

Diagnostic Value of Lung Ultrasonography in Comparison with Killip Classes after Angiography in Acute Myocardial Infarction: A Study from Iran

Homa Hemmati¹, Ramin Khameneh Bagheri^{2,*}, Hedieh Alimi³, Hassan Mehrad-Majd^{4,5}

¹Cardiologist, Mashhad University of Medical Sciences, Mashhad, Iran

²Associated Professor of Cardiology, Fellowship of Interventional Cardiology, Department of Cardiovascular Diseases, Faculty of Medicines, Mashhad University of Medical Sciences, Mashhad, Iran

³Associated Professor, Vascular and Endovascular Surgery Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

⁴Clinical Research Development Unit, Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran

⁵Cancer Molecular Pathology Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

*Correspondence should be addressed to Ramin Khameneh Bagheri, khamenehbr@mums.ac.ir; research.medicine20@gmail.com

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Abstract

Background: Acute myocardial infarction (AMI) with heart failure (HF), is the main cause of increased mortality. Early risk stratification by Killip classification is essential for its management. Today, non-invasive diagnostic methods such as lung ultrasound (LUS) are on the rise due to their ability to provide valuable insights without invasive methods. In this study we aimed to evaluate diagnostic value of LUS in comparison with Killip classes after angiography in AMI patients.

Methods: In this cross-sectional study, 60 patients referred to Ghaem hospital in Mashhad, Iran during 2022-2023 with AMI were participated. LUS and echocardiography were performed for all patients before and after angiography and the results were compared with Killip classes. In order to perform LUS, the 8-zone method was used, and the number of B-lines in each zone was counted. All data were analyzed by SPSS software version 22.

Results: Of all the patients, 56.7% were male and the mean age was 59.11 ± 14.82 years. There was statistically significant difference in terms of TIMI score, B-lines in LUS, ejection fraction, E/EM, E/A, Killip class before and after angiography ($P < 0.05$). There was a moderate agreement between the results of Killip class and LUS before and after angiography (Cohen's kappa coefficient was 0.410 and 0.556, respectively).

Conclusion: Based on our findings, Killip Class and LUS can predict the mortality of AMI patients in the future and the results of LUS had a moderate agreement with the Killip class.

Keywords: Acute coronary syndrome, Ultrasonography, Myocardial infarction, Diagnosis

Introduction

The most common cause of death worldwide is cardiovascular diseases (CVDs). In Iran, about 43% of all mortalities are caused by CVDs [1,2] and their incidence and prevalence have grown in recent years [3]. The most serious clinical manifestation of CVDs is acute myocardial infarction (AMI)

[4]. AMI, a complication of heart failure (HF), is considered the leading cause of increased mortality. Early risk stratification is essential for the postoperative management of AMI [5]. In AMI patients, risk stratification is often performed using the Killip classification, it can assess pulmonary congestion by physical examination findings [6] with considerable prognostic value. However, poor sensitivity and accuracy of lung auscultation

in detecting mild pulmonary edema, can affect Killip classification accuracy [7].

Today, non-invasive diagnostic methods are on the rise due to their ability to provide valuable insights without invasive methods. One of these methods is lung ultrasound (LUS) [8]. In recent decades, LUS is considered as a sensitive tool for the detection and quantification of pulmonary congestion heart failure (HF) patients [9]. B-lines which provide diagnostic and prognostic information on LUS, are vertical lines that can be measured in predefined zones across the chest [10,11]. Recent data indicated that patients with acute coronary syndromes, including AMI with a higher number of B-lines at the time of admission can lead to increased risk of in-hospital mortality [12].

One study which investigate LUS in AMI patients revealed that, subclinical congestion identified by LUS was in correlation with higher risk of adverse outcomes such as HF, cardiac shock, and death [13]. The advantages of using LUS include ability in detecting changes in pulmonary congestion, adjustments in the treatment, shorter hospital stays, and reduced costs [14]. Another study showed that B-lines counted in LUS, can be considered as an independent predictor of HF in patients with AMI during their hospitalization and short-term follow-up and providing significant prognostic value to the Killip classification [15]. In this study we aimed to evaluate the diagnostic value of LUS in comparison with Killip classes after angiography in AMI patients.

Materials and Methods

Participants

This cross-sectional study was conducted on 60 patients with AMI who were referred to Ghaem hospital, Mashhad, Iran during 2022-2023. Inclusion criteria were age above 18 years, admission with ST elevation MI (STEMI), based on the presence of typical chest pain at rest with ST-segment elevation. Patients with absence of coronary artery disease in angiography, underlying lung disease, acute respiratory syndrome, pneumonia which was diagnosed during hospitalization, hemodialysis before hospitalization, life expectancy less than 6 months due to non-cardiac underlying diseases were excluded from the study procedure. Informed consent was obtained from all participants.

