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Original Article

Comparison of lung bedside ultrasound and brain natriuretic peptide in the diagnosis of acute heart failure in the emergency department

Seyed Hossein Ojaghi Haghighi[1], Neda Hamed[1], Shiva Ebrahimi[2], Jafar Ghobadi[3], Hoorolnesa Ameli[4*]

[1]Emergency Medicine Research Team, Tabriz University of Medical Sciences, Tabriz, Iran
[2]Pulmonary Department, Urmia University of Medical Sciences, Urmia, Iran
[3]Emergency Department, Fatemi Hospital, Ardabil University of Medical Sciences, Ardabil, Iran
[4]Clinical Research Development Center, Shahid Beheshti Hospital, Qom University of Medical Sciences, Qom, Iran

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Abstract

Introduction: Congestive heart failure is a heart muscle failure that causes pulmonary congestion and eventually pulmonary edema, which despite recent medical advances, is still a progressive syndrome with a high mortality rate. The prevalence of this condition has increased in recent decades. Therefore, in this study we compared lung ultrasound findings with plasma brain natriuretic peptide (BNP) in acute heart failure patients.

Methods: This study was performed in the emergency department of Imam Reza hospital in Tabriz. After obtaining a medical history from the patients, measurement of BNP and bedside ultrasound of the lung were performed. Ultrasound was performed at the same time as obtaining blood sample to ensure that the ultrasound specialist did not know the result of diagnosis. During the ultrasound, if there were multiple B-Lines that were at least 3 mm apart, the patient was diagnosed with pulmonary edema due to heart failure.

Results: The number of participants in this study was 108 patients, 54.6% of whom were men and the rest were women. The correlation coefficient between width and number of Kerley lines was 0.79, between N-terminal pro-B-type natriuretic peptide (BNP) and width of Kerley lines was 0.65, and between NT-pro-BNP and number of Kerley lines was 0.77, indicating a significant positive correlation (*P* value <0.001).

Conclusion: The results of the present study shows that in patients with acute heart failure, the number and the width of Kerley lines in pulmonary ultrasound evaluation rapidly increase. There is also a high correlation between the number and the length of Kerley lines with serum NT-pro BNP values.

Introduction

Congestive heart failure is a failure of the heart muscle that causes pulmonary congestion and eventually, pulmonary edema. Acute congestive heart failure is one of the most common cardiology emergencies that is managed in the emergency department.[1]

Diagnosis and treatment of patients with acute congestive heart failure is a challenge among emergency department physicians, and the evaluation and the management of a patient with acute congestive heart failure is important.[1] However, despite recent therapeutic advances, heart failure is still a progressive syndrome with high mortality, high prevalence, and incidence in recent decades.[2] Heart failure affects about 23 million people worldwide and leads to hospitalization and medical expenses.[3]

The first step in diagnosing acute congestive heart failure in patients with acute shortness of breath is obtaining patient's history, and performing clinical examinations; In addition to history and clinical examinations, a standard set of examinations are performed for people suspected of having acute congestive heart failure, including chest radiographs, electrocardiograms (ECGs), and measurements of cardiac enzymes, especially troponin and brain natriuretic peptide (BNP).[1] These evaluations may have their own limitations, especially in older people.[4]

In the last two decades, pulmonary ultrasound has been recognized as an effective tool in the study of acute shortness of breath, which is used to differentiate acute heart failure from non-cardiac causes of acute shortness of breath.[5] There is ample evidence today that lung tissue ultrasound gives better results than clinical and radiographic examinations of the chest, and even the results of BNP measurements in the diagnosis of acute congestive heart failure. In addition, lung tissue ultrasound is an effective tool in differential diagnosis or fellow diagnosis with heart failure such as pneumonia. For this purpose, lung tissue ultrasound is placed superior to chest radiography and is even comparable to CT scan of

***Corresponding Author:** Hoorolnesa Ameli, Email: h.med81@yahoo.com

the chest.[6,7]

Due to the importance of using lung tissue ultrasound to diagnose acute heart failure and due to the lack of studies in this field, we decided to design a comparative study between lung ultrasound findings and N-terminal pro b-type natriuretic peptide (NT-pro BNP) in patients with acute heart failure, referred to the emergency department of Imam Reza hospital in Tabriz.

Methods

The sample of the study

A cross-sectional study was performed in Imam Reza Medical and Educational Center in Tabriz for one year. The sample of this study was all the patients referred to the emergency department of this center. The patients were included in the study according to the clinical definition in the text, and the findings were then obtained and analyzed.

Sample size and the method of sample selection

The study sample included all the patients with acute shortness of breath referred to the emergency department of this center during the time of the study. To calculate the sample size, according to other studies,[8-10] using Lin Naing software and considering the sensitivity of 83%, the specificity of 83%, the approximate prevalence of 28% in the emergency department, and 95% confidence, the sample size was calculated to be 108 patients.

