UDC 616

THE CORRELATION BETWEEN THE IMPROVEMENT OF DYSPNOEA CONDITION AND THE DECREASE B-LINE COUNTS IN THE OBSERVATION OF NITRATE THERAPY FOR ACUTE HEART FAILURE

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ABSTRACT
Acute heart failure is common in emergency department. Patients with acute heart failure generally come with dyspnoea. Diagnosing acute heart failure should be done rapidly so that therapy can be given immediately. The use of ultrasound for diagnosis is increasingly common. With a sensitivity exceeding 90% to assess alveolar interstitial syndrome to diagnose acute heart failure, it is expected that B-line in lung ultrasound can be used to monitor acute heart failure therapy objectively. Therapy of acute heart failure includes oxygenation with continuous positive airway pressure, nitrates, and diuretics. Monitoring of this therapy in Dr. Saiful Anwar general hospital emergency department is still based on subjective improvement of dyspnoea, while ultrasound is rarely used. This article is to analyse the correlation between dyspnoea improvement and decrease of B-line count in the monitoring of acute heart failure therapy. The research was an observational analytic, cross-sectional study to analyse the correlation between dyspnoea improvement with decrease of B-lines count in the monitoring of acute heart failure therapy. As many as 45 subjects were included in this study. The correlation between dyspnoea improvement and decrease of B-Line count in minute 0 to minute 15 using independent samples t-test showed no significant result (p= 0.711). The correlation between dyspnoea improvement and decrease of B-Line count in minute 15 to minute 30 using Kruskal-Wallis test also showed no significant result (p= 0.153). The results find that there was no significant correlation between dyspnoea improvement and decrease of B-line counts in the initial 30 minute in monitoring of acute heart failure therapy.

KEY WORDS
Acute heart failure, B-Line, dyspnoea, lung ultrasound.

Acute heart failure is one of common cases in emergency units. Patients are usually brought to the hospital in a state of shortness of breath (dyspnoea) within acute onset, while some others experienced the dyspnoea for the first time. Some patients also experienced worse dyspnoea than usual. The diagnosis of this syndrome should be done immediately, quickly, and precisely, allowing effective therapies to be given for the patients within an efficient amount of time. Access to medical history (anamnesis) and physical examination are done in the emergency units prior to the diagnosis of the acute heart failure. Electrocardiography (EKG), chest cardiography or chest X-ray strengthen the diagnosis of this syndrome.

The result of a research done by an intensivist, Daniel Lichenstein, has popularized the use of portable ultrasound device (bedside ultrasound) to monitor patients' heart rhythm and lung congestion. The effectiveness of this device has been proven in some research in providing precise and faster diagnosis of acute heart failure in emergency units. Compared to the radiogram device, portable ultrasound device has some advantages, providing faster and repeatable radiation-free cardiac tests despite of its weakness related to the operator-dependance fo this device (Lichtenstein, 2014).

A number of studies have successfully confirmed the preciseness of acute heart failure using the portable ultrasound device in fulfilling the gold standard computed tomograpjy (CT). Ultrasound device detects lung congestion as accurate as the CT device. B-line that looks like lighthouse is presented in the device, showing the artifacts of vertical hyperechoic. Research have also been done to count the B-line counts cut-off that indicate lung congestion through the presence of 10 or more B-line in 8 zones or in more than 2 zone that has more than 3 B-lines (Anderson, 2013).

Lung ultrasound device is a device that has been widely used to precisely diagnose acute heart failure. B-line shown in lung USG has 96.2% sensitivity and 54% specificity in diagnosing acute heart failure. Combined with measurements of vena cava diameter and heart ejection fraction increase to the sensitivity of the device up to 94.3% and specificity 91.9-100% (Anderson, 2013; Kajimoto, 2012).

With sensitivity exceeding 90% that is adequate enough to detect alveolar interstitial syndrom, this device is able diagnose acute heart failure. In addition, B-line can also be employed to monitor the therapy of the syndrom more objectively and more accurately. As supported by Lichtenstein, the amount of lung congestion is parallel to the the B-line counts (Lichtenstein, 2014)..

