Agreement between Emergency Physicians and a Cardiologist on Cardiac Function Evaluation after Short Training

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ABSTRACT

Objective: Delayed diagnosis and treatment of shock patients may lead to multiorgan dysfunction syndrome and death. Volume status assessment in shock patients is crucial for guiding early management. Focused echocardiography has become an important tool for assessing volume status because it is non-invasive and easy to perform. We aimed to ascertain the degree of agreement between emergency medicine (EM) residents and a cardiologist on cardiac function evaluations using echocardiography. We also assessed the extent of agreement on pericardial effusion diagnoses.

Methods: A cross sectional study was conducted at the Emergency Department, Siriraj Hospital. The EM residents who had limited experience in ultrasound examination underwent a 3-hour echocardiography training course consisting of a lecture and a workshop before starting the study. Patients with shock or suspected hypervolemia were included. Echocardiography was performed by EM residents to evaluate ventricular function of each patients. With visual estimation, they classified the left ventricular function (LVF) into 3 categories: good, moderate and poor. The video files were recorded and re-evaluated by a cardiologist offline. The correlation of left ventricular function estimation and the diagnosis of pericardial effusion between the two operators were determined.

Results: Ninety-two patients were enrolled between October and December 2014. The overall agreement of ventricular function assessment between the EM residents and the cardiologist was 79.4% (weighted kappa = 0.73). The degree of agreements of LVF classified as poor, moderate and good LVF were 87.5%, 37.5% and 95% respectively. Moreover, the residents diagnosed the pericardial effusion with 100% accuracy, compared to the cardiologist.

Conclusion: Following a short educational training, the EM residents efficiently assessed the left ventricular function with a high level of agreement with a cardiologist.

Keywords: Cardiac function evaluation; limited echocardiography; volume assessment (Siriraj Med J 2019; 71: 253-260)

INTRODUCTION

Delayed diagnosis and treatment of shock can lead to multi-organ dysfunction syndrome and possibly death. In general, shock can be classified into four categories[1]: hypovolemic, distributive, cardiogenic, and obstructive. The different types of shock need different approaches to the management of volume resuscitation. Most types of shock improve with fluid bolus except cardiogenic shock, for which fluid bolus may be harmful. Therefore, a left ventricular function (LVF) assessment is one of the important

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initial steps in deciding whether to give fluid. Cardiogenic shock should be considered if the LVF is poor, but fluid should not be given for that condition. Furthermore, performing an accurate volume status assessment is one of the critical steps in effectively and safely managing shock, and it results in a decrease in mortality.[2,3] However, volume assessment using only a physical examination has some limitations, for example, in overweight patients or when it is performed by inexperienced physicians.[4] Moreover, a physical examination alone is inadequate for differentiating hypovolemic from cardiogenic shock.[5] A chest radiograph is another measure used to evaluate volume status; however, it might not be feasible for use with some overweight patients or those who cannot inspire deeply. Even when interpreted by a radiologist, the sensitivity of chest radiographs has been found to be only 53%, with an accuracy of only 68% for diagnosing acute congestive heart failure.[6]

Nowadays, point-of-care ultrasound (PoCUS) has become an important tool for assessing the LVF and volume status because it is non-invasive, is easy to perform, and can be used to perform a dynamic assessment of fluid responsiveness in critically-ill patients.[7] Moreover, the combination of PoCUS applications, which are inferior vena cava variation, lung ultrasound, and focused echocardiography, may enable physicians to give more accurate fluid therapy.[8] Many studies have shown that echocardiography is comparable to other invasive methods, such as central venous catheterizations and pulmonary artery catheters, in terms of cardiac function assessment and fluid treatment guidance.[9,10] Furthermore, focused echocardiography performed within 15 minutes of Emergency Department (ED) arrival significantly reduces errors in diagnosing shock patients.[11]

Previous studies have shown that emergency physicians (EPs) have been able to assess the LVF by visual estimation with a high degree of agreement with cardiologists (> 80%).[12,13] However, the investigators in those studies were experienced EPs or emergency medicine (EM) residents who had used PoCUS for at least 150 cases each. At our institution, which is the largest tertiary hospital in Thailand, EM is still a relatively new department, having been established for less than 10 years. Although the usage of ultrasound in the ED is becoming more common, the number of experienced operators is limited.

