Evaluating Bedside Lung Ultrasound Examination (BLUE Protocol) Training and Learning among Emergency Medicine Residents of Iran University of Medical Sciences

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Abstract: Introduction: Research conducted in the department of emergency over the past years has shown that ultrasound in the patient's bedside can improve care in the hospital's department of emergency. The purpose of this study was to examine the learning of the BLUE protocol in the emergency medicine resident. **Material & Methods:** This study was designed as a qualitative study of pretest and posttest type that was conducted on emergency medical assistants who were employed in teaching hospitals of Iran University of Medical Sciences. In this study, sampling was done as a whole. In this study, patients' data was collected through pre-designed questionnaires. Then, after teaching the theory and practice of sonography by faculty of emergency medicine, the learning curve of ultra-sonographies performed by the assistants were studied separately until they reached the full competencies and confirmed by the corresponding professor. **Results:** In this study, a total of 85 emergency medical assistants were evaluated in terms of education and chest sonography (blue protocol) learning. The agreement between the performance of each assistant and the corresponding teacher was evaluated in 23 consecutive steps for assessing Lung sliding, determining the lung profile, and also identifying the B lines, and eventually identifying the complication in 747 patients with a mean age of 48.2 ± 6.1 which required pulmonary examination. The agreement rate increased by 0.09, 0.43, 0.08, and 0.371 respectively. There was a significant difference in the statistical analysis of the mean changes in the blue protocol. In the study of changes in the mean of the agreement coefficients, we reduced these changes and the average of the total coefficients of the agreement was increasing the convergence coefficient. **Conclusion:** The course of lung ultrasonography in the patient's bedside, according to the BLUE protocol, in the emergency medicine resident shows that during the training, the experience of the assistants has been increased and the professors are close to recognizing the BLUE protocol profiles.

Keywords: Learning; BLUE Protocol; Emergency.

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Introduction

In medical sciences, residency refers to a practical and complementary course in higher education, which is passed by physicians in many countries after obtaining a professional doctorate degree. Graduates of this course will enter the labor market as a specialist with a degree of specialization in the above field. Therefore, teaching and learning during the residency course, in addition to the syllabus, will lead to an increase in the residents' awareness and insight after graduation. In view of the development of emergency medicine in the country and also presence of its specialist(s) in hospitals on an official working basis with K coefficient in the university or by a free or (agreed) medical contract, on one hand, and considering the widespread employment of these specialists in the country on the other hand, the emergency medicine department exists in all assigned educational hospital in the country. Therefore, to take advantage of medicine physicians and reach the least error rate and the highest efficiency, it is necessary to increase these physicians' level of knowledge of this field as individuals on the front line of facing and taking care of with patients so as (Perina, Collier, Harold & Witt, 2009; Perina, Collier, Counselman, Jones & Witt, 2011).

Emergency medicine is an acute and sub-acute medicine practice. A trained emergency physician is able not only to manage the trauma, but also can manage the majority of other acute and non- acute imaginable things. Since most hospital admissions are carried out through the emergency department, it is important that the emergency physician, in addition to having extensive knowledge in all medical fields, knows about other paraclinical disciplines such as ultrasound, etc. (Williams, Blomkalns, & Gibler, 2004; Stead, Schafermeyer, Counselman, Blackburn, & Perina, 2001). Undoubtedly, the training of specialists with academic and practical capabilities is one of the most fundamental goals of the medical centers. To achieve this goal, research in education can be a pave the way for many professors to design their training methods. Ultrasound is an inexpensive, safe and available measure. It can also be used in areas where there it is impossible to perform radiography and CT scan, such as rural areas or war zones or space travel. Ultrasound is easier and faster than other diagnostic tools, in other words, it has made it possible to perform sonography at any point of the patient, which is called point-of-care ultrasound in the medicine. Lung ultrasound can help to diagnose the pleural effusion and atelectasis, mass, raised hemidiaphragm, empyema and hemothorax. It is also dynamic and allows the sonographer perform further evaluation along the patient's bedside, provides easy and safe

serial evaluation without radiation, and, if necessary, can act as a guide for thoracentesis and other invasive interventions (Balik, et. al., 2006). Although ultrasound has advantages over other diagnostic tools, there are some limitations, since pulmonary lesions can usually be detected by sonographer only when the lesion is of peripheral type and spreads to the pleural space, there is no air in the pleural space (except for pneumothorax) and subcutaneous emphysema and the lesion is not hidden behind a bony structure (Reissig, Copetti, & Kroegel, 2011).