In the emergency unit of Rumah Sakit Saiful Anwar (RSSA) Malang, nitrate monitoring is given to the patients with acute heart failure prior to their clinical symptoms, dyspnoea, and vital signs such as blood pressure, pulse, respiratory rate, and oxygen saturation. The nitrate monitoring has not yet been regularly done using ultrasound device even though portable ultrasound devices that can be brought to the bedside are available in the emegency unit of RSSA. This research was done to find out if dyspnoea symptoms have any meaningful correlation with the change of B-line counts in lung ultrasound devices used for nitrate monitoring of acute heart failure.

METHOD OF RESEARCH

Patients. Most of patients diagnosed with acute heart failure were brought to the emergency unit of RSSA had clinical classification of acute cardiogenic pulmonary edema (ACPE) or acute decompensated heart failure (ADHF).

Inclusioni criteria:

1. Patients with acute cardiogenic pulmonary edema or acute decompensated heart failure with pulmonary edema;
2. Patients' age between 50 to 70 years old;
3. Willing to sign the informed consent.

Exclusion criteria:

- Heart failure followed by cardiogenic shock;
- Blood pressure below 150/100 mmHg;
- Hypotension occurs during nitrate titration;
- Decreased consciousness;
- Need endotracheal intubation.

Design. This reserch is an analytical observational cross-sectional reseach done to measure the correlation between dsypena and the decrease in B-line counts shown in lung usg during the nitrate therapy for patients with acute heart failure.

This research had been approved by the Ethical Committee of Rumah Sakit Saiful Anwar Malang to be conducted in the emergency unit of the hospital from March 2017 – February 2018.

Patients who matched the inclussion criteria were given 100%-concentrated oxygen through CPAP at 7 cmH2O pressure started from the intravenous nitroglycerin titration at the dose of 20mcg/min, increased to 10mcg/min evey 3 minuts, while B-line is counted from the beginning (minute 0). In the 15^{th} munute and the 30^{th} minute, patients' respiratory rate, oxygen saturation, pulse, blood pressure and dyspnoea were examined.

The B-line was counted in 8 examination zones using a portable GE vivid e USG device set at the probe linear (7.5 – 10 MHz) and 6-10 cm depth. Dyspnoea was examined based on patients' description. The monitoring and control of USG data were done by emergency physician level 2 or higher, and 1 patient was monitored by 1 physician.

Data Analysis. Correlation between dyspnoea symptopm and the deviation of B-line in minute 15th was measured using the independent sample statistical test which obtained alpha level $\alpha = 0.05$ significant at $p < 0.05$. The analysis on the correlation between dyspnoeaand the average gap of B-line in minute 30th was done using the Kruskal-Wallis Statistical test as the data were not normally distributed.

RESULTS OF STUDY

Description of Research Samples. There were 45 patients who participated in this study, 57.8% (26 people) were male, while 42.2% (19 people) were female.

Table 1 – Sample Distribution based on Sex

Sex	n	%
Male	26	57.8
Female	19	42.2
Total	45	100

Table 2 – The Distribution of Patient Diagnosis Frequency

Diagnosis	n	%
Acute Pulmonary Edema dt Chronic Kidney Disease stage V	28	62.2
Severe Acute Decompensated Heart Failure	8	17.8
Acute Cardiogenic Pulmonary Edema due to Acute Coronary Syndrome	6	13.3
Severe Acute Decompensated Heart Failure due to Peripartum Cardiomyopathy	2	4.4
Acute Cardiogenic Pulmonary Edema due to Pre-Eclampsia	1	2.2
Total	45	100

Acute pulmonary edema dt chronic kidney disease stadium 5 were found in 28 patients (62.2%). Meanwhile, severe acute decompensated heart failure, acute cardiogenic pulmonary edema due to acute coronary syndrome and the severe acute decompensated heart failure due to peripartum cardiomyopathy were found in 8 patients (17.8%), 6 patients (13.3%), and 2 patients (4.4%) respectively.

Data. Standardized therapy was given to all of the samples, while the B-line, dyspnoea, respiratory rate, pulse, blood pressure and oxygen saturation were observed in minute 0.15 and 30.

