung phenotypes were correlated with BMI (R=0.236; p=0.016), troponin levels at admission and in 6–12 h (R=0.231; p=0.019 and R=0.212; p=0.033, respectively), NT-proBNP (R = 0.276; p=0.035), E (R=0.241; p = 0.019), GLS (R = –0.208; p = 0.034), and LVEDD (R = 0.351; p = 0.0004).

The effect of subclinical pulmonary congestion on long-term outcomes was analyzed. Two patients were lost to follow-up during the period of interest. Among 101 (98%) patients, the endpoint was reported in 17 (16.8%) patients.

Table 4. Comparative characterization of patients without an increase in the number of B-lines during exercise and patients with the wet/very wet lung phenotype (n=99)

Parameter	Increased number of B-lines < 2 during exercise (n = 35)	Wet/very wet lung (n = 64)	p
CRUSADE	25 [16; 32]	28 [24; 37]	0.016
BMI, kg/m²	27.15 ± 4.29	29.57 ± 4.81	0.016
Troponin-1, ng/mL	0.1 [0.02; 0.73]	0.3 [0.07; 2.12]	0.019
Troponin-2, ng/mL	3.84 [0.79; 22.62]	17.67 [2.17; 59.92]	0.033
NT-proBNP, pg/mL	332 [263.7; 877.1]	877 [175.5; 3002.2]	0.035
E, cm/s	0.52 [0.4; 0.6]	0.53 [0.42; 0.67]	0.019
GLS, %	-14 [-16.75; -12.00]	-14 [-16; -11]	0.657
LVEDD, cm	4.39 ± 0.46	4.82 ± 0.66	< 0.001

The data are expressed as the absolute values and percentages or the medians with the 25th and 75th percentiles or as the means ± standard deviations. CRUSADE, the score of bleeding risk during hospital stay in patients with non-ST-segment elevation ACS; BMI, body mass index; troponin-1 at admission to the intensive care unit; troponin-2 in 6–12 hours after hospitalization; NT-proBNP, N-terminal pro-brain natriuretic peptide; E, peak transmitral flow velocity; GLS, global longitudinal strain; LVEDD, left ventricular end-diastolic dimension.

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Table 5. Factors associated with an increase in the number of B-lines during stress lung ultrasound after 6MWD test in the general patient group (n=99)

Parameter	OR	95 % CI	p
LVEF < 50%	2.56	1.14–5.73	0.020
LV wall motion abnormality index > 2	2.58	1.33–11.26	0.001
History of atrial fibrillation	5.44	1.25–27.6	0.041

LVEF, left ventricular ejection fraction; OR, odds ratio; CI, confidence interval. 6MWD, 6 minute walking distance.

Table 6. Univariate Cox regression analysis for clinical examination parameters in relation to hospitalization for HF in patients with AMI

Parameter	HR	95 % CI	p
Sum of B-lines ≥10 after 6MWD test	5.24	1.68–16.3	0.004
LVEF ≤ 48 %	5.66	1.99–16.10	0.001
NT-proBNP > 877.1 pg/mL	1.00	1.00–1.01	0.024
PASP > 27 mm Hg	3.49	1.29–9.45	0.014

6MWD, 6 minute walking distance; LVEF, left ventricular ejection fraction; NT-proBNP, N-terminal pro-brain natriuretic peptide; PASP, pulmonary artery systolic pressure; HR, hazard ratio; CI, confidence interval.

Patients with HF were significantly older (67.88±10.6 and 60.91±11.7 years old, respectively; p=0.011), had higher PASP (32 [25; 37] mm Hg and 23 [15; 29] mm Hg, respectively; p=0.002) and TIMI scores (5 [4; 5] and 4 [2; 4], respectively; p=0.001) than patients without HF. The results of the univariate Cox logistic regression analysis are provided in Table 6.

