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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

FOCUS in Emergency Room For Dyspnea: Bedside Diagnosis is Now Possible For Pulmonary Embolism

Nefes Darlığı için Acil Serviste FOCUS: Pulmoner Emboli için Yatak Başı Teşhis Artık Mümkün

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ABSTRACT

Aim: It's known that computed tomographic pulmonary angiography (CTPA) is the gold standard in imaging techniques for pulmonary embolism (PE). Echocardiography and focused cardiac ultrasonography (FOCUS) are the most beneficial bedside diagnostic and treatment tools for unstable patients. Our aim was to determine the value of FOCUS in the diagnostic algorithm of pulmonary embolism.

Material and Methods: This study was designed prospectively in a tertiary medical center's emergency medicine department. All the patients which were presented with dyspnea triaged with Emergency Severity Index triage criteria 1-2, after that if PE was involved in differential diagnosis and the patients whose had Wells score as moderate or high risk randomized for whether to carry out FOCUS or not. The patients who underwent CTPA were included to study. FOCUS protocol consisted of the views of parasternal long axis, parasternal short axis, subxiphoid and apical four chamber views. The ratio of right ventricle to the left ventricle, right ventricular dilatation, septal flattening, septal paradoxal movement, right atrial and ventricular thrombus, vena cava inferior (VCI) and ejection fraction (EF) were evaluated from these views. Final diagnoses of patients and the statistical significance of FOCUS parameters in the diagnosis of pulmonary embolism were examined.

Results: 102 patients were included in the study, of which 45 (44,1%) were women. Patients mean age was 63,8 -+ 15. PE was found as final diagnosis at the 60(%58,8) patients. The FOCUS parameters which were the ratio of right ventricle to the left ventricle over 0,9[sensitivity %45(%32,12-%58,39) and specificity %80,95(%65,88-%91,40)(p=0,0069)], septal paradoxal movement [sensitivity %21,67(%12,07-%34,20) and specificity %95,24(%83,84-%99,42)(p=0,0182)], full VCI(>21 mm, <%50 collapsibility) and hyperdynamic EF(>%70) relation [sensitivity %28.33(%17.45-%41.44) and specificity %97.62(%87.43-%99.94) (p=0,0004)] were found as the most valuable.

Conclusion: FOCUS could be a valuable diagnostic tool that saves lives in unstable patients by making early diagnosis.

Keywords: FOCUS, Pulmonary embolism, Echocardiography

ÖZ

Amaç: Pulmoner Emboli(PE)'de altın standart görüntüleme yöntemi Pulmoner Anjiyografik Bilgisayarlı Tomografi (PABT) olarak bilinmektedir. Anstabil hastalarda yatak başı ekokardiyografi ve odaklanmış kardiyak ultrasonografi (FOCUS) en yararlı tanı ve tedavi araçlarındandır. Amacımız FOCUS'un akut PE tanı algoritmasındaki değerliliğini saptamak olacaktır.

Gereç ve Yöntemler: Bu çalışma 3.basamak bir acil servis kliniğinde prospektif olarak dizayn edilmiştir. Acil Servise solunum sıkıntısı ile başvuran hastalar ESI triaj kriterlerine göre (kriter 1-2) triaj yapılmıştır ve bundan sonra ayırıcı tanısında PE varsa ve Well's Skoru orta ve yüksek risk grubunda olanlara randomizasyon yapılarak yatak başı FOCUS yapılıp yapılmayacağına karar verilmiştir. PABT görüntülemesi yapılmış olan hastalar çalışmaya dâhil edilmiştir. FOCUS protokolü parasternal uzun aks penceresini, parasternal kısa aks penceresini, subksifoid pencereyi ve apikal 4 odacık penceresini içermiştir. Bu pencerelerden sol ventrikül fonksiyonu, sağ/sol ventrikül oranları, sağ ventrikülün dilatasyonu, septal düzleşme, septal paradoksal hareket, sağ atrial ve ventriküler trombüs varlığı ve inferior vena kava ve sol ventrikül ejeksiyon fraksiyonunun birlikteliği değerlendirilmiştir. Hastaların son tanıları ve FOCUS'ta bulunan parametrelerin pulmoner emboli tanısında istatistiksel olarak anlamlılıkları incelenmiştir.