Table 3 – The Characteristics of the Research Samples

Variable	Average	Standard of Deviation
B-line counts in minute 0	45.82	10.066
B-line counts in minute 15	38.20	9.275
B-line counts in minute 30	33.16	8.099
Respiratory rate in minute 0	45.53	9.885
Respiratory rate in minute 15	37.47	7.282
Respiratory rate in minute 30	32.36	5.909
Systolic Pressure in minute 0	200.73	33.704
Systolic Pressure in minute 15	186.53	29.188
Systolic Pressure in minute 30	178.13	25.797
Diastolic Pressure in minute 0	114.42	22.643
Diastolic Pressure in minute 15	106.80	19.460
Diastolic Pressure in minute 30	100.82	15.293
Pulse in minute 0	126.51	22.188
Pulse in minute 15	118.93	20.617
Pulse in minute 30	114.91	20.389
Oxygen Saturation in minute 0	84.07	7.803
Oxygen Saturation in minute 15	93.24	5.993
Oxygen Saturation in minute 30	95.73	4.261

Generally, the B-line counts decreased in minute 15 compared to the one in minute 0. Similarly, in minute 30. B-line counts also decreased compared to the one in minute 15 for all of the samples. There was not found any sample which has their B-line increased across minutes. Hence, the average B-line counts declined at the most significant rate than the ones in minute 0 or in minute 30.

Table 4 – Dyspnoea Improvement Data

Dyspnoea symptom in minute 0	Minute 15	
	Yes	No
Yes	25	20
No	-	-

Dyspnoea symptom in minute 15	Minute 30	
	Yes	No
Yes	14	11
No	0	20

All samples complained of dyspnoea in minute 0. In minute 15, 25 patients still complained of dyspnoea while it no longer occurred to the other 20 patients. In minute 30 out of the 25 patients who had still experienced dyspnoea in minute 15, 14 patients still experienced it, while 11 patients reported no dyspnoea occurred. The change of dyspnoea occurrence from minute 0 to minute 15 and from minute 15 to minute 30 obtained p<0.05 in Mc-Nemar test.

Table 4 – The Change of B-line counts

Change of *B-line counts*	Average + SD	p
Minute 0 – Minute 15	7.622 + 6.813	0.000
Minute 15 – Minute 30	5.044 + 6.019	0.000
Minute 0 – Minute 30	12.667 + 8.602	0.000

The change of B-line counts in a paired t-test from minute 0 to minute 15, and from minute 15 to minute 30 showed p value at <0.05.

The Correlation between Dyspnoea and Different Numbers of B-Line. 45 samples employed in this study were divided into two groups; dyspnoea group and non-dyspnoea group in minute 15 and minute 30. The gap between the numbers of B-line was calculated from each group.

Table 5 – The Correlation between Dyspnoea and the Gap of B-line counts from Minute 0 to Minute 15

Dyspnoea State	N	The Average Gap of B-line counts + SD
Dyspnoea	25	-7.28 + 6.354
No Dyspnoea	20	-8.05 + 7.494
		p = 0.711 (>0.05)

In minute 15, there were 25 patients who still experienced dyspnoea, while 20 others no longer felt it. The dyspnoea group showed average gap in B-line counts at -7.28 and the standard of deviation at 6.354, while the non-dyspnoea group obtained -8.05 and standard of deviation at 7.494. This values were then measured using the independent sample t-test which result showed no significant correlation (p = 0.711)

Table 6 – The Correlation between Dyspnoea and the Gap of B-line counts from Minute 15 to Minute 30

Dyspnoea State	N	The Average Gap of B-line counts + SD
Still occurred	14	-2.5 + 3.228
No longer occurred	11	-5.82 + 5.419
No dyspnoea	20	-6.4 + 7.366
		p = 0.153 (>0.05)

In minute 30, 14 patients still experienced dyspnoea, while 11 patients no longer experienced it. Whilst, 20 patients reported no dyspnoea from the beginning. It is found that the still-occurring dyspnoea group obtained an average gap of B-line counts at -2.5 and standard of deviation at 3.228, the no-longer-occurring dyspnoea group obtained an average gap of B-line counts at -5.82 and standard of deviation at 5.419, and the no-dyspnoea group obtained an average gap of B-line counts at -6.4 and standard of deviation at 7.366. Seen from the result of Kruskal-Wallis test, the data of B-line gap from minute 15 to minute 30 were not normally distributed, and it resulted to a meaningless correlation (p = 0.153) between changes in dyspnoea state and the average gap of B-line counts in minute 15 to minute 30.