ROC analysis was performed and area under the curve (AUC) was calculated to determine the cut-off values of these parameters. According to stress lung ultrasound, the sum of B-lines ≥10 (sensitivity 90%, specificity 82.8%; AUC 0.918; p<0.0001), NT-proBNP >877.1 pg/mL (sensitivity 100%, specificity 100%; AUC 0.829; p<0.0001), PASP >27 mm Hg (sensitivity 65%, specificity 69%; AUC 0.722; p<0.001), and LVEF ≤48% (sensitivity 71%, specificity 73%; AUC 0.669; p<0.0385) were associated with a higher risk of hospitalization for HF during the follow-up period.

Multivariate regression analysis including sex, age, GLS, WMA index, LVEDD, NT-proBNP, showed that only LVEF ≤ 48% (HR 4.04; 95% CI 1.49–10.9; p=0.006), the sum of B-lines ≥10 (HR 3.10; 95% CI 1.06–9.52; p=0.038), and PASP >27 mm Hg (HR 3.7; 95% CI 1.42–9.61; p=0.007) were independent predictors of adverse outcome (Figure 3).

Discussion

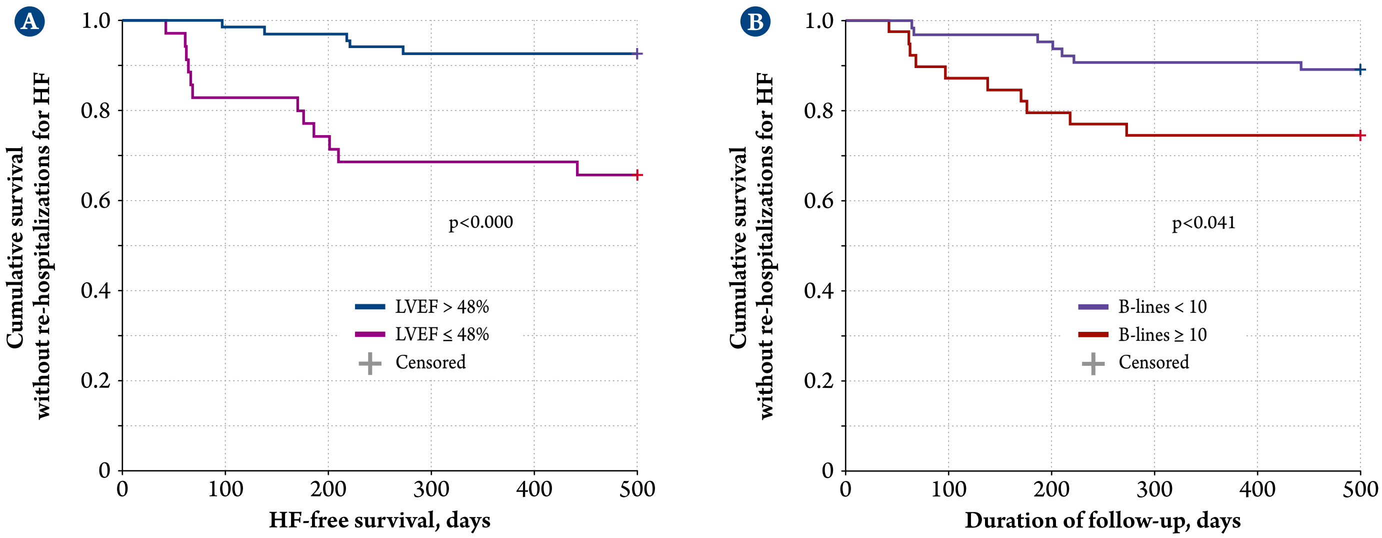
Prevalence, severity, and phenotypes of subclinical pulmonary congestion in patients with new-onset AMI who underwent PCI were studied for the first time using stress lung ultrasound in this study. High prevalence of subclinical pulmonary congestion after stress lung ultrasound (99.03%) in the absence of clinical signs was shown, while the prevalence of NT-proBNP higher than the diagnostic level [9] was detected in only 51.5% of cases.

There are several protocols for lung ultrasound including 4 to 28 zones of scanning [14]. We performed lung ultrasound using accordance with the 4 zone technique M. S. Scali et al. [12], which is the most preferred and informative after stress test. It was shown that lung scan in 4 zones is only slightly inferior to scanning in 28 zones and can be used to diagnose pulmonary venous congestion during stress tests [12, 14].

