THE DETERMINATION OF LEFT VENTRICULAR WALL MOTION ABNORMALITY BY EMERGENCY MEDICINE RESIDENTS USING A BRIEF TRAINING MODULE

KISA BİR EĞİTİM MODÜLÜ KULLANILARAK ACİL TIP ASİSTANLARI TARAFINDAN SOL VENTRIKÜL DUVAR HAREKET ANORMALLİKLERİNİN BELİRLENMESİ

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ABSTRACT

Introduction: Evaluation of wall motion abnormalities by emergency physicians (EP) is a new subject and has not yet been included in emergency ultrasound guidelines. This study aims to evaluate the contribution of a short training module (STM) to the ability of EPs to recognize wall motion abnormalities.

Material and Methods: This prospective experimental study was conducted in the emergency department of a tertiary training and research hospital. EPs who were included in the 1-3-year postgraduate education program were included in the study. For the study, a short video-supported STM containing the thirty-minute wall motion error abnormality was created. A thirty-question test, including normal and wall motion defects, was prepared. The residents were subjected to three tests before the training (pre-test), immediately after the training (post-test), and one month after (final test). ANOVA was used to compare the tests. In post-hoc analyses, the Bonferroni test was used to calculate the statistical significance value (0.05/3=0.016), a value of 0.016 was considered statistically significant.

Results: 23 EMRs were included in the study. The residents answered an average of 50±12 of 90 questions correctly in the pre-tests before the training, 70±12 questions in the post-test, and 63±12 questions one month later. The short training model had a statistically significant effect on residents' recognition of wall motion defects ($p<0.001$). There was a significant difference between pre-test and post-test scores in post-hoc analysis ($p<0.001$).

Conclusion: The short 30-minute training model, which includes all wall motion defects and normal wall motion, was found to be an effective training method for EPs to visually recognize wall motion abnormalities

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ÖZET

Giriş: Duvar hareket anormalliklerinin acil servis hekimleri (ASH) tarafından değerlendirilmesi yeni bir konudur ve henüz acil ultrason kılavuzlarına dahil edilmemiştir. Bu çalışmanın amacı, kısa bir eğitim modülünün (STM) ASH'lerin duvar hareketi anormalliklerini tanıma becerisine katkısını değerlendirmektir.

Gereç ve Yöntemler: Bu prospektif deneysel çalışma üçüncü basamak bir eğitim ve araştırma hastanesinin acil servisinde yürütülmüştür. Çalışmaya 1-3 yıllık mezuniyet sonrası eğitim programına dahil olan ASH'leri dahil edildi. Çalışma için otuz dakikalık duvar hareket hatası anormalliğini içeren video destekli kısa bir STM oluşturuldu. Normal ve duvar hareket kusuru patolojilerini içeren otuz soruluk bir test hazırlandı. Asistanlar eğitimden önce (ön test), eğitimden hemen sonra (son test) ve bir ay sonra (son test) olmak üzere üç teste tabi tutuldu ve testleri karşılaştırmak için ANOVA kullanıldı. Post-hoc analizlerde, istatistiksel anlamlılık değerini hesaplamak için Bonferroni testi kullanılmıştır (0.05/3=0.016), 0.016 değeri istatistiksel olarak anlamlı kabul edilmiştir.

Bulgular: Çalışmaya 23 ASH dahil edilmiştir. Asistanlar eğitim öncesi ön testlerde 90 sorudan ortalama 50±12'sini, son testte 70±12'sini ve bir ay sonra 63±12'sini doğru yanıtlamıştır. Kısa eğitim modelinin asistanların duvar hareket kusurlarını tanıması üzerinde istatistiksel olarak anlamlı bir etkisi vardı ($p<0.001$). Post-hoc analizinde ön-test ve son-test puanları arasında anlamlı bir fark vardı($p<0.001$).

Sonuç: Tüm duvar hareket kusurlarını ve normal duvar hareketini içeren 30 dakikalık kısa eğitim modeli, ASH'lerin duvar hareket anormalliklerini görsel olarak tanımaları için etkili bir eğitim yöntemi olarak bulundu.

