

## Review Article

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# Ultrasonography in Emergency Department; a Diagnostic Tool for Better Examination and Decision-Making

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## Abstract

**Context:** The aim of this study is to evaluate the applications of ultrasonography (US) as a diagnostic tool in emergency settings.

**Evidence acquisition:** In the present review article, search engines and scientific databases of Google Scholar, Science Direct, PubMed, Medline, Scopus, and Cochrane were searched for the applications of US in emergencies. Finally, related articles which were published between 2000 and 2017, were selected and by reviewing them an attempt was made to evaluate various applications of US for examining and facilitating decision-making in emergency department (ED).

**Results:** As a diagnostic tool, US can be of diagnostic help in emergency settings for the specialists and the treatment team regarding trauma, measuring intracranial pressure (ICP), hemothorax pneumothorax, abscess and its drainage, deep vein thrombosis (DVT), dyspnea, acute abdomen, appendicitis and biliary problems, renal colic and renal stones, shock, foreign object, bone fracture, peripheral nerve block, establishing central and peripheral venous access, lumbar puncture (LP), and confirmation of nasogastric tube (NGT) and endotracheal tube (ETT) placement.

**Conclusion:** The results of this review study showed that US can be of help to EMPs as a diagnostic tool in a wide range of diseases and clinical conditions, which in turn can result in a decrease in the time needed for diagnosis and treatment, and therefore improve both the quality and quantity of the service provided in ED.

**Key words:** Diagnosis; Emergency Treatment; Emergency Service, Hospital; Ultrasonography

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## CONTEXT

What measures can be taken by an emergency medicine physicians (EMP) using ultrasound (US) in the emergency department (ED)? Can this tool be used for more accurate examination of the patient on the bedside, speeding up diagnostic measures and finally, more proper disposition of the patients in ED?

Ultrasonography (US) is a diagnostic method that has received more attention than before in recent years. This tool uses high-frequency sound waves for evaluating the structure and function of internal organs and tissues. Recent advances in the quality of imaging and increased portability of the devices have facilitated the use of US in difficult situations and have therefore introduced as a great, readily available and inexpensive screening and diagnostic method for various patients (1). For this reason, in the past decade use of US has significantly increased among EMP and the topic of "point of care ultrasound" has received much attention (2, 3).

Using ultrasonography, EMP have been able to improve the speed and accuracy of diagnosis and consequently, treatment of diseases (4-6). Researchers believe that with proper training, EMP are able to perform ultrasonography with a reliable accuracy, which will therefore have a significant effect on the quality of their diagnostic and therapeutic measures (1, 7).

## EVIDENCE ACQUISITION

In the present review article, search engines and scientific databases of Google Scholar, Science Direct, PubMed, Medline, Scopus, and Cochrane were searched for the applications of US in emergencies. Finally, related articles which were published between 2000 and 2017, were selected and by reviewing them an attempt was made to evaluate various applications of US for examining and facilitating decision-making in ED.

## RESULTS

The findings were categorized in 3 parts including

critical care, medicine and surgery, and procedures. Thereafter, in each part, subheadings were defined.

### **Critical care**

#### **• Shock state**

Using the protocols of abdominal and cardiac evaluation with sonography in shock (ACES) and rapid ultrasound in shock (RUSH) for rapid diagnosis and treatment of critically ill and in shock patients by EMP has received attention from many researchers (8). ACES protocol with 6 views of cardiac, inferior vena cava, abdominal artery right and left flanks and pelvic view can provide the specialists with a relatively complete evaluation and RUSH protocol with its 3-step algorithm can provide the specialists with a rapid assessment in emergency settings to evaluate the probable differential diagnoses for the patients in shock (9-18).

In critical clinical situations, these protocols can evaluate important differential diagnoses such as hypotension with undetermined cause, sepsis, cardiac arrest and other cases in the shortest time and with the most accuracy and therefore, significantly increase the probability of diagnosis, treatment, and successful resuscitation (19-23). For quantify intravascular volume status, carotid artery corrected flow time (FTc) has recently been introduced, but the researches in this era is still on (24-27).