Bulgular: Çalışmaya 102 hasta dâhil edilmiş olup, bunların 45 tanesi (%44,1) kadındır. Hastaların ortalama yaşı 63,8-+15 yıldır. PABT çekilen 102 hastanın 60 (%58,8)'ında son tanı olarak PE saptanmıştır. FOCUS parametrelerinden; sağ/sol ventriküle oranı >0,9 [duyarlılığı %45 (%32,12-%58,39) ve özgüllüğü %80,95 (%65,88-%91,40)(p=0,0069)], septal paradoksal hareket [duyarlılığı %21,67 (%12,07-%34,20) ve özgüllüğü %95,24 (%83,84-%99,42)(p=0,0182)], dolu VCI (>21 mm, <%50 kollabilite) ve hiperdinamik EF (>%70) ilişkisi [duyarlılığı %28.33 (%17.45-%41.44) ve özgüllüğü %97.62 (%87.43-%99.94)(p=0,0004)], en değerli olarak görülmüştür.

Sonuç: FOCUS erken tanıyı mümkün kılabilen ve anstabil hastada hayat kurtaran değerli bir tanı aracıdır.

Anahtar Kelimeler: FOCUS, Pulmoner emboli, Ekokardiyografi

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Introduction

Pulmonary Embolism (PE) is one of the main and most mortal causes of dyspnea (1). Patients who is suspected of PE should be evaluated by clinical gestalt and then it is important to remember that Wells or Geneva score have to be calculated (2, 3). Computed tomographic pulmonary angiography (CTPA) is the gold standard imaging technique of PE (4).

For unstable patients bedside echocardiography and Focused Cardiac Ultrasonography (FOCUS) can be used for diagnosis (5). Objectives of FOCUS in symptomatic patients are; evaluation of the presence of pericardial effusion and global cardiac systolic function, describing right and left ventricular enlargement, assessment of internal vascular volume and measuring inferior vena cava (VCI) size and it's changes under spontaneous respiration (6). FOCUS has a good correlation with consultative echocardiography, even when it is performed by physicians who are not very experienced (7). The role of FOCUS in suspected PE patients is to make differential diagnosis before further investigations and to help treatment in critical care patients (8).

In this study our primary aim was to determine the value of FOCUS protocol for PE. Our secondary aim was to find out if vital parameters (blood pressure, heart rate, respiration rate, blood oxygen saturation) are related with PE.

Material and Methods

2.1. Study design, setting and population

This study was designed as a single center prospective observational study. The study was executed after approval of the ethics committee (ethics committee document number: *09.2016.082/70737436-050.06.04).* The patients who admit to emergency department of Marmara University Hospital; were enrolled as a convenience sample from February 2016 to December 2016. All the patients which were presented with dyspnea triaged with Emergency Severity Index triage criteria 1-2, after that if PE was involved in differential diagnosis and the patients whose had Wells score as moderate or high risk randomized for whether to carry out FOCUS or not and the patients who underwent CTPA were included to study. The written consent was obtained from the patients who had received the FOCUS protocol.

Patients who had diagnosed other cardiac emergency by ECG, required urgent non-invasive or invasive airway, refused to give consent were excluded.

The physician who performed FOCUS was 4th year resident in emergency medicine training program and who had basic and advanced ultrasonography (USG) certificate, was capable of performing cardiac and thoracic USG's and spent 8 hours observing FOCUS in the echocardiography laboratory and did not take part in the treatment of the patients. The practitioner was supervised by an experienced emergency medicine specialist who have advanced ultrasonography and echocardiography certificate.

2.2 Study Protocol

After a detailed history, examination and 12-lead ECG, if the primary physician thought that the patient was preliminary diagnosed for PE, patient was evaluated according to the pulmonary embolism Kline Algorithm (Figure 1)(9). Wells score was calculated in order to determine the risk of PE while the evaluation of the patients was continuing (5, 6). Wells score contains; clinical symptoms of Deep Vein Thrombosis 3 points, other diagnosis less likely than DVT 3 points, heart rate greater than 100 beats per minute 1,5 points, immobilization or surgery within past 4 weeks 1,5 points, previous DVT or PE, hemoptysis 1 point, malignancy 1 point. Risk score interpretation (probability of PE) was made as follows: > 6 = high risk, 2-6 = moderate risk, <2 = low risk