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Introduction

Bedside ultrasound (B-USG) has become an indispensable component of critical patient management in the emergency department. B-USG was first described as a practicable tool for emergency physicians in 1994 (1). In subsequent years, it came to be used in several fields in the emergency department, such as pulmonary embolism diagnosis (2), volume status evaluation (3), and the differential diagnosis of dyspneic patients (4). The American College of Emergency Physicians (ACEP) added non-cardiac themes that had not previously been included, such as bowel ultrasound and airway ultrasound, to its latest emergency ultrasound guideline published in 2016. (5) Pericardial effusion, tamponade, evaluation of cardiac activity, global systolic function assessment, and volume status evaluation remain included in the guideline among the cardiac themes (5). However, bedside evaluation of wall motion abnormality by emergency physicians is still not included in the B-USG guidelines, and studies on the subject are limited (6). New studies concerning the evaluation of wall motion abnormality by emergency physicians using B-USG are therefore needed.

Echocardiography is one of the first diagnostic tools recommended in the evaluation of both acute coronary syndromes and the complications thereof in patients presenting with chest pain (7). Bedside echocardiography is a valuable tool in the detection of pathologies at differential diagnosis of chest pains, such as pericardial tamponade, pulmonary embolism, and free wall rupture (8). However, echocardiography has been reported to have much higher sensitivity (91%) in predicting cardiac events in patients with probable cardiac ischemia than electrocardiography (40%), which is widely employed to determine cardiac ischemia (9). Several studies have shown that wall motion abnormality is an effective tool in assessing myocardial ischemia in the evaluation of patients with suspected acute coronary syndrome (10, 11). The addition of wall motion abnormality to the B-USG parameters for emergency physicians can contribute to the early assessment and identification of these patients (9, 8).
However, the evaluation of wall motion abnormality by emergency physicians with limited experience on the subject requires specific training and experience.

The purpose of this study was to develop a short training module to improve the abilities of emergency physicians to identify wall motion abnormalities and to investigate the effectiveness of that module.

Method

Study design and setting

This prospective experimental study was conducted in the emergency medicine clinic of a tertiary training and research hospital in Turkey with a 1200-bed capacity and receiving approximately 200.000 patient visits a year. The study began following the approval from the hospital ethical committee under protocol number 265.

Study population

Our team included emergency medicine 1st to 3rd-year residents, working in the emergency medicine clinic, and with no previous training regarding wall motion abnormality in the study. Consent was obtained from all participants regarding voluntary participation in the study. The residents included in the study had previously completed B-USG courses and had a mastery of basic cardiac window images. Residents who had not yet completed their six months of training and with no practical experience or education on basic cardiac windows, and residents in their fourth year with experience of wall motion abnormality were excluded from the study.

Study protocol and data collection

The study was carried out with emergency department residents in two sessions in the emergency department teaching room. The emergency department residents taking part in the study were administered a pre-test measuring their wall motion abnormality testing skills and involving 30 pre-prepared pathological and non-pathological video clips. Following the pre-test, a brief, 30-minute training module was applied containing normal and abnormal wall motions. The teaching session was then followed by a post-test. Pre-test and post-test results were assessed using a pre-prepared answer key, and the data obtained were recorded. To test the permanence of the instruction, the same test questions from the brief training module were re-administered after one month to the same residents, although in a different order. No resident received any other instruction regarding wall motion abnormality during that one month, and the residents were also unaware that they would subsequently be subjected to a final test after one month. The emergency department residents were also unaware of what proportions of the test would consist of pathological and non-pathological images.

Brief Training Module and Test Processing

The test module comprised 30 videos, 22 involving abnormal wall motions and eight involving normal motions. The video clips lasted 5-10 sec each and were retrieved from the hospital archive and individual archives. The video clips involving both pathological and non-pathological images were taken from the parasternal long and short axis and apical four-chamber views. Video clips showing normal wall movements from all three windows were present. The pathological videos were prepared to include at least one example of both hypokinesia and akinesia pathologies on all walls evaluated from all three windows. In addition, two videos showing apical dyskinesia, one from the parasternal long axis and one from the apical four-chamber windows, were included. Each video was numbered before the test. Participants were asked to respond to each video in three stages. In the first step, they were asked to assess whether pathology was present. In the second step, they were asked to locate the pathology, if applicable. In the third step, they were asked to determine the type of pathology, if applicable (hypokinesia, akinesia, or dyskinesia). No time restriction was imposed on the test steps. A score of one was given for each step in class assessment. The highest total possible score for each of the 30 three-step videos was 90.

The brief training module was applied following the pre-test. The module first described all cardiac wall images capable of evaluation from the parasternal long axis, parasternal short axis, apical four-chamber, and subcostal windows. Videos containing at least one example of normal wall motion, hypokinesia, akinesia, and dyskinesia for each wall were shown. This training was completed in 30 min, after which the post-test consisting of 30 videos in three steps was applied. The same videos as shown in the pre-test were used in the post-test but in a different order. The brief training module was prepared by an experienced emergency medicine physician who had been an instructor in the Turkish Emergency Physicians Association ultrasound section for five years and by a specialist cardiologist.