Data collection

Demographic characteristics of patients including age, gender, underlying diseases (diabetes mellitus, hypertension, hyperlipidemia, chronic kidney diseases) and smoking were recorded. Angiography reports were examined in terms of infarct location (anteroseptal, anterolateral, extended, inferior, posterior, and right ventricle), target vessel (including left anterior descending (LAD), left circumflex (LCX), right coronary artery (RCA)). Physical examination was performed for all patients based on Killip class.

Assessment of B-lines number was performed by LUS. Ejection fraction (EF), left atrial volume (LAV), and pulmonary artery pressure (PAP) were assessed by echocardiography. Thrombolysis in MI frame count (TIMI FC), Thrombolysis in MI flow (TIMI F), early trans mitral flow velocity to the early diastolic tissue velocity (E/EM), peak velocity blood flow from left ventricular relaxation in early diastole to peak velocity flow in late diastole caused by atrial contraction (E/A). Patients underwent LUS and echocardiography at the admission time and after angiography.

In order to perform LUS, the ultrasound was performed by the 8-zone method, and B-line numbers in each zone were counted, in supine position [16]. The degree of pulmonary edema was classified using the number of B-lines as follows: normal (B-line index <5), mild ($5 \leq$ B-line index <15), moderate ($15 \leq$ B-line index <30), severe ($30 \leq$ B-line index) [17]. Finally, finding Killip class, LUS, and echocardiography before and after angiography was compared and their correlation was investigated.

Statistical analysis

All statistical analyses were performed by SPSS software version 22. Qualitative variables were expressed as frequency (percentage) and quantitative variables were expressed as mean $\pm$ standard deviation. Comparison of measured variables before and after PCI was done using paired sample t-test (in case of normal distribution) or Wilcoxon signed-rank test (in case of non-normal distribution). The agreement between the results of LUS and Killip class was measured using the Cohen's kappa coefficient. P -value <0.05 was considered as statistically significant.

Results

From the total of 60 patients, 56.7% were male and the mean age was 59.11 ± 14.82 years. In our study, most of the patients had inferior MI (35%) and RCA in 41.7% of cases was target vessel in angiography (**Table 1**).

Based on **Table 2**, which indicate comparison echocardiography, TIMI score, Killip class, and LUS score findings of patients, there was statistical significant difference in terms of TIMI FC, TIMI F, B-lines in LUS, EF, E/EM, E/A, Killip class before and after angiography ($P < 0.05$), whereas, LAV and PAP did not have significant difference ($P > 0.05$).

As shown in **Table 3**, 85% of patients with Killip class 1 were normal in terms of pulmonary edema, while the percentage of normal people in Killip class 2 was decreased to 50%, and in Killip class 3 and 4, no patient was normal in terms of pulmonary edema. The Cohen's kappa coefficient was 0.410 ($p < 0.001$), which demonstrated that there was a moderate agreement between the results of Killip class and LUS before angiography.

Table 1. Demographic and clinical characteristics of studied population.		
Variables		N (%), Mean ± SD
Age (years)		59.11 ± 14.82
Gender	Male	34 (56.7)
	Female	26 (43.3)
Underlying diseases	DM	13 (21.7)
	HTN	5 (8.3)
	HLP	7 (13.3)
	CKD	5 (8.3)
	Multi diseases	18 (30)
Smoking		12 (20)
MI location	Anteroseptal	8 (13.3)
	Anterolateral	6 (10)
	Extended	13 (21.7)
	Inferior	21 (35)
	Posterior	9 (15)
	Right ventricle	3 (5)
Target vessel	LAD	27 (45)
	LCX	8 (13.3)
	RCA	25 (41.7)
DM: Diabetes mellitus; HTN: Hypertension; HLP: Hyperlipidemia; CKD: Chronic Kidney Diseases; MI: Myocardial Infarction; LAD: Left Anterior Descending; LCX: Left Circumflex; RCA: Right Coronary Artery		

Table 2. Comparison of echocardiography findings, TIMI score, Killip class and lung ultrasound score at the time of admission and after angiography.			
Variables	Before	After	P-value
TIMI FC	1.60 ± 4.61	21.80 ± 3.04	<0.001*
TIMI F	1.60 ± 4.61	21.8 ± 3.04	<0.001**
B-lines in LUS	10.55 ± 12.73	4.70 ± 7.22	<0.001*
EF	39.08 ± 14.24	42.25 ± 13.32	<0.001*
E/EM	8.90 ± 3.78	7.77 ± 2.45	<0.001*
E/A	1.04 ± 0.49	0.96 ± 0.37	0.002*
LAV	29.48 ± 2.78	29.41 ± 2.70	0.159*
PAP	25 ± 12.51	24.85 ± 12.36	0.219*
Killip class	2.1 ± 1.02	1.4 ± 0.64	<0.001**
TIMI FC: Thrombolysis in Myocardial Infarction (MI) Frame Count; TIMI F: Thrombolysis in MI Flow; EF: Ejection Fraction; E/EM: Early trans mitral flow velocity to the early diastolic tissue velocity; E/A: Peak velocity blood flow from left ventricular relaxation in early diastole (the E wave) to peak velocity flow in late diastole caused by atrial contraction (the A wave); LAV: Left Atrial Volume; PAP: Pulmonary Artery Pressure			
* Paired samples T-test. ** Wilcoxon Signed Ranks Test.			