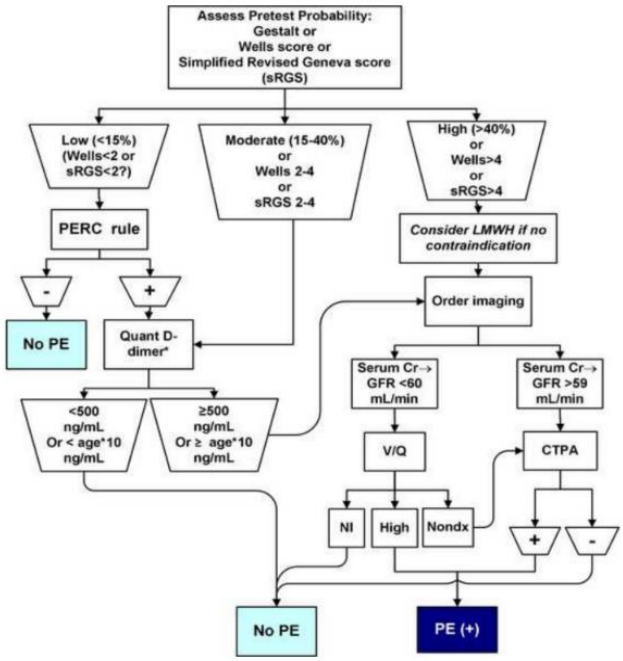


Figure 1. Pulmonary Embolism Kline Algorithm

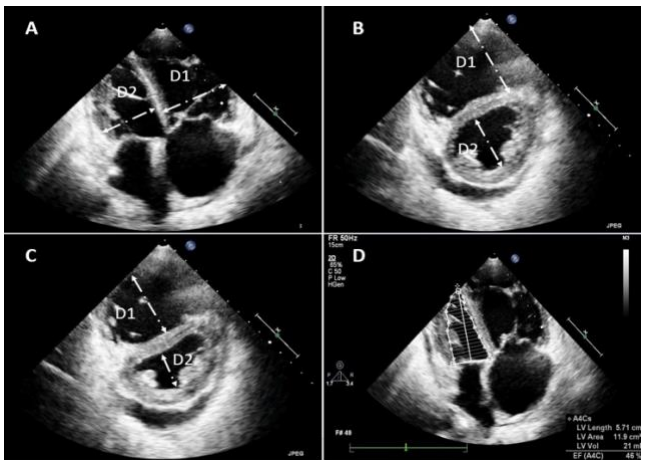
Coin flip (heads or tails) was performed to determine whether or not apply FOCUS in patients with moderate or high risk. The parameters measured in the FOCUS were recorded in the patient's data collection form.

2.3 FOCUS Protocol

The views used for FOCUS are similar to echocardiography. These views are parasternal long axis view (PSLAV), parasternal short axis view (PSSAV), apical 4 chamber view (A4CV) and subxiphoid view (SXV)(Figure 2). FOCUS was performed with 1-5 MHz phased array transducer of CHISON i3 USG device in the PSLAV view, PSSAV, SXV and A4CV while lying on their back (semi-recumbent position) and left. Left ventricular function, right/left ventricular ratios, dilatation of right ventricle, septal flattening, septal paradoxical movement, and measurement of inferior vena cava and

ejection fraction were examined from these windows and it was noted if there was visible thrombus.

Ratio of right ventricle to left ventricle above 0.9 supports PE. It can be visualized at A4CV and PSSAV on papillary muscle level. It is calculated by proportioning measurements derived from the basal portion of the ventricles (10). Dilatation of the right ventricle means that having 3 cm or above size right ventricular end diastolic diameter) (Figure 2) (11).



A: A4CV, Ratio of right ventricle to left ventricle above 0.9 (D1/D2>0.9)
B: PSSAV on papillary muscle level (D1/D2>0.9)
C: Septal paradoxical movement
D: Left ventricular EF, 2-plane Simpson method
Figure 2. FOCUS views and FOCUS parameters

Septal flattening: The ratio of the axial diameter of the left ventricle to the horizontal (perpendicular to the septum) diameter> 1 is significant for septal flattening. It means the shortening of the horizontal diameter and the displacement of the septum towards the left ventricle (12).

Septal paradoxical movement can be visualized from parasternal short axis at the papillary muscle level of the right ventricle. It is the detection of the displacement of the septum towards the left ventricle at the end of the systole due to excessive pressure in the right ventricle (Figure 2)(12).