Table 7 – The Correlation between Changes in Dyspnoea State and the Average Gap between B-line counts from Minute 0 to Minute 30

Dyspnoea State	N	The Average Gap of B-line counts $\pm$ SD
Still-occurred	14	-9 $\pm$ 6.325
No longer occurred	31	-14.32 $\pm$ 9.060
		p = 0.054 (>0.05)

The data shows that from minute 0 to minute 30, 14 samples still experienced dyspnoea while 31 others no longer experienced it. The still-occurring dyspnoea group showed B-Line average gap at -9 with the standard of deviation at 6.325, while the group of patients whose dyspnoea no longer occurred showed B-line average gap at -14.32 and standard of deviation at 9.060. An independent samples test was employed to measure the correlation between changes in the dyspnoea state and the average gap of B-line counts from minute 0 to minute 30 resulted to a meaningless correlation (p=0.054).

DISCUSSION OF RESULTS

Monitoring the Acute Heart Failure Therapy. This research involved 45 patients as the subjects, whose dyspnoea symptoms, B-line counts, pulse, blood pressure, and oxygen saturation were monitored and counted in minute 0 before the therapy was given, and in minute 15 and minute 30 after the therapy started.

Previous research such as the ones conducted by Volpicelli, Lichtenstein, Andrus, and others on interstitial lung edema and B-line in pulmonary lung had not yet employed the B-line shown in lung USG device to monitor lung edema therapy. Previous research only used the B-line shown in the device that reflects the existence of interstitital lung edema to diagnose the occurrence of acute heart failure. Thus, this research is a ground-breaking research to employ B-line shown in lung usg to monitor the therapy of acute heart failure.

Despite of the 5 different cases occurred to the samples of this study, all of samples received one type of therapy in which they were treated with CPAP 7 cmH2O oxygen and continuum intravenous infusion of nitroglycerin started from 20mcg/min dose which was increased to 10mcg/min every 3 minutes. Even though the samples were diagnosed with 5 different cases, they shared similar clinical and pathophysiological conditions in the form of pulmonary congestion due to the elevated pulmonary capillary hydrostatic pressure caused by failure of the left-ventricular cardiac in pumping the blood. Thus, all of the samples shared homogeneous diagnosis and pathophysiology condition.

The therapy given to the samples has been confirmed effective as shown by the significant decrease in B-line counts in each phase. In addition, dyspnoea that occurred to some subjects no longer occurred in the next minutes after the therapy was given, even though 14 subjects did not feel any improvement at all. Subjects who reported no improvement in their dyspnoea until minute 30 might be caused by longer durations from when dyspnoea occurred to the time they arrived in the emergency unit compared to the ones of the subjects who found significant improvement in their condition though the B-line counts in both groups were significantly declined. The second possibility is related to the state of pulmonary congestion, remaining plenty of B-line counts even after it decreased (see Attachment). Another possibility relates to the psychological side effects of CPAP, causing patients to feel uncomfortable, smothered, and still experienced the dyspnoea due to high oxygen pressure from the therapy.

In minutes after the therapy was given, patients' respiratory rate, pulse, systolic blood pressure, diastolic blood pressure and oxygen saturation significantly improved. CPAP and nitrate given to the patients with acute heart failure has allowed the preload to decrease, followed by the decrease in afterload, which eventually decreased patients' diastolic and systolic blood pressure. In early minutes after the nitrate was infused, some subjects experienced an increasing pulse rate which later decreased as the sympathetic stimulation declined due to the nitrate reaction. Respiratory rate is an objective sign of subjects' dyspnoea condition. Statistically, patients' respiratory rate significantly decreased even though some patients showed an increase or stagnant respiratory rate. The increase or stagnancy of respiratory rate might be caused be longer dyspnoea duration from the onset stage or patients were still in the midst of the process of hydrostatic pressure increase. Another possible cause was related to the psychological effects of CPAP application that made the patients feel uncomfortable due to high oxygen pressure.

The Correlation between Dyspnoea Improvement and the Decrease in B-line counts in Acute Heart Failure Therapy. The analysis administered in this research was meant to correlate the reduce in dyspnoea symptoms and the declining B-line counts shown in lung USG. The result of this analysis shows whether or not patients who feel their dyspnoea reduced also have significantly lower B-line counts, and whether the B-line counts of patients who still feel the dyspnoea after being given with the treatment declines.