The study of subclinical lung congestion phenotypes using stress lung ultrasound revealed the 62.1% of patients belong to the very wet lung phenotype. This result is of great clinical significance, because this group is characterized by a particularly high risk of multivessel coronary artery involvement and HF. The studied patients had single-vessel and multivessel coronary artery involvement [7].

In our study, the sum of B-lines ≥ 2 at stress lung ultrasound correlated with the parameters of cardiac function including WMA index and LVEF, GLS, diastolic filling index (E/e'), and NT-proBNP. This correlation relationship has been described in previous studies. As in our work, one study showed high correlation between the sum of B-lines and the levels of NT-proBNP (R=0.65; p<0.001), LVEF (R= –0.46; p<0.001), and E/e' (R=0.62; p<0.001) [15]. In another study, the number of B-lines shown by lung ultrasound in patients with new-onset AMI performed after PCI correlated with LV end-diastolic pressure and higher levels of NT-proBNP [16]. Similar to our findings, the sum of B-lines correlated with LVEF (R= –0.32; p<0.0001) in a study that included patients with various cardiovascular diseases [17]. The sum of B-lines correlated with LVWMA index in our patients. This is likely to reflect more severe myocardial damage, which was the main predictor of adverse outcomes in other studies [18, 19].

Figure 3. Kaplan-Meier curves of cumulative survival probability (without all-cause death) with hospitalization for HF depending on LVEF (**A**), the presence and severity of subclinical pulmonary congestion after stress lung ultrasound (**B**), PASP – pulmonary artery systolic pressure (**C**)



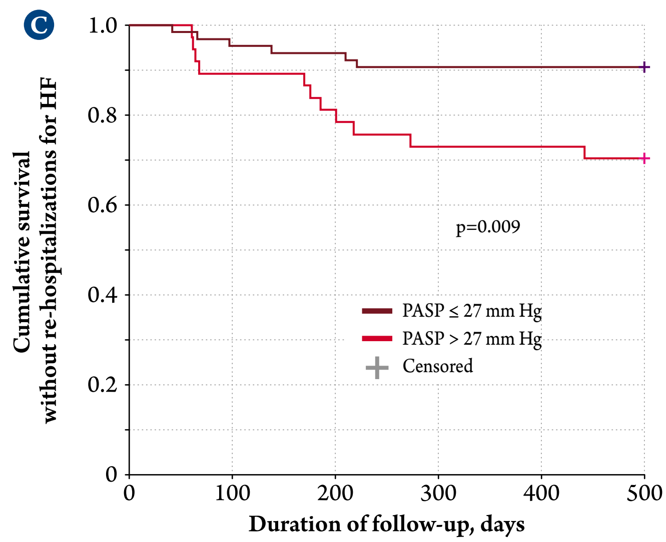
According to our data, LVEF ≤ 48%, WMA index >2, and a history of AF were the predictors of an increase in subclinical pulmonary congestion during stress lung ultrasound. In the study by Scali et al. [7], stress-induced increase in WMA index, as well as impaired coronary reserve and LV contractility, was observed in patients with the sum of B-lines ≥10 during stress ultrasound.

The prognostic significance of subclinical pulmonary congestion, estimated by the sum of B-lines during stress lung ultrasound, was studied for the first time in relation to the long-term risk of hospitalization for HF. In our study, LVEF ≤ 48% and sum of B-lines ≥10 were associated with a higher likelihood of hospitalization for HF within 1.5 year after discharge. There are several studies estimating the sum of B-lines during stress lung ultrasound in patients with AMI to identify and predict the development of long-term adverse outcomes [15, 16, 20–23] (Table 7).

Our study differs from these large multicenter studies by earlier timing (days 5–6 after MI), an alternative stress test during lung ultrasound, and the absence of a separate statistical analysis of this subgroup in previous large studies.