After visualization of the right atrium from the SXV, the VCI is visualized by a 90-degree rotation over the axis of the right atrium and a diameter measurement is made on the junction of the distal VCI and hepatic vein (Figure 3). After switching USG to M-mode, the collapse of VCI resulted from the pressure change during spontaneous inspiration and expiration is examined. VCI value of more than 2.1 cm and collapse of less than 50% is associated with overvolemia and PE (6).

The left ventricular EF is measured using the 2-plane Simpson method. For the calculation of EF, the left ventricular end-systolic and end-diastolic measurements are made by the Simpson method. EF is calculated by subtracting the end-systolic area from the end-diastolic area and dividing the value by the end-diastolic area (Figure 2)(13).

After the FOCUS findings were recorded, CTPA was performed to the patient if there was no contraindication. The researcher was blind to results. The final diagnoses of the patients with an official CT report were obtained. The statistical significance of FOCUS parameters for PE was analyzed.

A: SXV, Dilatation of the right ventricle
B: SXV and M-mode, VCI>2,1 cm, collapse <50%

Figure 3. FOCUS views and FOCUS parameters

Results

102 patients who performed FOCUS protocol and CTPA between February 2016 and December 2016 were included in the study. The mean age was 63,8 years, %55,9 of them were male. Demographic and clinical information are listed in Table 1. According to CTPA results, there was no statistical significance between vital parameters.

In the evaluation of the preliminary diagnoses (Table 2) top three places were taken by; pulmonary embolism with 102 (100%) patients, acute decompensated heart failure with 72 (70.6%) patients, pneumonia with 68 (66.7%) patients.

As a result of evaluation and imaging, the final diagnosis were found as below (Table-2), pulmonary embolism took 1st place in the table with 60 (58.8%) patients.

Discussion

Echocardiography is one of the first place tools in the ESC PE management guide published in 2014 in the management of unstable patients (14). Again, in this guideline, it is mentioned that it is not appropriate for the patients to leave the critical care area and if echocardiography shows signs supporting right ventricular strain, treatment for PE may be applied to the patient. In the diagnosis, bedside POCUS and its component FOCUS, come to prominence.

In this study, we aimed to see the value of FOCUS in the diagnosis of PE in patients with dyspnea. There are many congestive heart failure studies in the literature with POCUS. Russell et al.(15) and Anderson et al.(16) investigated the importance of lung and cardiac USG in the diagnosis of CHF in patients presenting with undifferentiated dyspnea.

It is known that with adequate education, the FOCUS performed by the emergency physician can provide sufficient correlation with echocardiography. Rutz et al.(17)showed similar results between right ventricular dilatation in detailed echocardiography and FOCUS performed by the emergency physician.

	CTPA Result				
	PE (-) (n=42)		PE (+) (n=60)		
	Median	IQR	Median	IQR	P[1]
Age (years)	66,0	52,0 - 76,0	63,5	55,0 - 73,0	0,6535
Body Temperature (°C)	37,0	36,6 - 37,4	36,9	36,5 - 37,1	0,3237
SBP (mmHg)	115,0	91,0 - 149,0	114,0	100,0 - 138,0	0,9241
DBP (mmHg)	70,5	55,0 - 80,0	70,0	52,5 - 80,0	0,9919
MAP (mmHg)	86,5	68,0 - 100,0	86,5	67,5 - 100,0	0,9593
Heart Rate(/min)	116,0	110,0 - 126,0	116,0	109,0 - 124,5	0,4646
SpO_2 (%)	88,0	80,0 - 89,0	87,0	80,5 - 89,5	0,7624
RR(/min)	30,0	25,0 - 36,0	30,0	26,0 - 33,0	0,6969
Wells Score					
Moderate	41(%97,6)		59(%98,3)		
High	1(%1,7)		1(%1,7)		

Table 1. Age, vital signs and Wells score of patients according to CTPA results

Demonstrating right ventricular strain could be a good tool to predict mortality (18). In a study conducted by Dresden et al.(19), the role of right ventricular dilatation in bedside echocardiography performed by an emergency physician in the diagnosis of PE was investigated. The sensitivity and specificity of the Right ventricular dilatation on echocardiography was found 50% (95% CI 32% to 68%), specificity 98% (95% CI 95% to 100%) respectively. The sensitivity and specificity of septal paradoxical movement were in turn 27% (11% - 43%) and 100% (96.65% - 100%)(19). We found similar results but some of them were slightly lower in our study. If we expanded our sample size we probably could find closer results to the literature data.