This study aimed to evaluate the ability of EM residents with limited experience to evaluate the LVF using echocardiography. To this end, we aimed to ascertain the level of agreement between the EM residents and a cardiologist on cardiac function estimations. Furthermore, we assessed their agreement on pericardial effusion diagnoses as well as evaluated the appropriateness of the echocardiographic views and the time taken for the residents to complete the scans.

MATERIALS AND METHODS

A cross sectional study was conducted between October and December 2014 at the Emergency Department, Siriraj Hospital. The hospital, located in Bangkok, is the largest tertiary care university hospital in Thailand. We enrolled patients aged over 18 years who needed a volume status assessment. The conditions with which the patients would require an assessment of the LV function were 1) shock (systolic blood pressure < 90 mmHg or diastolic blood pressure < 60 mmHg); and 2) suspected heart failure, defined as having at least 1 of the Framingham criteria.[14] Patients were excluded if they were uncooperative or had an ST-segment elevation myocardial infarction. Intubated patients were excluded because of the difficulty of placing the patients in an appropriate position for scanning. Patients for whom focused echocardiography might delay their standard treatment were also excluded. This study was approved by Siriraj Institutional Review Board (Si 546/2014) and complied with the Code of Ethics of the World Medical Association.

The study investigators who performed the ultrasounds in this study were second- and third-year EM residents. The residents had been working in the ED for less than 3 years. They had not participated in any formal ultrasound training courses because emergency ultrasound was not part of the EM curriculum.

We arranged our study into two phases: training and data collection. In the training phase, we provided a focused echocardiography course for the residents. This course consisted of a 2-hour lecture and a 1-hour hands-on workshop conducted by a cardiologist. After the course, each participant had to practice on at least two patients in the ED. All recorded images and video files of the practice were subsequently sent to the cardiologist to assess the residents' ability to perform focused echocardiography. The cardiologist had to approve each participant's performance before he or she was permitted to proceed to the next phase.

During the data collection phase, the attending EP staff assessed the eligibility of patients. If the patients met the inclusion criteria, written, informed consent was obtained. They then notified a study investigator (i.e., one of the 2nd or 3rd year EM residents who had attended the training course) who was not the primary treating physician of the patients to perform focused echocardiography. The patients were scanned in the supine position for as long as they could tolerate. A Philips HD15 PureWave ultrasound machine was used in this study. The LVF was assessed using parasternal long axis, parasternal short axis, apical 4-chamber, and apical 5-chamber views with an S5-2 phased array transducer (5-1 MHz). The LVF was categorized into three groups, based on the left ventricular ejection fraction (LVEF): normal/good (LVEF > 55%), moderate (LVEF 30%-55%) and poor (LVEF < 30%). Pericardial effusion was also assessed using the subxiphoid view with a C 5-1 convex array transducer (5-1 MHz). The patients' baseline characteristics and details of the medications or inotropic agents administered to the patients in the ED were also recorded. All images and video files of the focused echocardiographic findings were sent to the cardiologist to assess the LVF and appropriateness of the echocardiographic views. The cardiologist was blinded to the patients' clinical information, the identity of the study investigators, and their results.

Sample size calculation

From a previous study by Randazzo[13], the kappa statistic of agreement between EPs and cardiologists on cardiac function evaluation was 0.71. With a confidence interval of 95% and a margin of error of 5%, a sample size of 88 patients was required (nQuery Advisor). After adding 10% to adjust for potential missing data, the final total sample size was 97.

Statistical analysis

We used SPSS Statistics for Windows, version 18.0 (SPSS Inc., Chicago, Ill., USA) to analyze the data. Frequency and percentage were used to describe the categorical data. Mean and standard deviation were used to describe continuous data with normal distribution. Median and interquartile range were used to describe data with non-normal distribution. The kappa statistic and 95% confidence interval were used to assess the degree of agreement between the EPs and the cardiologist on the LVF evaluations. Fisher's exact test was used to find the factors that affected the correlation.