#### **• Multiple trauma**

Performing ultrasonography in trauma patients [Focused Assessment with Sonography in Trauma (FAST)] is one of the most common applications of US in ED (28). When there is an acute hemorrhage it has the ability to flow and is seen without an echo (black). However, when the hemorrhage is sub-acute and blood has clots it is hypoechoic (gray) (29). Various studies have shown that FAST has a high sensitivity in diagnosis of diseases in ED (from 73% to 99%) (30). In addition, a meta-analysis performed on 62 studies and 18000 patients showed that FAST can have a sensitivity of 78.9% and specificity of 99.2%, which indicates the high diagnostic value of this tool in trauma patients (31).

#### **• Cardiac tamponade**

Injuries to large thoracic vessels and cardiac tamponade are among the most important reasons for death before reaching the hospital in patients with blunt or penetrating trauma to the thoracic area (32). Rapid diagnosis of tamponade in a few seconds can significantly increase the chance of survival for the patient (32-35). A study by Mandavia et al showed that US can diagnose

pericardial effusion with 97.5% accuracy (36); meanwhile, it was claimed that computed tomography (CT) scan and magnetic resonance imaging (MRI) have a lower value compared to US and performing them is not necessary most of the time (37).

#### **• Intracranial pressure assessment**

Increase in intracranial pressure (ICP) is a relatively common and dangerous phenomenon in brain injuries and its severity and duration have a significant correlation with patients' mortality (38, 39). A study by Chesnut et al showed that there is no significant difference between invasive methods and non-invasive imaging regarding ICP measurement (40). Since invasive methods of measuring ICP can bring about side effects such as infection or bleeding, using US as a non-invasive method in measurement of ICP in emergency situations can be very helpful (41-43). Studies have shown that ultrasonography can be used as a rapid, inexpensive, and reliable method for measuring ICP in emergency settings as a replacement for the common invasive measurement methods (44).

### **Medicine and surgery**

#### **• Musculoskeletal injuries**

Using US for detecting fractures in ED has many advantages, among which not needing to move the patient out of the ED and not having ionizing radiations can be pointed out (45-47). Studies have shown that US can detect fractures with 93% sensitivity and 83% specificity for long bones in adults, 98% sensitivity and 69% specificity for various types of fracture in children and 95% sensitivity and 96% specificity for clavicle fractures in children. The study by Griffith et al showed that regarding detection of fractures, ultrasonography can detect more fractures (10 times) and in more patients (6 times) in comparison with radiography, which is higher than similar studies in this regard (48-52). This diagnostic superiority is especially proposed regarding rib fractures, and metastases, nose fractures, sternal fractures, metatarsal bone stress fracture, clavicle and lower arm fracture in newborns and children, calcaneus fracture, and pelvic fracture. Meanwhile, various evaluations have shown that chest radiography can detect rib fractures in only 12% of the cases (53, 54). The numerous benefits of US in detection of chest diseases have resulted in its use as a proper diagnostic method in patients with unexplainable chest pain and without a history of trauma, patients who cough and clinical cases with suspected

fracture despite their chest radiography results being normal (55).

Low frequency US has also been used for diagnosis of shoulder dislocation and required assessment after reduction in the ED. In comparison to radiography, US had a sensitivity of 100.0%, specificity of 80.0% in diagnosis of shoulder dislocation; as well, the specificity of US in diagnosis of proper reduction of the joint, was estimated to be 98.7% (56).

US was also used regarding diagnosis of tendon ruptures following penetrating extremity trauma and the overall sensitivity and specificity were reported as 94.4% and 100% respectively. Therefore, US is now being considered as one of useful modalities in this area (57).

#### • Eye trauma

Retinal detachment (RD) is an eye emergency, which needs rapid intervention for preventing irreversible blindness (58, 59). Definitive diagnosis must be done by an ophthalmologist, but since most patients visit the ED first, using a method for a reliable primary diagnosis by EMP is of great importance (60). Despite the high value of fundoscopy in these patients, due to the problems of using it, especially in patients with cataract or bleeding in the eyeball, its use in ED has not been recommended (60). Using ultrasonography for diagnosis of RD has started from 1970 and its clinical value in diagnosis of eye pathologies, especially RD, has been confirmed little by little (61, 62).