One of the protocols used to evaluate the chest contents is a bedside lung ultrasound examination (BLUE) that is used to check patients with acute respiratory failure, which has an accuracy rate of 90.5%. Therefore, it helps us diagnose and treat patients with acute respiratory failure who make up the major population of the patients who refer to the emergency department. On the other hand, while referring to the emergency department, these patients have unstable situation and should be treated promptly; hence the use of a fast and low-cost tool is very helpful in prognosis and management of patients with shortness of breath and the patient also does not receive radiation (Lichtenstein, et. al., 2004). On the other hand, the training and learning of the BLUE protocol does not require much time and cost, and it can easily be carried out at the bedside, unlike other modalities require the expert to attend and patient to move to the imaging room (Manno, et. al., 2012). Since this is the research carried out in the Department of Emergency Medicine and the lack of similar information in the archives of this department, the aim of this study was to investigate the education and diagrams of the bedside lung ultrasound examination (Blue Protocol) study in emergency medical residents of Iran University of Medical Sciences.

Materials and Methods

This qualitative study of pre-test/post-test design was conducted on emergency medicine residents who were employed in educational hospitals of Iran University of Medical Sciences. In this study, all emergency medical residents employed in hospitals affiliated to Iran University of Medical Sciences were studied using the consensus sampling was carried. The residents received the training as 2 hours practical, 2 hours of practice on the pseudopatient and then the patient who is under the supervision of the professor. After teaching the theory and practice of ultrasound by emergency medicine professors, level of agreement between residents and professors over the results of ultrasound and Blue protocol components was studied separately in the form of comparing the average and the relevant

learning curve until the residents acquired full competencies and also professors' approval for their carrying out sonography alone (23 times) (Mandavia, Aragona, Chan, Chan & Henderson, 2000). The data collection tool was a questionnaire, which was completed and the obtained data was later analyzed based on the research objectives and its analysis in SPSS software. The research objectives were statistically analyzed using Kappa correlation coefficient, repeated measure ANOVA and ANOVA and post hoc T-test. Data was collected using a checklist that included demographic data and the number of lines B and profiles A, B, and AB, and the presence or absence of Lung sliding and consolidation and final diagnosis. Data analysis was carried out using statistical indices (frequency, median, mean, standard deviation, etc. and other statistical tests and the central indices (mean, median, mode and etc.) and measures of dispersion (standard deviation, variance, etc.) in SPSS ver.21.

Ethical considerations

All costs of the project will be funded by research funds, the names and secrets of emergency medicine residents will be remained confidential. The results will also be reported as whole and all stages of the projects will adhere to the principles of the Helsinki Treaty throughout the study period.

Results

In this study, a total of 85 emergency medicine residents were evaluated in terms of training and the learning ultrasound examination beside lung ultrasound examination (Blue Protocol). The present study investigated the agreement between the performance of each resident and the corresponding professor in 23 consecutive days in terms of evaluating the lung sliding, determining the lung profile, and also identifying the B-lines, and final diagnosis of the complication in 747 patients requiring the pulmonary examination. The Kappa coefficient test was used to examine the agreement between the total number of residents and professors during the 23 days of ultrasound in 4 criteria and the results obtained from this statistical analysis are presented in Table 1. According to previous studies such as Landis & Koch, the Kappa coefficient <0, 0-0.2, 0.21-0.4, 0.41-0.6, 0.61-0.8 and 0.81-1 indicates no agreement, a very slight, low, moderate, significant and complete agreement, respectively. However, this guideline is not globally accepted, and therefore, some later studies, such as Fleiss et al., concluded that the Kappa coefficient of less than 0.4, .0.4-0.75 and higher than 0.75 indicates a weak, moderate and excellent agreement, respectively.

Considering both of these criteria and comparing the results of the current researches, it can be concluded that the excellent agreement coefficient was obtained for detecting B-lines and the lung sliding during all days (from 1 to 23).