Outcome measurement

The primary outcome measurements were the pre- and most-training test scores. The aim was to compare the initial training levels of the brief training module applied to emergency medicine residents with the post-training levels. The secondary outcome measurement was the final test results one month after training. This test aimed to test the permanency of the knowledge imparted by the brief training module on the subject of wall motion abnormality.

Primary data analysis

Percentage distributions and pie charts were used to evaluate categorical variables at descriptive analyses, while central distribution and prevalence criteria were employed to examine continuous variables. The t-test was used to check for confounding at two-way independent variable analysis, and ANOVA for three-way analysis variables. Since the continuous variables to be analyzed at repeated measurements were found to be normally distributed, ANOVA was used for repeated measurements and the independent samples t test at post-hoc analyses. The Bonferroni test was employed to calculate the statistical significance value at post-hoc analyses, a value of (0.05/3=0.016) 0.016 being determined significant.

Results

Thirty-three residents, 20 of whom were men (60%), were included in the study. Sixteen (26.1%) were in their first year after graduation, nine (39.1%) in their second year, and eight (34.8%) in their third. The residents answered a mean of 50 ± 12 questions correctly at pre-tests before training, 70 ± 12 questions at the post-test, and 63 ± 12 after one month. A comparison of the test scores at repeated measurements revealed that the residents' mean scores altered significantly between the tests ($p<0.001$) (Table 1). Bonferroni-corrected post-hoc analysis performed to identify the source of the difference between two measurements detected at repeated measurements revealed a highly significant difference between mean pre-test and post-test scores ($p<0.001$). No significant difference was determined between mean post-test and final-test scores ($p=0.018$). A significant difference was also determined between mean pre-test and final-test scores ($p=0.004$) (Table 1).

Table 1: A comparison of mean pre-test, post-test and final-test scores

*: p value of repeated measures ANOVA (p<0.05 statistically significant)

	Mean ± SD	Median	Interquartile percentile (25%-75%)	P**
Pre-test	50 ± 12	51	38 - 59	**P****
				<0.001
Post-test	70 ± 12	71	62 - 77	
				0.018
Final-test	63 ± 12	65	55 - 74	
P*	**P <0.001**			

**: p value of Bonferroni correction post-Hoc analysis (p< 0.016 statistically significant)

Test scores were also compared according to gender and number of years spent as a resident to check confounding factors. Mean pre-test values were 44 ± 8 for women and 53 ±13 for men ($p=0.068$), mean post-test values were 66 ± 10 for women and 72 ± 14 for men ($p= 0.212$), and final-test values were 67 ±10 for women and 60 ± 13 for men ($p= 0.251$). A comparison of resident physicians' mean scores in terms of gender and years spent as a resident is shown in Table 2. Gender and years spent as residents did not emerge as confounding factors for analyses.

Table 2: A comparison of pre-test, post-test, and final test scores by gender and years of residency

		PRE-TEST (mean± SD)	POST-TEST (mean± SD)	LAST-TEST (mean± SD)
Gender	**Male n:20**	53±13	72±14	60±13
	Female n: 13	44 ±8	66±10	67±10
	P*	0.068	0.212	0.251
Post graduate year	**I First postgraduate year n:16**	48 ±7	69±7	67±10
	Second postgraduate year n:9	48±13	68±7	59±12
	Third postgraduate year n:8	53±15	72±19	66±12
	P**	0.599	0.820	0.372

***:** p value of Student's t-test for comparison of normally distributed continuous variables in independent groups (p<0.05 regarded as statistically significant)
****:** p value of repeated measures ANOVA (p<0.05 regarded as statistically significant)

Discussion

B-USG has been effectively employed in several different areas, especially in the last two decades, such as in the evaluation of cardiac functions (12), volume status (13), and major vascular pathologies (14), and in the management of cardiopulmonary resuscitation (15). The areas of use of B-USG in the emergency department are also increasing as users acquire experience (5, 6). Echocardiography is an important diagnostic tool in determining wall motion abnormalities showing cardiac ischemia or infarction in patients with chest pain and for the differential diagnosis of chest pain. Since echocardiography is known to be successfully used in showing cardiac ischemia (16), attention in the last decade has focused on the use of bedside echocardiography in the evaluation of cardiac ischemia in the emergency department (6). Wall motion abnormality is still a new subject for emergency departments, and has still not been included in the ACEP ultrasound guideline (5). However, studies investigating the recognition of wall motion abnormality by emergency physicians have commenced (6), and this should be included in the emergency curriculum in the near future.