Studies have shown that using Emergency Department Ocular Ultrasound (EOUS) has a similar sensitivity and specificity to ultrasonography performed by ophthalmologists in diagnosis of RD and based on the studies only 19% false positive results have been reported (63). Dislocation of eye lens can happen following blunt trauma or in an idiopathic manner in patients. These patients usually present to ED with reduced eyesight (64). Studies have shown that US can detect dislocation and subluxation of the eye lens easily and in the shortest time possible (64, 65). Blunt trauma of the eye can also lead to scleral rupture of the eye, the diagnosis of which is a clinical challenge in clinical emergencies and US can help the physicians to diagnose it in the shortest time possible (65). However, in eye traumas it should be noted that in case of suspicion to eye globe rupture, using US is contraindicated. Applying more pressure does not lead to improvement of the image and theoretically it leads to worsening of the eye injury (66).

#### • Foreign body

Numerous evaluations have shown that US can be a reliable tool for diagnosing foreign bodies in soft tissue (67, 68). Radiography can only detect radiopaque foreign objects such as sand, glass, metal, with 98% sensitivity, but does not have the ability to detect radiolucent foreign objects like wood, plastic, or cactus spine. Meanwhile, based on existing studies, 36% of foreign bodies are wood; this might be the reason that based on the studies 38% soft tissue foreign bodies are not detected in initial examinations (48). Sensitivity of US for detection of foreign bodies is 40% for sand, 45% for metal, 50% for glass and wood, 30% for cactus spine and 40% for plastic. Its overall, sensitivity, specificity, false negative and false positive for detection of foreign bodies are 43%, 70%, 50% and 30%, respectively. False negative and false positive for detection of foreign objects with radiography are 50% and 1.6%, respectively (69). In comparison with radiography, US can detect most of the foreign objects with accuracy and is therefore considered a proper approach for detecting as well as removing foreign bodies in ED.

#### • Abdominal Aortic Aneurysm

The importance and place of US in diagnosis of abdominal aortic aneurysm (AAA) was determined in 1992-1993 and with the initiation of screening using US for early detection of this disease (70). Many of the patients who visit ED are unaware of their abdominal aortic aneurysm; and since most of these patients are affected with cardiovascular risk factors, therefore, not diagnosing it in a timely manner is a common medical problem (71, 72). Evaluations have shown that combination of clinical examination and US can have a high clinical value in timely detection of AAA (70, 72). Meanwhile, CT scan and angiography have a much less important diagnostic place due to their long duration of performance, high cost, and complications (72).

#### • Aortic Dissection

Aortic dissection is a life threatening disease (73). Clinical diagnosis of aortic dissection is a medical challenge; because the symptoms of patients can vary based on the affected organ and therefore, the true prevalence of this disease is not known (73). Not diagnosing this disease in a timely manner can be associated with a mortality rate more than 1% in each hour during the first 24 hours and 80% after 2 weeks (74). Aortography, as a diagnostic method for aortic dissection, has 88% sensitivity, 94% specificity, 96% positive predictive value, and 84% negative predictive value. However, this method cannot differentiate many of the pathologies of aorta and is also an expensive, time-

consuming method associated with a high rate of side effects compared to other imaging methods (73). Studies have shown that US in combination with various performance techniques can have 97-99% sensitivity and 99-100% specificity in diagnosis of this disease (73, 75).

#### • Deep vein thrombosis

Annually, 20 million new cases of deep vein thrombosis (DVT) occur in the United States (76). Sensitivity and specificity and positive and negative predictive values of US in detection of DVT in symptomatic patients and patients after undergoing surgery is higher than 92%. In addition, US with 86% specificity and 96% sensitivity can help EMP detect DVT following ankle fracture (77). Different studies have shown that US can be used as a non-invasive method for early detection of DVT in ED. These studies have expressed 93% sensitivity and 99% specificity for US in comparison with venography (78). In addition, among other points indicating the superiority of US to other methods in detection of DVT are its high accuracy, low cost, portability of the device and not having ionizing radiations (79, 80).

#### • Pulmonary system

Shortness of breath is a common complaint among patients visiting ED and differentiating its cardiac and non-cardiac causes is among the common clinical problems (81, 82). Various studies have shown that US can diagnose the causes of shortness of breath with 93.6% sensitivity, 84% specificity, 87.9% positive predictive value and 91.3% negative predictive value. Actually, using ultrasonography of lung and pleural cavity for patients with shortness of breath in ED by can be efficient for accurate and timely diagnosis of cardiac or non-cardiac causes of shortness of breath and diagnosing alveolar-interstitial syndrome and also be used for diagnosis of respiratory failure and monitoring response to treatment (81, 83).