The result of the analysis done during minute 0 to minute 15 shows no significant correlation between the improvement of patients' dyspnoea condition and the decline in the B-line counts. Whilst, the B-line counts of subjects who still experienced dyspnoea or those who no longer felt it did not significantly decline ($p = 0.711$), even though the B-line counts of patients who no longer experienced dyspnoea declined as much as -8.05 ± 7.494, while the one of patients who still experienced dyspnoea has declined at -7.27 ± 6.354

Observations were done in minute 15 to minute 30 to the patients based on 3 groups; patients with dyspnoea, patients with no dyspnoea, and patients who no longer experienced dyspnoea. The declines of B-line counts in those three groups were found insignificant ($p = 0.153$). Statistically, the B-line counts in patients who no longer experienced dyspnoea declined at higher rate than the one of patients who still experienced it (-5.82 ± 5.419 vs -2.5 ± 3.228), while patients with no dyspnoea from the beginning showed the most significant decline in B-line counts (-6.4 ± 7.366).

Practical Implications. Seen from the correlation between the betterment in patients' dyspnoea condition and the decrease in B-line counts counted from the time the patients arrived at the hospital (minute 0) up to minute 30 after being given with the therapy, the correlation is approaching the level of significance ($p = 0.054$). This result describes that patients who experienced better dyspnoea condition in minute 30 tend to have significantly lower B-line counts at the same time. Whereas, patients who did not experience any dyspnoea in minute 30 did not show any significant decrease in the number of B0line. The numerical data also show that the B-line counts in patients whose dyspnoea reduced in minute 30 declined more dramatically than the one from the patients who remained under dyspnoea condition (-14.32 ± 9.060 vs -9 ± 6.325). The result of this analysis also indicates that the patients' state of dyspnoea can be used to predict the state of patients' pulmonary congestion.

The result of the data analysis also highlights that patients whose dyspnoea conditions enhanced do not always have their numbers of B-line significantly decreased. In another word, patients who still experience dyspnoea after the treatment might show significant decline in B-line counts. This fact also underlines that patients' descriptions upon their dyspnoea condition are too subjective in determining if the acute heart failure therapy is been successfully done. Instead, the tapering down CPAP and glyceryltrinitrate should be used as the parameter of B-line that precisely reflect the state of pulmonary congestion.

As B-line is used as a parameter in assessing the success of acute heart failure therapy and timing the tapering down CPAP and glyceryltrinitrate, portable USG devices that can be put next to bed are needed. The portable USG device that can be moved next to patients' bed is called the Point of Care Ultrasound (POCUS).

Research Limitations:

- The preciseness of USG data interpretation is highly operator-dependant, making it possible for biased interpretation to occur, even though observers have met certain qualifications.
- The initial numbers of B-line in each subject was not exactly the same, even though the inclusion and pathophysiological criteria were fulfilled. Hence, patients might have shown different responses toward the therapy.
- The time spent by each patient to arrive at the hospital after the onset of dyspnoea symptoms might be different from each other. Thus, patients who took longer time to arrive at the emergency unit might show weaker responses than those who came early.

CONCLUSION AND SUGGESTIONS

There is no significant correlation between dyspnoea condition and the decline in B-line counts found in the first 30 minutes of acute heart failure therapy.

Patients' description upon their dyspnoea condition cannot be used to determine the timing of tapering down therapy for patients with acute heart failure for the description has no significant correlation with the B-line counts.

The therapy using CPAP oxygen and continuum GTN infusion has been proven as an effective therapy for patients with acute heart failure since the therapy is able to reduce the B-line counts and significantly improve patients dyspnoea condition.

Suggestions:

- Emergency units are expected to provide USG point of care devices to be regularly used in diagnosing and monitoring the therapy given for patients with acute heart failure.
- The use of patients' description upon dyspnoea should no longer be used as the parameter in observing the therapy for it does not reflect the true condition of patients' pulmonary congestion.
- Experimental research should be conducted to study changes in dyspnoea state and its correlation with the B-line counts within 2-3 hours after the therapy starts in order find out to what extent the B-line counts decreases and how it can be used as parameter to start giving the tapering down therapy for patients with acute heart failure.

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