In our study, sensitivity and a specificity of coexistence of greater than 21 mm VCI, less than 50% VCI collapse rate and more than 70%, left ventricular EF were found 28.33% (17.45%-41.44%), 97.62% (87.43%-99.94) respectively. In clinical practice, full VCI and hyperdynamic left ventricle can contribute diagnosis of PE, but the absence of these findings does not exclude PE (6).

All of the FOCUS parameters were found to be consistent with the echocardiographic data in the literature. It could be said that it is strong in diagnosis and weak in exclusion. In other words, it could be used in dyspnea cases that the underlying causes unclear for differential diagnosis. Combining the data, we found in our study with the practical advantage of FOCUS, we can see that FOCUS can replace echocardiography soon in diagnosis and treatment of PE.

Limitations

The study was organized as a single center and USG's were made by a single practitioner. If more patients were enrolled to the study it could have made closer our results to literature. It would have been better if pulmonary ultrasound had been performed as well as cardiac ultrasound. Our study protocol did not contain McConnell finding. Adding McConnell finding to FOCUS parameters would make more valuable studies in future researches. Advanced echocardiography could have been performed to understand whether right ventricle strain was acute or chronic.

Pre-diagnosis	%	Final diagnosis	%
PE	102(%100)	**PE**	60(%58,8)
ADHF	72(%70,6)	**ADHF**	26(%25,5)
Pneumonia	68(%66,7)	**Pneumonia**	17(%16,7)
COPD exacerbation	27(%26,5)	**COPD exacerbation**	20(%19,6)
Other Causes (Lung Cancer, Acute coronary syndrome, Vena cava superior syndrome)	7 (6,8%)	**Other Causes** (Lung cancer, Acute coronary syndrome, Vena cava superior syndrome, Chronic thromboembolic pulmonary hypertension, Pericardial effusion, Acute respiratory distress syndrome, Cardiogenic Shock)	15 (14,8%)

Table 2. Pre-diagnosis and final diagnosis list

	Sensitivity (95% CI)	Specificity (95% CI)	AUC (95% CI)	+LR (95% CI)	-LR (95% CI)	P
Right ventricle to the left ventricle ratio over 0.9	45,00 (8,39 - 32,12)	80,95 (65,88 - 91,40)	0,63 (0,53 - 0,72)	2,36 (1,19 - 4,68)	0,68 (0,52 - 0,89)	**0,0069**
Right ventricular dilatation	65,0 (51,60 - 76,87)	71,43 (55,42 - 84,28)	0,68 (0,58 - 0,77)	2,28 (1,36 - 3,80)	0,49 (0,33 - 0,73)	**0,0003**
Detection of septal flattening	43,33 (30,59 - 56,76)	78,57 (63,19 - 89,70)	0,61 (0,51 - 0,70)	2,02 (1,06 - 3,86)	0,72 (0,55 - 0,95)	**0,0225**
Septal paradoxical movement	21,67 (12,07 - 34,20)	95,24 (83,84 - 99,42)	0,58 (0,48 - 0,68)	4,55 (1,08 - 19,12)	0,82 (0,71 - 0,95)	**0,0182**
Presence of thrombus in the right atrium or right ventricle	3,33 (0,41 - 11,53)	100,00 (91,59 - 100,00)	0,52 (0,42 - 0,62)	-	0,97 (0,92 -1,01)	0,2344
Hyperdynamic left ventricle (EF> 70%) with full inferior vena cava (VCI value> 21 mm collapse <50%)	%28,33 (%17,45 - 41,44)	%97,62 (%87,43 - 99,94)	-	11,90 (1,65 - 86,01)	0,73 (0,62 - 0,87)	**0,0004**

Table 3. Comparison of clinical value of FOCUS parameters

Conclusion

From the FOCUS parameter data we found in our study, the right / left ventricular ratio, septal paradoxical motion, and detection of hyperdynamic EF with full VCI were found correlate with the echocardiographic data in the literature.
In the diagnosis of PE; it can be seen that FOCUS is highly specific. However, its sensitivity is quite poor. The possibility of bedside use and its ability to be performed successfully by non-cardiologist physicians even with a short education are important for FOCUS in examination and evaluation of undifferentiated dyspnea patients in emergency and intensive care units. When our study is compared to recent studies, it can be understood that FOCUS and POCUS must be involved in routine evaluation of acute dyspnea.