Physicians should be properly trained in both wall motion defects and other areas of use that have just entered the scope of B-USG, which is already widely employed in the emergency department. The requisite training modules must therefore be established for each of these areas. The content of the education provided for emergency physicians should therefore be defined for fields newly entering into use. Training standards to permit emergency physicians with no experience in this subject to be capable of identifying wall motion defects must therefore be established. The present research is one of the rare studies proposing an effective training module for wall motion defects (6). The 30-minute brief training module applied in the present study was found to increase residents' abilities to visually identify wall motion defects, irrespective of gender or years of residency, for at least one month.

The participants in this study correctly answered 50 (56%) of the 90 questions involved at the pre-test, but 70 (78%) at the post-test. Chris et al. used a 30-minute brief training module, as in the present study, and reported a correct pre-test response rate of 67% and a correct post-test response rate of 87% (6). However, the questions in that study were multiple-choice questions consisting of only two options, 'wall motion defect present' or 'no wall motion defect.' In the present study, however, one-third of the questions were in 'pathology present-absent' form, another third involved the site of the pathology, and a third involved describing the pathology as hypokinesia, akinesia, or dyskinesia. Our test module and training required more detailed knowledge and pathology identification. Initial and post-test result success was therefore lower than that reported by Chris et al. However, identification of the pathology in this way may be more useful as a training model. Bearing this difference in mind, we observed that the location and type of wall motion abnormality pathology can be learned utilizing a 30-minute video-supported training model, and that it produces visual memory with permanency of at least one month.

Wall motion defect was not part of the education curriculum in our clinic, and no resident had received any previous training on the subject. There was no difference in pre-test correct response rates between the one-year residents at 53%, the two-year residents at 53%, and the three-year residents at 59% (p=0.599). This also applied to the post-test and final-test results, showing that the success of the training module was independent of the years of residency. The gender-based analysis also revealed no difference in the establishment of visual perception with brief 30-minute training between men and women. These results show that the success of the brief training module produced was similar in all participants regardless of years of residency and gender.

Limitations

The principal limitation of this study is that the model developed targeted only visual perception. Echocardiography training sessions should be conducted in the form of two-stage training. The first stage should involve the visual identification of normal structures and pathological images, while the second concerns the user's ability to obtain appropriate axes and improvement of the user's manual skills. The present study involved only the first stage and was intended to provide the training required for users to detect wall motion abnormality on a visual basis. Future studies after the present research should concentrate on training models aimed at also increasing users' manual skills.

Wall motion defect does not only occur in acute ischemia. A large proportion of observed wall motion abnormalities are chronic and sequelae of previous events. The physician evaluating the wall motion abnormality should therefore interpret the wall motion information obtained from echocardiography together with such factors as the patient's history, medical history, and examination findings.

Conclusions

The 30-minute brief training model developed in this study can be sufficient for the visual identification of wall motion abnormality. The visual perception formed in the training model can persist for at least one month, irrespective of the years of residency.

