The Functional Meaning of B-profile During Stress Lung Ultrasound

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**Authors' contributions:** McS is the subproject leader, had the original idea and helped to recruit 188 patients; AZ and NZ recruited 615 patients, critically revised the manuscript for an intellectually important contribution and approved the submitted version; QC is the principal investigator of SE2020, helped to organize the structure of training, contributed to developing the web-based training, recruited 402 patients, critically revised the manuscript for an intellectually important contribution and approved the submitted version; LC recruited 242 patients, critically revised the manuscript for an intellectually important contribution and approved the
submitted version; all other authors contributed to the study design, undertook the quality control up to certification, are active members of SE 2020 consortium, recruited patients, critically revised the manuscript for an intellectually important contribution and approved the submitted version; RC and PC also coordinated the involvement of SIEC (Italian Society of Cardiovascular Echography and Cardiovascular Imaging). CC is responsible for data quality control and reader certification, performed the data analysis, and helped to draft the manuscript. EP is the study chairman, designed the protocol, organized the content of web-based training, contributed to data analysis and drafted the manuscript.

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The B-profile of normal lung sliding with B-lines by lung ultrasound (LUS) identifies pulmonary congestion at rest and during exercise stress echocardiography (SE) in coronary artery disease (CAD) (1) or heart failure (HF) patients with either reduced (2) or preserved (3) resting left ventricular ejection fraction (EF).

We hypothesized that patients developing B-lines during physical or pharmacological SE are likely to have a functional ischemic or extra-ischemic cause of vulnerability to interstitial pulmonary edema which can be unmasked with simultaneous transthoracic echocardiography (TTE).

In this prospective study, we evaluated 2036 patients (727 female, 1309 male; age 63±11 years; EF 58±11%) with known or suspected CAD and/or HF recruited by 21 accredited laboratories of 8 countries (Argentina, Bulgaria, Brazil, Hungary, Italy, Poland, Russian Federation, Serbia) of the SE 2020 study network (4). Exclusion criteria were severe arrhythmias, valvular or congenital heart disease evaluated with clinical records and resting TTE before the enrollment. Of recruited patients, 780 (38%) had previous coronary revascularization procedure; 519 (25%) previous myocardial
infarction; 312 (15 %) history of dyspnea; 142 (7%) chronic obstructive pulmonary disease. The employed stress was exercise in 1167 (semi-supine, n=812; upright bicycle, n=348; post-treadmill, n=7) or pharmacological testing in 869 patients (dipyridamole, n=709; dobutamine, n=150; adenosine, n =10). The same cardiac transducer was used for TTE and LUS. We adopted the 4-site simplified scan (3, 4), from midaxillary to mid-clavicular lines on the third intercostal space. The positivity criterion for B-lines ("wet lung") was a stress score higher than rest for ≥ 2 points.

Non-parametric Spearman’s coefficient was used to assess linear correlation. Multivariate logistic regression analysis was performed to find predictors of any appearance or increment in stress B-lines. Statistical significance was set at p<0.05.

Interpretable images were obtained in all patients. Regional wall motion abnormalities (RWMA) were present in 483 patients (24 %). A "wet lung" was present in 512 patients (25 %). Ischemic heart with wet lung in 213 patients (11%).

Peak Wall Motion Score Index (WMSI) was correlated with B-lines (R=0.46, P=0.001) (Fig. 1). At multivariate logistic regression analysis, stress WMSI (OR=4.89, 95% CI=3.65-6.55,p<0.001), peak systolic blood pressure (OR=1.008, 95%CI=1.004-1.011,p<0.001), severe mitral regurgitation (OR=2.38, 95% Cl=1.03-5.54, p<0.001), systolic pulmonary arterial pressure > 40 mmHg (OR=4.94, 95% CI=1.41-17.32, p<0.012), hypertension (OR=1.36, 95% CI=1.04-1.79,p<0.024) and history of dyspnea (OR=1.37, 95% CI=0.98-1.92, p=0.066) were associated with B-lines during SE. Stress E/e’ was more frequent in wet lungs (44 vs 14%, p<.001) but not significant at multivariate analysis. Stress B-lines appearance or increment were present in 3/27 patients with no CAD (11%), 5/26 (19%) with single,8/22 (36%) with double, and 15/27 (55%) with triple vessel disease (p=0.003 for trend test).

Dual imaging TTE-LUS during SE is feasible and simple, with 100 % success rate and only minimal increase of imaging time. Stress B-lines are associated to more severe and/or extensive
RWMA and CAD. In patients without inducible ischemia, stress B-lines are associated to severe mitral insufficiency, increased pulmonary pressure, excessive systolic blood pressure rise during stress. The same probe was used for TTE and LUS and this may lower the image quality but does not affect to any significant extent B-lines quantification. B-lines also originate from pulmonary interstitial fibrosis, but these fibrotic B-lines do not increase during stress. **During stress, B-lines are simpler to image and to measure, not degraded by hyperventilation and tachycardia, and inherently more quantitative, than RWMA.**

The integration of TTE and LUS identifies a spectrum of functional responses ranging from non-ischemic heart and dry lung up to very abnormal ischemic heart and wet lung, with all intermediate responses in between (5).

**REFERENCES**


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5. A full listing of the members of the Stress Echo 2020 study group can be found at http://se2020.altervista.org. Please note that these are members of the Stress Echo study group and not coauthors of this manuscript.

Legend of Figure

Fig. 1. Wet lung and regional wall motion abnormalities during stress. The correlation between peak WMSI (x-axis) and stress B-lines (y-axis) in the entire population.