RESULTS

A total of 101 patients were assessed for eligibility between October and December 2014. Of those, 9 (8.9%) were excluded due to incomplete data, leaving 92 patients. Forty-one patients (44.6%) presented with hypotension, and the remaining 51 patients (55.4%) were suspected to have hypervolemia based on the Framingham criteria. The patients' mean age was 67 years, and the mean systolic blood pressure was 108 mmHg. The baseline characteristics are shown in Table 1. The focused echocardiography was performed by four second-year and three third-year EM residents.

The residents classified the patients' LVF as "good contraction" in 60 patients (65.2%), "moderate contraction" in 24 (26.1%), and "poor contraction" in 8 (8.7%). The cardiologist classified the patients as having good, moderate, and poor contraction in 69 (75%), 12 (13%), and 11 (12%) patients, respectively (Table 2). The overall agreement on the LVF assessments by the EM residents and the cardiologist was 79.4%, with a weighted kappa of 0.73 (95% CI 0.58-0.89). The patients with a moderate contraction represented the majority in the disagreement category (Fig 1). No factors affected the correlation of the cardiac function evaluations. The studied factors included a BMI of more than 23 kg/m^2 and inotropic drug use. The agreement between the EM residents and the cardiologist on the pericardial effusion diagnoses was 100%.

The most appropriately performed views were the subxiphoid and inferior vena cava views (94.6%). The least properly performed view was the apical 5-chamber (Fig 2). The EM residents were able to achieve all appropriate views in 47 patients (51.1%; Fig 3). None of the following factors had an effect on the appropriateness of the echocardiographic views: being overweight, the operators, and patients having congestive heart failure.

The final diagnoses are detailed in Table 3. The most common cause of shock was sepsis or septic shock (92.6%). The lowest level of agreement on LVF evaluation was found in patients with pneumonia (42.9%); however, there was no statistically significant difference from other diagnoses. The mean time taken for the residents to perform the focused echocardiographies was 19.8+7.1 minutes.

DISCUSSION

In our study, EM residents with limited experience in focused echocardiography were able to assess the LVF by visual estimation alone with a high level of agreement with a cardiologist (weighted kappa = 0.73) and after only a short training course. This result is similar to the findings of previous studies, which also reported a high level of agreement between experienced and inexperienced scanners.[9,12]

We categorized the LVFs into three groups using visual estimation because this method was easy and not time-consuming. Moreover, previous studies have shown no clinical difference between LVF assessments by visual estimation and other complex methods.[15,16]

TABLE 1. Baseline characteristics.

Baseline characteristics	N = 92 (%)
Age (mean ± SD; years)	68 ± 14
Sex (males)	39 (42.4)
BMI† ≥ 23 kg/m²	36 (39.1)
Comorbidities	
Hypertension	50 (54.3)
Diabetes mellitus	34 (37.0)
Heart disease	26 (28.3)
Others	9 (9.8)
SBP‡ (mean ± SD; mmHg)	108 ± 30 (50–190)
HR‡ (mean ± SD; bpm)	90 ± 21 (49–153)
Inotropic drugs	
Dopamine	2 (2.2)
Norepinephrine	6 (6.5)
Indication	
Hypotension	41 (44.6)
Suspected hypervolemia	51 (55.4)
Performer	
Resident 2	27 (29.3)
Resident 3	65 (70.7)

†BMI: Body Mass Index; BMI ≥ 23 kg/m² represents being overweight[15]
‡while performing focused echocardiography

TABLE 2. LVF categorizations by EM residents and cardiologist.

Emergency Physicians	Cardiologist		
	Good contraction no. (%)	Moderate contraction no. (%)	Poor contraction no. (%)
Good contraction no. (%)	57 (95.0)	3 (5.0)	0 (0)
Moderate contraction no. (%)	11 (45.8)	9 (37.5)	4 (16.7)
Poor contraction no. (%)	1 (12.5)	0 (0)	7 (87.5)

TABLE 3. Final diagnoses and correlations for LVF evaluations.