References

1. Mateer J, Plummer D, Heller M, Olson D, Jehle D, Overton D, Gussow L. Model curriculum for physician training in emergency ultrasonography. Ann Emerg Med. 1994 Jan;23(1):95-102. doi: 10.1016/s0196-0644(94)70014-1. PMID: 8273966.
2. Nazerian P, Vanni S, Volpicelli G, Gigli C, Zanobetti M, Bartolucci M, Ciavattone A, Lamorte A, Veltri A, Fabbri A, Grifoni S. Accuracy of point-of-care multiorgan ultrasonography for the diagnosis of pulmonary embolism. Chest. 2014 May;145(5):950-957. doi: 10.1378/chest.13-1087. PMID: 24092475.
3. Zengin S, Al B, Genc S, Yildirim C, Ercan S, Dogan M, Altunbas G. Role of inferior vena cava and right ventricular diameter in assessment of volume status: a comparative study: ultrasound and hypovolemia. Am J Emerg Med. 2013 May;31(5):763-7. doi: 10.1016/j.ajem.2012.10.013. Epub 2013 Apr 17. PMID: 23602752.
4. Laursen CB, Sloth E, Lassen AT, Christensen Rd, Lambrechtsen J, Madsen PH, Henriksen DP, Davidsen JR, Rasmussen F. Point-of-care ultrasonography in patients admitted with respiratory symptoms: a single-blind, randomised controlled trial. Lancet Respir Med. 2014 Aug;2(8):638-46. doi: 10.1016/S2213-2600(14)70135-3. Epub 2014 Jul 3. PMID: 24998674.
5. Akhtar S, Theodoro D, Gaspari R, Tayal V, Sierzenski P, Lamantia J, Stahmer S, Raio C. Resident training in emergency ultrasound: consensus recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference. Acad Emerg Med. 2009 Dec;16 Suppl 2:S32-6. doi: 10.1111/j.1553-2712.2009.00589.x. PMID: 20053207.
6. Kerwin C, Tommaso L, Kulstad E. A brief training module improves recognition of echocardiographic wall-motion abnormalities by emergency medicine physicians. Emerg Med Int. 2011;2011:483242. doi: 10.1155/2011/483242. Epub 2011 Jul 2. PMID: 22046540; PMCID: PMC3200256.
7. Amsterdam EA, Wenger NK, Brindis RG, Casey DE Jr, Ganiats TG, Holmes DR Jr, Jaffe AS, Jneid H, Kelly RF, Kontos MC, Levine GN, Liebson PR, Mukherjee D, Peterson ED, Sabatine MS, Smalling RW, Zieman SJ. 2014 AHA/ACC Guideline for the Management of Patients with Non-ST-Elevation Acute Coronary Syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2014 Dec 23;64(24):e139-e228. doi: 10.1016/j.jacc.2014.09.017. Epub 2014 Sep 23. Erratum in: J Am Coll Cardiol. 2014 Dec 23;64(24):2713-4. Dosage error in article text. PMID: 25260718.
8. Kontos MC, Arrowood JA, Paulsen WH, Nixon JV. Early echocardiography can predict cardiac events in emergency department patients with chest pain. Ann Emerg Med. 1998 May;31(5):550-7. doi: 10.1016/s0196-0644(98)70200-8. PMID: 9581137.
9. Kontos MC. Role of Echocardiography in the Emergency Department for Identifying Patients with Myocardial Infarction and Ischemia. Echocardiography. 1999 Feb;16(2):193-205. doi: 10.1111/j.1540-8175.1999.tb00804.x. PMID: 11175141.
10. Buda AJ, Zotz RJ, Pace DP, Krause LC. Comparison of two-dimensional echocardiographic wall motion and wall thickening abnormalities in relation to the myocardium at risk. Am Heart J. 1986 Mar;111(3):587-92. doi: 10.1016/0002-8703(86)90068-2. PMID: 3953368.
11. Kaul S, Pandian NG, Gillam LD, Newell JB, Okada RD, Weyman AE. Contrast echocardiography in acute myocardial ischemia. III. An in vivo comparison of the extent of abnormal wall motion with the area at risk for necrosis. J Am Coll Cardiol. 1986 Feb;7(2):383-92. doi: 10.1016/s0735-1097(86)80509-5. PMID: 3944358.
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 Mar;9(3):186-93. doi: 10.1111/j.1553-2712.2002.tb00242.x. Erratum in: Acad Emerg Med 2002 Jun;9(6):642. PMID: 11874773.

13. Çelebi Yamanoğlu NG, Yamanoğlu A, Parlak İ, Pınar P, Tosun A, Erkuran B, Aydınok G, Torlak F. The role of inferior vena cava diameter in volume status monitoring; the best sonographic measurement method? Am J Emerg Med. 2015 Mar;33(3):433-8. doi: 10.1016/j.ajem.2014.12.014. Epub 2014 Dec 18. PMID: 25616587.
14. Yamanoğlu A, Celebi Yamanoğlu NG, Sogut O. Male With Hypertension. Ann Emerg Med. 2016 Nov;68(5):e85-e86. doi: 10.1016/j.annemergmed.2016.04.030. PMID: 27772690.
15. Yamanoglu A, Celebi Yamanoglu NG, Evran T, Sogut O. How much can synthetic cannabinoid damage the heart? A case of cardiogenic shock following resistant ventricular fibrillation after synthetic cannabinoid use. J Clin Ultrasound. 2018 Nov;46(9):605-609. doi: 10.1002/jcu.22581. Epub 2018 Feb 26. PMID: 29479764.
16. Kontos MC, Arrowood JA, Paulsen WH, Nixon JV. Early echocardiography can predict cardiac events in emergency department patients with chest pain. Ann Emerg Med. 1998 May;31(5):550-7. doi: 10.1016/s0196-0644(98)70200-8. PMID: 9581137.