In a survey that US was compared with chest x-ray for diagnosing patients with acute shortness of breath indicated more than 95% conformity in most pulmonary diseases, especially lung edema; in addition, there was no significant statistical difference between ultrasonography and radiography regarding lung disorders such as free pleural effusion, lobulated pleural effusion, pneumothorax and lung consolidations. Other studies also showed similar findings (84, 85).

#### • Abdomen

Acute abdomen is one of the common complaints by patients presenting to ED and the differential

diagnoses of this pain include a wide range of clinical problems from self-limited diseases to those with high morbidity (86). Various studies have shown that US can aid in detection of acute appendicitis with 75-90% sensitivity, 86-100% specificity, 87-96% accuracy, 91-94% positive predictive value and 89-97% negative predictive value (87-91). Considering the difficulty of differentiating appendicitis with many gynecologic disorders, US must be routinely performed for all the young women presenting to ED with right lower quadrant (RLQ) pain. In addition, due to the lack of ionizing radiations in ultrasonography, it is the method of choice in pregnant women and children (86, 92).

The study by Allemaann et al. in University of Zurich showed that using ultrasonography in acute abdominal pain can increase the probability of correct diagnosis from 70% to 83%. Additionally, the diagnostic accuracy for acute appendicitis and biliary tract diseases changed from 92% to 98% and from 93% to 99%, respectively, which can increase the speed and quality of diagnosis and treatment, and decrease the duration of hospitalization (86).

#### • Renal stone and colic

The numerous problems of various methods of imaging in detection of urinary tract stones such as the side effects of the contrast agent and long duration in intravenous urography, low diagnostic sensitivity in plain radiography and the high dose of ionizing radiation and high cost in CT scan have been assessed in various studies.

In a study by Patlas et al. diagnostic sensitivity of ultrasonography was reported to be relatively equal to CT scan, 93% vs. 91%. In another study, the sensitivity of US regarding renal colic was 95% and its specificity was 67%. These variables have been reported as 81% and 100%, respectively, in hydronephrotic kidneys (9, 10, 93, 94).

In fact, considering the many advantages of US in detection of kidney stones in ED, it has been suggested to use CT scan only in cases that ultrasonography is not available or there is suspicion regarding the diagnosis (10).

#### • Soft tissue

Infection of soft tissue can commonly cause cellulite or abscess (95). Differentiation of cellulite with abscess for selecting the proper treatment is a routine challenge in ED (96). Various studies have shown that US can be a valuable tool in diagnosis of abscess and differentiating the two mentioned diseases (97, 98).

Ultrasonography not only can differentiate them, but can also determine normal structures of the

tissue as well as cellulite and abscess changes (98-101). In addition, after timely and correct diagnosis of abscess using US, drainage can be attempted (102).

### Procedures

#### • Peripheral nerve block

Using US compared to peripheral nerve stimulation for blocking neural branches can significantly increase the success rate, shorten the duration of procedure, accelerate the onset of the block and elongate the duration of block (103). Additionally, based on existing studies, other variables such as the required dose of anesthetic agent, pain at the time of performing block, the number of needles required, percentage of success in the first attempt and patient satisfaction in performing nerve block are also in favor of US (104-109). In addition, using US can increase the accuracy and quality of performing brachial neural network block (110). Similar results were obtained by Casati et al. for femoral nerve block; the result of this study showed that US not only leads to increase in the speed and quality of performing nerve block, but can also decrease the volume of anesthetic agent required for block by 42% (111). Other studies confirm more than 95% success for blocking ilioinguinal and iliohypogastric nerves (112).

#### • Peripheral vein access

Establishing peripheral venous access is one of the very important and usual initial measures taken in ED. Using US for placing a peripheral vein route in difficult cases has been considered in the past two decades and different studies have reported its success rate between 94% and 97% (113-115). In addition to the high success rate, less time is required compared to other methods and less complications are among the other benefits of using US for placing peripheral vein catheter by EMP, which are important especially in critically ill patients, children, obese patients, and those with venous pathologies and chronic diseases (116-120).