Final Diagnosis	Correlation (%)	No correlation (%)
Hypotension (n = 45)		
Severe sepsis/septic shock	26 (92.9)	2 (7.1)
Hypovolemic shock	5 (62.5)	3 (37.5)
Cardiogenic shock	2 (100.0)	0
Unknown	7 (100.0)	0
Suspected hypervolemia (n = 47)		
Congestive heart failure	28 (77.8)	8 (28.6)
Pneumonia	3 (42.9)	4 (57.1)
Others	3 (75.0)	1 (25.0)

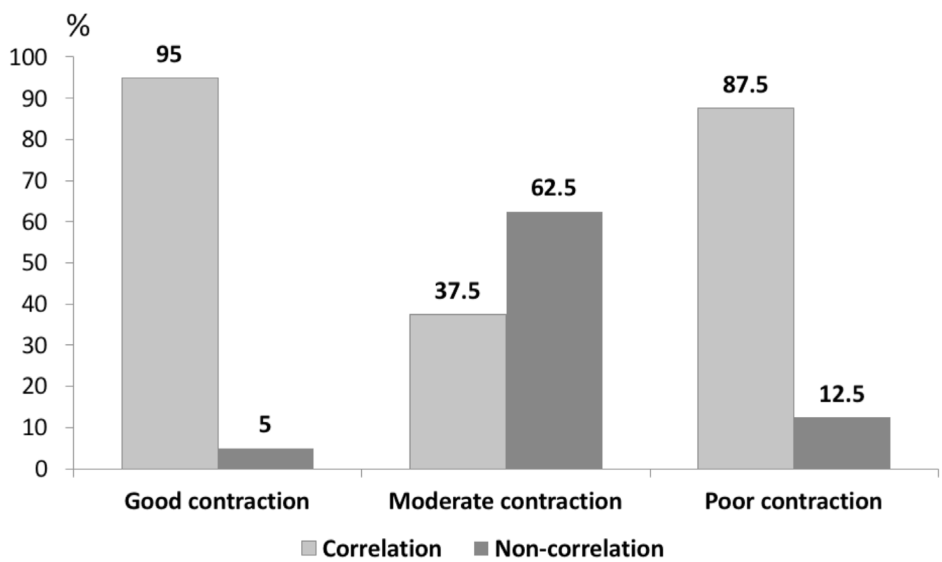

Fig 1. Percentage of correlation between EM residents and cardiologist in LVF assessment.

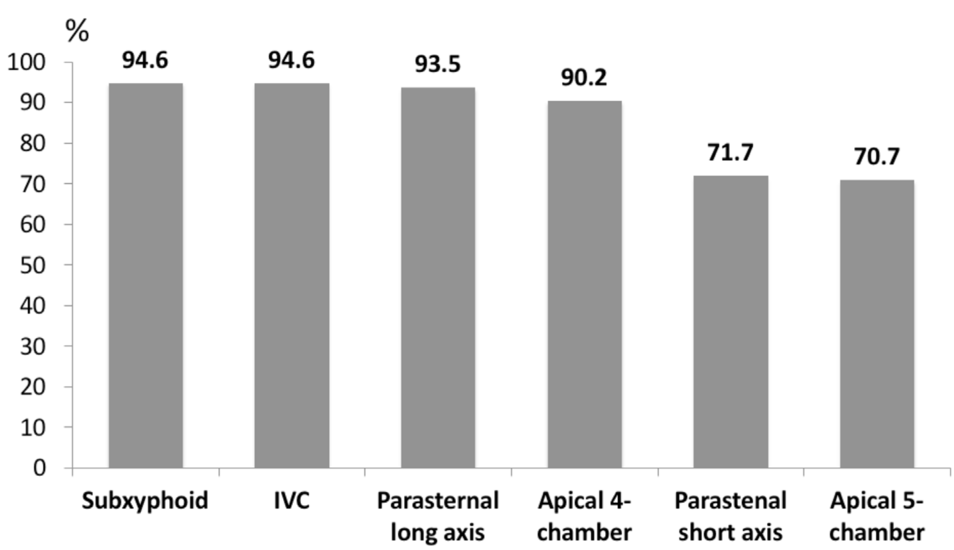

Fig 2. Appropriateness of each echocardiographic view.