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Authors' Contribution: Conceptualization, Data curation, Project administration, Resources, Supervision, Roles/Writing - original draft, Writing - review & editing (HİA, SO, MD, CO) Formal analysis, Methodology, Validation, Visualization (SO, CO, ES, ÖO, ADA) Funding acquisition, Investigation, Methodology, Project administration, Software (HİA, ES, CO, AD)

Ethical Statement: The study was approved by the Clinical Research Ethics Committee of a tertiary hospital with the decision number 09.2016.082/70737436-050.06.04.
All authors declared that they follow the rules of Research and Publication Ethics.

References

1. Ray P, Birolleau S, Lefort Y, et al. Acute respiratory failure in the elderly: etiology, emergency diagnosis and prognosis. Crit Care. 2006;10(3):R82.
2. Wells PS, Ginsberg JS, Anderson DR, et al. Use of a clinical model for safe management of patients with suspected pulmonary embolism. Ann Intern Med. 1998;129(12):997-1005.
3. Le Gal G, Righini M, Roy PM, et al. Prediction of pulmonary embolism in the emergency department: the revised Geneva score. Ann Intern Med. 2006;144(3):165-71.
4. Kim KI, Muller NL, Mayo JR. Clinically suspected pulmonary embolism: utility of spiral CT. Radiology. 1999;210(3):693-7.
5. Labovitz AJ, Noble VE, Bierig M, et al. Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. J Am Soc Echocardiogr. 2010;23(12):1225-30.
6. Yamanoglu A, Celebi Yamanoglu NG, Parlak I, et al. The role of inferior vena cava diameter in the differential diagnosis of dyspneic patients; best sonographic measurement method? Am J Emerg Med. 2015;33(3):396-401.
7. Moore CL, Rose GA, Tayal VS, et al. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. Acad Emerg Med. 2002;9(3):186-93.
8. Bova C, Greco F, Misuraca G, et al. Diagnostic utility of echocardiography in patients with suspected pulmonary embolism. Am J Emerg Med. 2003;21(3):180-3.

9. Kline JA, Kabrhel C. Emergency Evaluation for Pulmonary Embolism, Part 2: Diagnostic Approach. J Emerg Med. 2015;49(1):104-17.

10. Fremont B, Pacouret G, Jacobi D, et al. Prognostic value of echocardiographic right/left ventricular end-diastolic diameter ratio in patients with acute pulmonary embolism: results from a monocenter registry of 1,416 patients. Chest. 2008;133(2):358-62.

11. Grifoni S, Olivotto I, Cecchini P, et al. Utility of an integrated clinical, echocardiographic, and venous ultrasonographic approach for triage of patients with suspected pulmonary embolism. Am J Cardiol. 1998;82(10):1230-5.

12. Ryan T, Petrovic O, Dillon JC, et al. An echocardiographic index for separation of right ventricular volume and pressure overload. J Am Coll Cardiol. 1985;5(4):918-27.

13. Franchi F, Cameli M, Taccone FS, et al. Assessment of left ventricular ejection fraction in critically ill patients at the time of speckle tracking echocardiography: intensivists in training for echocardiography versus experienced operators. Minerva Anestesiol. 2018;84(11):1270-8.

14. Konstantinides SV, Torbicki A, Agnelli G, et al. Corrigendum to: 2014 ESC Guidelines on the diagnosis and management of acute pulmonary embolism. Eur Heart J. 2015;36(39):2642.

15. Russell FM, Ehrman RR, Cosby K, et al. Diagnosing acute heart failure in patients with undifferentiated dyspnea: a lung and cardiac ultrasound (LuCUS) protocol. Acad Emerg Med. 2015;22(2):182-91.

16. Anderson KL, Jenq KY, Fields JM, et al. Diagnosing heart failure among acutely dyspneic patients with cardiac, inferior vena cava, and lung ultrasonography. Am J Emerg Med. 2013;31(8):1208-14.

17. Rutz MA, Clary JM, Kline JA, et al. Emergency Physicians Are Able to Detect Right Ventricular Dilation With Good Agreement Compared to Cardiology. Acad Emerg Med. 2017;24(7):867-74.

18. Taylor RA, Davis J, Liu R, et al. Point-of-care focused cardiac ultrasound for prediction of pulmonary embolism adverse outcomes. J Emerg Med. 2013;45(3):392-9.

19. Dresden S, Mitchell P, Rahimi L, et al. Right ventricular dilatation on bedside echocardiography performed by emergency physicians aids in the diagnosis of pulmonary embolism. Ann Emerg Med. 2014;63(1):16-24.