Table 1: Agreement coefficients for the criteria considered in the current research during different days of ultrasound

Day	Lung Sliding	Profile	B Line	Final Diagnosis
1	0.817	0.364	0.899	0.561
2	0.84	0.514	0.901	0.698
3	0.801	0.364	0.915	0.675
4	0.897	0.463	0.917	0.671
5	0.907	0.364	0.919	0.662
6	0.891	0.320	0.928	0.781
7	0.802	0.213	0.917	0.738
8	0.844	0.462	0.919	0.71
9	0.866	0.514	0.897	0.672
10	0.891	0.533	0.94	0.759
11	0.925	0.414	0.92	0.846
12	0.932	0.475	0.919	0.798
13	0.923	0.584	0.928	0.813
14	0.919	0.463	0.962	0.862
15	0.931	0.364	0.957	0.835
16	0.939	0.641	0.957	0.756
17	0.952	0.575	0.936	0.911
18	0.949	0.575	0.958	0.89
19	0.95	0.553	0.956	0.96
20	0.976	0.579	0.962	0.847
21	0.968	0.553	0.957	0.907
22	0.97	0.788	0.98	0.928
23	0.976	0.794	0.979	0.878
Mean	0.907	0.498	0.942	0.791
Variation through the study	+0.09	+0.43	+0.08	+0.371

However, weak-to-moderate, moderate and excellent diagnosis agreement was often obtained until the 7th day, 7th-21st says (except in the weak agreement rate obtained in the 15th day) and the last two days in terms of profile criterion, respectively. The mean agreement coefficient of 0.498 was obtained for this criterion during all days. There was a moderate agreement between residents and professors during the initial 10 days

(except in the excellent agreement obtained in the 6th day) in terms of final diagnosis. Afterwards, the highest agreement level was reported to be between the two groups by the end of the study. The agreement coefficient of 0.791 was obtained for this criterion at different times which means an excellent agreement level. Figure 1 shows the agreement variations between residents and professors in terms the studied criteria of the Blue Protocol during the various days. As shown in Fig. 1, the agreement coefficient in gradually increased all the criteria.

Figure 1: Coefficient variations of the studied criteria over time

The results of this research showed a coefficient change of +0.43, +0.09, +0.08 and 0.371 for profile, lung sliding, B-line and final diagnosis criteria, respectively. The ANOVA test was used to compare the mean of these coefficients and the results showed that there is a significant difference between the mean agreement coefficients for different criteria (p -value < 0.0001). Post-hoc Tukey test indicated that the mean lung sliding agreement was significantly higher than that of the profile (p -value < 0.001) and final diagnosis criteria (p -value < 0.001). However, this mean was significantly lower than the average agreement between the professor and the emergency medicine resident in determining B-lines (p value < 0.01) (Fig. 2).

Figure 2: Comparison of the mean agreement coefficient for the studied criteria

Considering the mean agreement coefficient obtained for all criteria at each day, One-way repeated measure ANOVA test was carried out using to examine the significance of the changes in the mean agreement coefficient between professors and residents with regard to the implementation of the Blue protocol (Fig. 3).

Figure 3: Trend of changes in mean agreement (k) coefficient

The result of the study showed that the average of total agreement coefficients increased significantly from 0.66 to 0.90 over time (p-value <0.001).

Figure 4: Variations of coefficients agreement

Discussion

Bedside ultrasound is rapidly being included in the curriculum and internship program of emergency medicine specialists. Over the recent years, leading emergency medicine-related organizations such as the American College of Emergency Physicians (ACEP), the Society for Academic Emergency Medicine (SAEM) and the American Academy of Emergency Medicine (AAEM) have pointed to the role of this technology in improving patient care in the emergency medicine (Ahern, et. al., 2010; Fox, et. al., 2010; Kuhn, et. al., 2000). The results of the bedside ultrasound examination indicate that the use of bedside ultrasound is necessary for patients with an emergency situation to quickly decide on their condition. The results of the bedside ultrasound examination can give the physician quick and important information that will influence the physician's decision for the patient, for example, in moving patients to the operating room (Jehle, Guarino, & Karamanoukian, 1993; Blaivas, Harwood, & Lambert, 1999). One of the applications of the bedside ultrasound is to evaluate patients with acute respiratory failure where the Bedside Lung Ultrasound in Emergency (BLUE