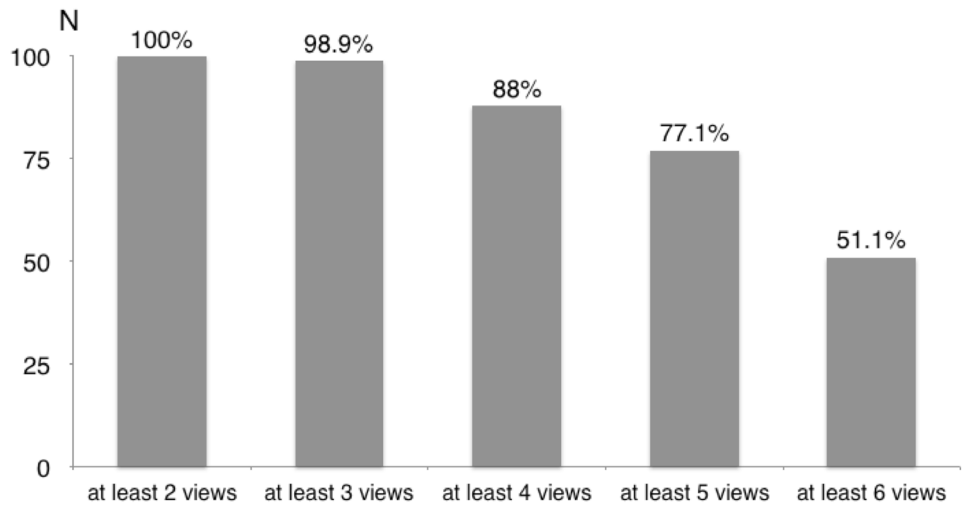

Fig 3. Percentage of appropriateness of echocardiographic views.

The credentials for performing PoCUS differ from country to country. In the United States, the American College of Emergency Physicians requires a physician to perform PoCUS in at least 25 cases in order to be qualified.[17] In contrast, the British Society of Echocardiography requires at least 250 scans and a written examination to be passed for emergency physicians who want to perform echocardiography.[18] In Australia, the Australasian College for Emergency Medicine requires 50 examinations of bedside echocardiography and a pass in a practical bedside examination.[19] In Thailand, the Emergency Medicine Residency training program was established in 2004; to date, however, no specific requirement regarding PoCUS training has been included in the curriculum. As a result, the EM residents in our study had various levels of experience in focused echocardiography. Accordingly, our results might indicate that after proper training, even performers with limited experience in PoCUS are able to assess the LVF with comparable accuracy to a cardiologist.

The duration of the didactic sessions and practice has varied from study to study, ranging from web-based learning to 12-hour, didactic lectures.[12,13,20,21] Similarly, the practice session duration has ranged from 5 scans of real patients to a 10-hour observation and practice.[12,13,20,21] In our study, the training session comprised only 2 hours of lecture and 1 hour of practice. Therefore, our findings suggest that a short training session could also enable physicians with limited PoCUS skills to achieve a high level of agreement with an expert. However, it might have been because the EM residents in our study were not blinded to the patients' clinical presentations; the general appearance of the patients might therefore have biased the residents' echocardiographic findings.

The best correlation for the LVF evaluations was seen in the good contraction group. This finding was also similar to those of previous studies, which demonstrated that the strongest correlation was found in the good and poor contraction groups.[12,13] However, the EPs in the current study could not evaluate the LVF as accurately in patients with a moderate contraction. This was also concordant with previous studies and might have been due to the less apparent findings. Nonetheless, echocardiography might help EPs to identify the cause of shock more rapidly, which could lead to a faster provision of appropriate treatment.