Inclusion and exclusion criteria of the study

All the patients over 18 years of age, non-traumatic, and suspected of acute heart failure who referred to the emergency department from 2016/3/27 to 2017/3/7 with signs of shortness of breath were included. Patients with cancer, clear evidence of sepsis, arrhythmia, pulmonary thromboembolism, cardiac tamponade, peripartum cardiopathy, massive pleural effusion, pneumothorax, BMI<40, pleural local fluid, and pleurodesis history were excluded.

After admission to the emergency room and obtaining a medical history, the patients were recruited in the study if they did not meet the excluding criteria. Measurement of BNP and bedside ultrasound of the lung were performed for all participants. To ensure that the sonographer was unaware of the diagnosis and the values of NT-pro BNP, the ultrasound was performed at the same time as the blood sample was taken.

The NT-pro BNP test was performed with the Vidas kit and the results were reported quantitatively. Based on this test, BNP >500 pg/mL strongly suggests acute heart failure, and BNP <100 pg/mL almost rules out the diagnosis of heart failure.[11]

Ultrasound was performed with a GE LOGIQ 200 ultrasound device with a 7.5 MHz probe. During the ultrasound process, if lines called "B-Line" are seen, the test is indicative of a specific pathology in the lungs. In the presence of multiple B-Lines that are at least 3 mm apart, diagnosis of pulmonary edema in patients with heart failure is made.[12]

Data analysis method

After collection, the data were entered into the 20.0 version of SPSS software and the results of the analysis of descriptive variables were reported as mean ± standard deviation and frequency (percentage). Pearson correlation test was used to determine the relationship between the variables. Analysis of variance (ANOVA) and *t* test tests were used to compare the means between the groups, and values less than 0.05 were considered significant.

Moral considerations

The information of all the patients were confidential. For the participation of illiterate people and their satisfaction, all the conditions and process of the study and benefits of the plan were explained. No costs were imposed on patients in this regard.

Results

The number of participants in this study was 108 patients, of which 59 (54.6%) were men and 49 (45.4%) were women.

The mean age of participants in this study was 58.72 years with a standard deviation of 14.95, the lowest age among patients was 32 years and the highest age was 86 years.

Descriptive statistics of width and number of Kerley lines in patients were evaluated, the results of which are presented in Table 1.

Also, the correlation between width and number of the Kerley lines was investigated. The correlation coefficient between these two variables was 0.79, indicating a positive and significant relationship between width and number of the Kerley lines, so that by increasing one, the other increases significantly (*P* value<0.001).

Also, the correlation coefficient between NT-pro BNP and the width of the Kerley lines was 0.65 and the correlation coefficient between NT-pro BNP and the number of the Kerley lines was 0.75, both statistically significant (*P* value<0.001). It can be said that the correlation between the changes in the NT-pro BNP variable and the number and the width of the Kerley lines is positive and in the same direction.

Evaluation of patients' results also showed that 18 out of 108 patients died (16.7%), 37 (34.3%) were discharged in the early stages, and 53 (49.1%) were discharged after

Table 1. Study variables descriptive statistics

Variable	Minimum	Maximum	Average	Standard Deviation
Width	2	11	4.6	2.2
Number	2	9	4.8	1.8
NT-pro BNP	315	1665	700.7	234

hospitalization and treatment. On the other hand, the average of width and number of the Kerley lines as well as NT-pro BNP were evaluated separately based on patient outcomes, the results of which are presented in Figures 1 and 2.

The mean width and number of the Kerley lines as well as NT-pro BNP were evaluated separately by the ANOVA mean comparison test among three groups of patients, the results of which are presented in Table 2.

As can be seen in this table, according to the statistical values and *P* values being <0.05, the means of width and number, and NT-pro BNP in the three groups of patients, differ significantly by the outcome.

The receiver operating characteristic (ROC) curve was used to determine which of the NT-pro BNP, the width and the number of the Kerley lines and their changes, were able to predict the outcome of death in patients. The diagrams for each variable are in Figure 3.

The area below the curve for the width of the Kerley lines is 0.84. In addition, according to the graph, the sensitivity and specificity of this variable were 0.78 and 0.82, respectively.

The area below the curve for the number of Kerley lines variable is 0.84. Also, according to the graph, the sensitivity and specificity of this variable were 0.77 and 0.69, respectively.

The area below the curve for the NT-pro BNP variable is 0.78. Also, according to the graph, the sensitivity and specificity of this variable were 0.72 and 0.77, respectively.