protocol) can be used. Acute respiratory failure is one of the most difficult conditions for patients referring to the emergency department (Lichtenstein, et. al., 2004; Bouhemad, Zhang, Lu, & Rouby, 2007). The BLUE protocol helps to diagnose diseases such as pneumonia, congestive heart failure, Chronic obstructive pulmonary disease (COPD), asthma, pulmonary arterial embolism, and pneumothorax with an accuracy of over 90%. The ultrasound also help reduces the X-rays dosage received by the patient. Since there is a similarity between lung landmarks in adults and children, they are very much considered in children (Mayo, Goltz, Tafreshi, & Doelken, 2004; Mathis, et. al., 2005). The BLUE protocol adopts a step-by-step approach to respiratory failure to prevent errors and to achieve correct diagnosis. Each respiratory failure has its own BLUE profile (Lichtenstein, et. al., 1999). These profiles are called A, B, and C (Volpicelli, et. al., 2012; Lichtenstein, & Mezière, 2008). A-profile refers to lung sliding with predominant A-lines in the anterior wall of the lung. Lung sliding refers to the respiratory movements of the visceral pleura against the parietal pleura. A-line is seen when the subpleural interlobular septa is very thin so that it can reflect the lateral lines. A-profile indicates the normal the anterior surface of lungs and shows pulmonary embolism (PE) when it is associated with DVT. B-profile refers to the lung sliding with lung rockets, which usually indicates pulmonary hemodynamic edema. The lung rocket refers to the state where there are three B-lines between two ribs. C-profile refers to consolidation in the anterior lung, regardless of the number and size. According to the BLUE protocol, a normal profile should be followed by screening for thrombosis in the foot veins (Lichtenstein, & Mezière, 2008). Screening of deep venous thrombosis is performed with the same probe performed for pulmonary ultrasound. If there is evidence of deep venous thrombosis in the foot veins, it will be indicative of the pulmonary embolism; otherwise, normal appearance is suggestive of respiratory disorders caused by obstructive pulmonary diseases such as asthma (Blaivas, Harwood, & Lambert, 1999; Volpicelli, et. al., 2012; Lichtenstein, & Mezière, 2008). The absence of lung sliding in the A-lines is indicative of pneumothorax. The presence of such association between a normal anterior profile with pleural effusion and posterior consolidation (profile A with posterior alveolar syndrome, pleural syndrome, or both), or anterior and posterior consolidation (C-profile) are indicative of pneumonia. Although the prominent B-line without lung sliding can also be suggestive of pneumonia (Blaivas, Harwood, & Lambert, 1999; Lichtenstein, & Mezière, 2008; Silva, et. al., 2013). This characteristic of the two-way A-B profile with symmetric B-lines that suggests the hemodynamics of the pulmonary edema (Bouhemad, et. al., 2007;

Lichtenstein, & Mezière, 2008; Dexheimer Neto, et. al., 2012). Research has shown that the proficiency of the BLUE protocol is improving over time with repetition. In the early studies, researchers investigated individuals who are specialized in bedside lung ultrasound so it was impossible to recognize the effect of training on improving the skill (Lichtenstein, & Mezière, 2008; Silva, et. al., 2013; Tutino, et. al., 2010; Chavez, et. al., 2014). Lichtenstein et al. reported the bedside lung ultrasound sensitivity and specificity value of 97%,95% and 94%,89% respectively for the diagnosis of lung hemodynamic edema and pneumonia (Lichtenstein, & Mezière, 2008). However, Dexheimer Neto et al. showed some change in the sensitivity and specificity of non-specialist physicians who performed bedside lung ultrasound for the diagnosis of pulmonary edema and pneumonia during training (Dexheimer, et. al., 2015). Therefore it can be concluded based on the results of these researches that the accuracy of the BLUE protocol can be changed and improved with practice. The training curves in this study indicate gradual improvement. We also achieved similar results in this study. In this study, we evaluated the extent of the agreement on the performance of profile, lung sliding, B-line and final diagnosis criteria of emergency medicine residents who are not skilled at BLUE Protocol, and skilled professors. The Kappa coefficient was excellent in determining this agreement across all domains over a period of 23 days. Also, the diagram of average of total agreement coefficients over time indicates an increase in the average total of agreement coefficients from 0.66 to 0.9. Additionally, the diagram showing the trend of variations in the mean agreement coefficients demonstrates a decrease in K coefficient over time. However, the variations trend has been the opposite of the overall trend during some days. In other words, there is a significant difference between the diagram of average of total agreement coefficients over time and the diagram of the trend of variations of average coefficients, which may be due to the fact that more experienced learners do not consider mild signs as symptoms and that course can also be justified by referring to the fact that the skill of all the learners does not increase equally over time.

Conclusion

The present study investigated the course of bedside lung ultrasound training in, in the emergency medicine residents according to the BLUE protocol. The results showed the residents first had acceptable skills and their experience increased over time during the training. They also approached the professors in terms of accuracy and skill in detecting the BLUE protocol profiles.

Limitations

The only limitation included lack of cooperation on behalf of emergency medicine residents led to the exclusion of the above-mentioned residents.

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