Furthermore, the accuracy of the pericardial effusion diagnoses was 100%, which was as high as that found by a previous study.[22] This might have been because our study investigators were familiar with the FAST (Focused Assessment with Sonography in Trauma) exam, which uses the subxiphoid view to evaluate pericardial effusion. The subxiphoid view was thus the most properly performed view by the EPs in this study. However, this finding was discordant with some previous studies,[20,23] which reported that the parasternal short and long axes were the most properly performed views. This might have been because those studies included performers who had some experience in focused echocardiography, making it easy for them to acquire the proper parasternal short and long axis views. In comparison, the subxiphoid view might be the easiest view to achieve in the case of inexperienced performers. Furthermore, the apical 5-chamber view was the least properly performed view in the present study, which might have been due to the need both cooperation from the patient and a skillful operator. Nevertheless, as the apical 5-chamber view is employed to evaluate cardiac output, we should improve providers' skill performing it.

The mean time taken to perform the focused echocardiographies was 19 minutes, which was comparable to the times reported by previous studies, which had mean durations ranging from 5 to 25 minutes.[9,11,12,24] Many factors can affect the scan time. The first influential factor is the performers' experience. If the investigators in the present study had performed many scans, they would have had more experience and would therefore have been able to complete the scans faster than the more inexperienced scanners.[9] In addition, the apical 5-chamber view, which is difficult to achieve, might have caused an increase in the scan time. Other factors that might have affected the scan time in the current study were machine familiarity, the cooperation of the patients, and the patients' habitus; however, those data were not collected.

Our study had some limitations. Firstly, the cardiologist did not perform the echoes on real patients but instead conducted a review of recorded pictures or video. This might have led to some misinterpretations of the LVFs due to inappropriate views. Moreover, no inter-rater reliability between experts was obtained because there was only one participating cardiologist. As well, we included some patients who could not tolerate a supine position for a long duration for various reasons. This could have made their focused echocardiographies more difficult and might have affected the appropriateness of their echocardiographic views. Fourthly, some conclusions could not be made due to the small number of patients in the subgroups, such as patients with diagnoses other than sepsis and patients with inotropic use. Finally, the number of supervised cases was very small. Therefore, further studies with increased supervised practice and real time feedback should be conducted in order to achieve a higher correlation.

From this study, we conclude that emergency physicians with only short training in focused echocardiography can assess the LVF by visual estimation, and they are able to achieve a high level of agreement with a cardiologist. This might help emergency physicians to more quickly and accurately identify the causes of shock, which in turn should lead to the more rapid and appropriate management of emergency patients.