An observational prospective study of the prognostic significance of stress lung ultrasound in acute STEMI (LUS-AMI) has been initiated recently [24], and the Stress Echo 2020 study continues that will determine the prognostic significance of stress ultrasound for patients with cardiovascular diseases [25].

Thus, early detection of subclinical pulmonary congestion using stress lung ultrasound, especially in combination with the assessment of echocardiographic parameters, allows identifying patients with AMI who have an increased risk of developing adverse outcomes in the long term.



PASP, pulmonary artery systolic pressure (C).

Limitations and prospects for research

The study limitations are associated with a small patient sample, a single-center design, and a relatively short follow-up period. Moreover, the study population was represented by patients with Killip I class and without significant LV dysfunction, which is why our findings cannot be extrapolated to patients with more severe clinical manifestations.

In our study, recurrent MI and all-cause death was reported in 10 and 3 patients, respectively, during the follow-up period However, we did not identify a significant correlation between subclinical pulmonary congestion and the above outcomes. This may be due to a short follow-up period and a small number of outcomes.

Large randomized multicenter studies should be conducted subsequently to investigate the role of stress lung

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Table 7. Prognostic significance of the sum of B-lines in patients with ACS calculated by different methods

Author, year	Sample	Number of patients	Timing of stress ultrasound	Number of zones and method of calculating the sum of B-lines	Sum of B-lines	Outcome in the follow-up period	Number of endpoint events
Bedetti, 2010	STEMI (29%); NSTEMI (49%); Unstable angina (22 %)	470	1–12 h after hospitalization	28 zones, score depending on the sum	Median: 7 [0–31]	Composite endpoint: all-cause death or non-fatal AMI (median follow-up 5 months)	102 (22%) (56 – death, 46 – non-fatal AMI)
Ye, 2019	Anterior LV STEMI	96	Ultrasound exam 1: within 5 hours after PCI; Ultrasound exam 2: on day 3–4 after PCI (n = 39)	28 zones, sum	Median: HF 32 [24–37]; no HF 5 [2–10]	Short-term outcome: symptomatic HF during hospitalization (Killip ≥ III). Long-term outcome: composite endpoint: all-cause death or hospitalization for HF (median follow-up 25.3 months)	19 (20 %) HF during hospitalization; 12 (13%) hospitalization for HF, 1 – death
Araujo, 2020	STEMI (100%); anterior LV STEMI (49%)	215	Immediately before CAG	8 zones, score	Dry lung: 105 (49 %); Wet lung: 110 (51 %)	In-hospital mortality	30 (14 %)
Parras, 2021	STEMI (67%); anterior LV STEMI (35%); NSTEMI (33%)	200	At admission	8 zones, sum	Median: HF 14; No HF 2	Short-term outcome: new-onset HF (Killip ≥ II).	3 (1.5 %) cardiogenic shock, 5 (2.5 %) pulmonary edema; 15 (8.5 %) moderate HF, 5 (2.5 %) death
Araujo, 2021	STEMI (100%); anterior LV STEMI (50%)	218	Immediately before PCI	8 zones, score	Median positive zones: 1 [0–5]	Short-term and long-term (30-day) outcome: severe adverse cardiovascular events	50 (23 %). Death – 36 (16 %); severe adverse cardiovascular events 63 (29 %)

ACS, acute coronary syndrome; STEMI, ST-segment elevation myocardial infarction; AMI, acute myocardial infarction; LV, left ventricular; PCI, percutaneous coronary intervention; CAG, coronary artery angiography; NSTEMI, non-ST-segment elevation myocardial infarction. Severe adverse cardiovascular events include in-hospital death, new-onset AMI, cardiogenic shock (except for patients with Killip IV at admission).

ultrasound in the prediction of cardiovascular complications in patients with new-onset AMI.

Conclusion

The sum of the B-lines in stress lung ultrasound is an available and highly informative method for detecting subclinical pulmonary congestion in patients with new-onset acute myocardial infarction who underwent percutaneous coronary intervention and for identifying patients with increased risk of developing heart failure in the long term.

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