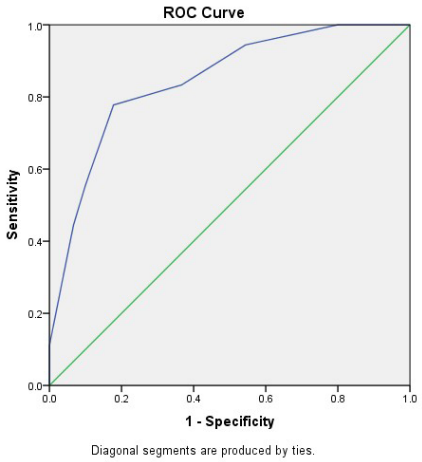

Figure 1. ROC carve of mortality prediction by Kerley line width variable

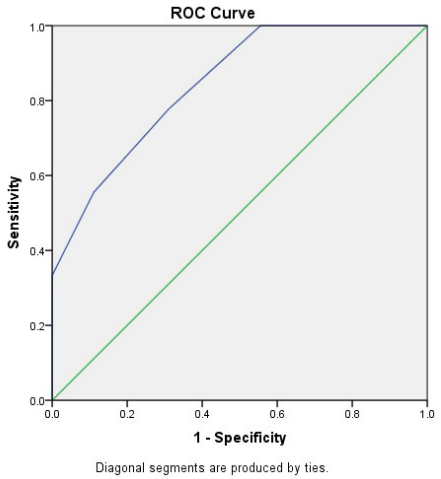

Figure 2. ROC carve for predicting mortality by variable number of curly lines

Discussion

Previously, various studies were conducted to investigate the changes in Kerley lines in various diseases. The results of a study by Carlino et al showed that various pathological factors cause multiple Kerley lines in the lungs. Studies of this group showed that any increase in vascular volume and inefficient circulation of fluids in the body due to heart, liver, and kidney failure can cause congestion of the pulmonary arteries and create Kerley lines in lung ultrasound.[5]

Recent studies by Martindale et al showed that the diagnosis of acute heart failure, especially in the emergency department, using current methods is somewhat difficult to the extent that delays the diagnosis and the onset of effective treatment.[7]

The results of the present study showed that in patients with acute heart failure, the number and length of the Kerley lines in lung ultrasound increased. Statistical studies showed that increasing the number and length

Table 2. ANOVA test results

	Group	Minimum	Maximum	Average	Standard Deviation	*P* value
Width	Early discharge	2	4	2.62	0.68	<0.001
	Discharge after hospitalization	3	8	5.13	1.20	
	Death	6	11	7.11	1.57	
Number	Early discharge	2	6	2.94	1.12	<0.001
	Discharge after hospitalization	4	7	5.5	0.93	
	Death	5	9	6.7	1.21	
NT-pro BNP	Early discharge	329	815	535	124	<0.001
	Discharge after hospitalization	315	934	715	130	
	Death	505	1665	992	330	

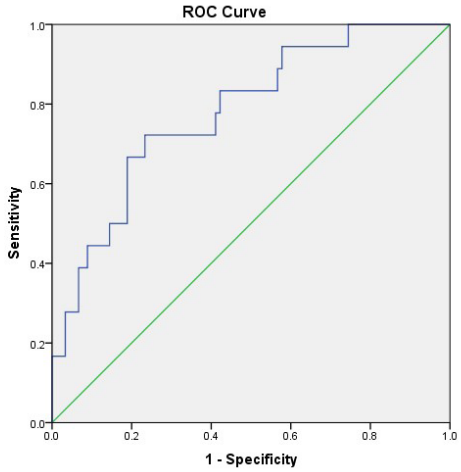

Figure 3. ROC carve related to mortality prediction by NT.ProBNP variable

of the Kerley lines in the lungs can predict acute heart failure in emergency patients with high specificity and sensitivity. It was previously shown that the Kerley lines in lung ultrasound are due to congestion of the pulmonary arteries. For this reason, the length and number of the Kerley lines can increase in patients with pulmonary edema, in patients under hemodialysis, and in patients with multiple lung metastases.

On the other hand, the results showed that there was a high correlation between the increase of pro BNP values and the number and length of the Kerley lines. This suggests that lung ultrasound in patients with suspected acute heart failure could be an alternative for pro-BNP. However, it should be noted that high pro-BNP in the patients alone does not indicate acute heart failure and also changes in the Kerley lines in lung ultrasound in patients with suspected heart failure cannot be predictive of acute heart failure without clinical evaluation. For this reason, this method can be used to confirm the diagnosis.

The results of the studied 108 patients showed that in patients with acute heart failure there was a significant correlation between the increase in pro BNP and the number and length of the kerley lines.

Conclusion

The results of the present study showed that in patients with acute heart failure, the number and length of Kerley lines in pulmonary ultrasound evaluation increase rapidly. There was also a high correlation between the number and length of Kerley lines with serum pro BNP values. Due to the diagnostic problems in patients referred to the emergency room with acute heart failure and high overlaps between other diseases of the cardiovascular system with this disease, it seemed that the use of pulmonary ultrasound in these patients could be more accurate and faster in the diagnosis.

Conflict of interest

The authors declare that there is no conflict of interest.

Study Highlights

What is current knowledge?

- For diagnosis of heart failure, usage of brain natriuretic peptide is useful

What is new here?

- We can use lung ultrasonography for diagnosing of heart failure in the cases we have not any achievement to lab test.

Ethical Approval

The ethical approval attained from the local medical ethics committee of Tabriz University of Medical Sciences is 94/3-10/30. Additionally, informed consent was obtained from all the individuals who participated in this study.

Authors' contribution

SHOH and NH designed the research. NH gathered the data and summarized it. HA and JG performed the statistical analysis and SE and SHOH reviewed the quality of the manuscript and revised it. All the authors read and approved the manuscript.

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