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REFERENCES

1. Voyce SJ, McCaffree DR. In: Irwin RS, ed. Intensive care medicine. Lippincott Williams & Wilkins. Philadelphia. 2003.p.45-67.
2. Rivers E, Nguyen B, Havstad S, Ressler J, Muzzin A, Knoblich B, et al. Early goal-directed therapy in the treatment of severe sepsis and septic shock. N Engl J Med 2001;345:1368-77.
3. Sebat F, Musthafa AA, Johnson D, Kramer AA, Shoffner D, Eliason M, et al. Effect of a rapid response system for patients in shock on time to treatment and mortality during 5 years. Crit Care Med 2007;35:2568-75.
4. Low D, Vlasschaert M, Novak K, Chee A, Ma IW. An argument for using additional bedside tools, such as bedside ultrasound, for volume status assessment in hospitalized medical patients: a needs assessment survey. J Hosp Med 2014;9:727-30.
5. McGee S, Abernethy WB, Simel DL. Is this patient hypovolemic? JAMA 1999;281:1022-29.
6. Mueller-Lenke N, Rudez J, Staub D, Laule-Kilian K, Klima T, Perruchoud AP, et al. Use of chest radiography in the emergency diagnosis of acute congestive heart failure. Heart 2006;92(5): 695-6.
7. Evans D, Ferraioli G, Snellings J, Levitov A. Volume responsiveness in critically ill patients: use of sonography to guide management. J Ultrasound Med 2014;33(1):3-7.
8. Atkinson P, Bowra J, Milne J, Lewis D, Lambert M, Jarman B, et al. International Federation for Emergency Medicine Consensus Statement: sonography in hypotension and cardiac arrest (SHoC): an international consensus on the use of point of care ultrasound for undifferentiated hypotension and during cardiac arrest. CJEM 2017;19(6):459-70.
9. Gunst M, Ghaemmaghami V, Sperry J, Robinson M, O'Keeffe T, Friese R, et al. Accuracy of cardiac function and volume status estimates using the bedside echocardiographic assessment in trauma/critical care. J Trauma 2008;65:509-16.
10. Kaul S, Stratienko AA, Pollock SG, Marieb MA, Keller MW, Sabia PJ. Value of two-dimensional echocardiography for determining the basis of hemodynamic compromise in critically ill patients: a prospective study. J Am Soc Echocardiogr 1994;7:598-606.
11. Jones AE, Tayal VS, Sullivan DM, Kline JA. Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients. Crit Care Med 2004:32: 1703-8.
12. Moore CL, Rose GA, Tayal VS, Sullivan DM, Arrowood JA, Kline JA. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. Acad Emerg Med 2002;9:186-93.
13. Randazzo MR, Snoey ER, Levitt MA, Binder K. Accuracy of emergency physician assessment of left ventricular ejection fraction and central venous pressure using echocardiography. Acad Emerg Med 2003;10:973-7.
14. Maestre A, Gil V, Gallego J, Aznar J, Mora A, MartínHidalgo A. Diagnostic accuracy of clinical criteria for identifying systolic and diastolic heart failure: crosssectional study. J Eval Clin Pract 2009;15(1):55-61.
15. Amico AF, Lichtenberg GS, Reisner SA, Stone CK, Schwartz RC, Meltzer RC. Superiority of visual versus computerized echocardiographic estimation of radionuclide left ventricular ejection fraction. Am Heart J 1989;118:1259-65.
16. Shahgaldi K, Dudmundsson P, Manouras A, Brodin L, Winter

R. Visually estimated ejection fraction by two dimensional and triplane echocardiography is closely correlated with quantitative ejection fraction by real-time three-dimensional echocardiography. Cardiovasc Ultrasound 2009;7:41.

17. American College of Emergency Physicians. Emergency ultrasound guidelines. Ann Emerg Med 2009;53:550-70.
18. British Society of Echocardiography. Accreditation. Available at: https://www.bsecho.org/accreditation/types-of-accreditation/ (Cited February 14, 2018).
19. International Federation for Emergency Medicine (IFEM) Point of Care Emergency Ultrasound Curriculum Guidelines; 2014. Available at: https://www.ifem.cc/wp-content/uploads/2016/07/IFEM-Point-of-Care-Ultrasound-Curriculum-Guidelines-2014.pdf (Cited February 14, 2018).
20. Chrisholm CB, Dodge WR, Balise RR, Williams SR, Gharahbaghian L, Beraud AS. Focused cardiac ultrasound training: how much is enough? J Emerg Med 2013;44:818-22.
21. Bustam A, Azhar MN, Veriah RS, Arumugam K, Loch A. Performance of emergency physicians in point-of-care echocardiography following limited training. Emerg Med J 2014;31:369-73.
22. Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by Emergency Physicians. Ann Emerg Med 2001;38:377-82.
23. Mark DG, Ku BS, Carr BG, Everett WW, Okusanya O, Horan A, et al. Directed bedside transthoracic echocardiography: preferred cardiac window for left ventricular ejection fraction estimation in critically ill patients. Am J Emerg Med 2007;25: 894-900.
24. Volpicelli G, Lamorte A, Tullio M, Cardinale L, Giraudo M, Stefanone V, et al. Point-of-care multiorgan ultrasonography for the evaluation of undifferentiated hypotension in the emergency department. Intensive Care Med 2013;39:1290-98.