Table 3. Cohen's kappa coefficient between Killip class and lung ultrasound results before and after angiography.							
Killip class		Lung ultrasound finding				Kappa	P-value
		Normal	Mild	Moderate	Severe		
Before	1	17 (85)	2 (10)	1 (5)	0 (0)	0.410	<0.001
	2	11 (50)	10 (45.5)	0 (0)	1 (4.5)		
	3	0 (0)	4 (40)	4 (40)	2 (20)		
	4	0 (0)	0 (0)	4 (50)	4 (50)		
After	1	38 (92.7)	2 (4.9)	0 (0)	1 (2.4)	0.556	<0.001
	2	6 (42.9)	7 (50)	1 (7.1)	0 (0)		
	3	0 (0)	2 (40)	3 (60)	0 (0)		
	4	0 (0)	0 (0)	0 (0)	0 (0)		

On the other hand, after angiography 92.7% of patients with Killip class 1 were normal in terms of pulmonary edema, while the percentage of normal people in Killip class 2 decreased to 42.9%. The Cohen's kappa coefficient was 0.556 ($p<0.001$), which shows that there was a moderate agreement between the results of Killip class and LUS.

Discussion

In patients with AMI, risk stratification is often performed by using the Killip classification [6], besides that, LUS has emerged as a sensitive tool for the pulmonary congestion detection in patients with HF [9]. Considering the several advantages of LUS [14], in this study we evaluated the diagnostic value of LUS in comparison with Killip classes after angiography in AMI patients.

Based on our findings, B-lines in LUS are in good agreement with the Killip class, and therefore, this method can be used as a marker of HF. These findings corroborate the ideas of Araujo *et al.*, who investigated the role of LUS in predicting in-hospital mortality in patients with STEMI, showed that the absence of pulmonary congestion in LUS could be a negative predictor for in-hospital mortality and adding LUS to the Killip class would lead to an increase in its sensitivity in predicting the mortality of patients [18]. Also, Parras *et al.* study revealed that B-lines number in patients with Killip class A was significantly lower than in patients with Killip class higher than A, and ultrasound in admission can predict HF during hospitalization in patients with AMI [19].

Evaluation of pulmonary congestion by LUS is increasingly included in the examination of patients with known or suspected HF, particularly in the acute conditions [6]. In another study conducted by Carreras-Mora *et al.*, the findings have been shown that in people with wet lungs (presence of 3 or more B-lines in at least one lung site), the possibility of acute HF, cardiogenic shock, or death during hospitalization was significantly higher than in people with dry lungs [20]. Pivetta *et al.*, suggested that integrating LUS with clinical assessment

to diagnose HF in the emergency department appears to be more accurate than the current diagnostic approach [10].

In our study, there was no significant difference in terms of LAV and PAP at the time of admission and after angiography. Our findings are in consistence with Platz *et al.*'s findings which showed that worse pulmonary congestion in LUS was associated with important prognostic echocardiographic parameters of LV filling pressure, PAP, and RV function at baseline [6]. In contrast, in studies between patients with acute HF, B-lines in the admission time type are less prognostically important for post-discharge outcomes [21,22].

It seems that, pulmonary congestion by LUS which performed on admission appears to be a common finding among patients admitted for acute coronary syndrome (ACS) and is in correlation with adverse in-hospital and long-term outcomes. Early risk stratification in patients with ACS is very important for further treatment decisions and can determine the need for long-term intensive monitoring with subclinical congestion signs in early hospitalization [12]. Although this procedure is still not performed in patients with AMI among most cardiologists. Recent data suggest that LUS can provide prognostic information beyond the Killip class in patients with AMI when assessed on the day of admission [15,23].

Conclusion

Due to the fact that Killip Class can predict the mortality of patients in the future and the results of LUS had a moderate agreement with the Killip class of patients, it can be concluded that LUS can also be used in prediction of mortality in AMI patients. Of course, in order to confirm these results, it is necessary to conduct more studies in the future and to determine with the follow-up of patients whether the results of LUS can predict the mortality of patients or not.

Ethical Statement

Informed written consent was obtained from all subjects

using approved protocols by Research Ethics Committee of Mashhad University of Medical Sciences (IR.MUMS.MEDICAL.REC.1401.450). This study complies with the Declaration of Helsinki.

Conflict of Interest

The authors declared no conflict of interest.

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Author Contributions

Study concept and design: Kh.B R, A H, Acquisition of data: H SH, A H, Statistical analysis: M.M H, Drafting of the manuscript: H SH, Study supervision: Kh.B R.

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