#### • Central vein access

Placing central vein access: each year about 200000 operations of central vein access placement are performed in the United States (121). In various studies success rate, problems, number of attempts, and the time required for placement of central vein access via internal jugular vein using anatomic indices have been evaluated in detail (122-124). Based on these studies in only 57.3% of the patients, central vein access could be placed in first attempt and reaching a success rate over 99.3% required repeated

attempts, which results in complications such as carotid perforation, hematoma, hemothorax, horner syndrome, and dysphagia. However, in the study by Denys et al. on 1230 patients using US no important complications, including pneumothorax, were seen (125). In another study, carried out on critically ill patients, a significant superiority was reported for using US compared to other common methods (125). A meta-analysis on 208 studies, aiming to compare the placement of central vein access using US with other methods, revealed a decrease in complications when placing vein access via internal jugular vein (RR=22; CI=95% 0.10 to 0.45) or subclavian vein ((RR=0.11; CI=95% 0.02 to 0.56), drop in the number of attempts needed for placement (RR=0.60; CI=95% 0.45 to 0.79), decrease in the time needed, and increase in the probability of success after failure of placement using other methods (126).

#### • Lumbar puncture

Lumbar puncture (LP) under US guide was described in 1971 for the first time and can be used for patients in whom using the landmarks method can be difficult (for example patients who are obese, are affected with scoliosis or those who cannot make a kyphotic spinal curve for performing this process) (127). Different studies have shown the high value of US in LP performance, especially in children (128). The study by Nomoura et al. indicated the significant superiority of LP placement using ultrasonography compared to other methods and this superiority was higher in patients with BMI>30 and those who did not have proper landmarks (129).

#### • Nasogastric tube placement

Traditional methods used for confirming nasogastric tube (NGT) placement such as kidney, ureter, and bladder (KUB) x-ray with contrast, pH test of stomach secretions and etc. are time consuming and do not always have 100% sensitivity or specificity (130). Auscultation with stethoscope is not reliable, especially in crowded places like ED, and pulmonary sounds might be mistaken for NG sounds (131). Evaluations have shown that US can be used for stomach lumen imaging as a rapid and non-invasive method without exposing the patient to radiation. Using US for confirming the placement of gastrostomy tube (G-tube) is still a relatively new concept but recent studies support its high sensitivity and accuracy (130).

#### • Endotracheal place assessment

Various tools and methods exist for confirming the proper placement of endotracheal tube (ETT), the most common and available of which is pulmonary

auscultation (131). Studies have shown that pulmonary auscultation is an unreliable method for assessing the placement of ETT (132). In addition, using capnography also lacks sufficient accuracy in determining the placement of ETT in situations such as cardio-pulmonary arrest and long duration of ventilation with mask and bag (133). Despite some recommendation against, meanwhile, based on numerous studies and considering the ability of US to differentiate anatomic structures, such as pleura, lungs, and esophagus, and directly monitor pulmonary movements during ventilation, by using US the placement of ETT can be assessed with a high sensitivity (134-138).

### Discussion

Considering the large amount of available evidence regarding various application of US in ED, it is logical to use the tool more extensively. When it comes to trauma, detecting intra-abdominal free fluid and tamponade are among the uses of US in critical situations. On the other hand, it is useful for diagnosis of musculoskeletal injuries including bone fractures, joint dislocation, and tendon ruptures. Apparently, US is also applicable for foreign body detection and helpful regarding its removal. Differentiation of abscess and cellulitis was another challenging task in ED that can be easily resolved using US. Assessing the proper placement of ETT, NGT, or as a guide for better LP performance or inserting central and peripheral vein access or peripheral nerve block are among other uses of US. In dealing with vascular disorders, benefit of its usage for diagnosis of DVT and AAA is undeniable.

The easy and complication-free application of US devices has provided most of the physicians and

even other treatment team members with the opportunity to use them. Changes in the devices' structure and facilitation of their use in recent years have resulted in proposition of more applications for US and their consideration and assessment by researchers. It might be safe to say that ultrasonography has transformed into a tool for performing more accurate clinical examinations.

### CONCLUSIONS

The results of this review study showed that ultrasonography can be of help to EMPs as a diagnostic tool in a wide range of diseases and clinical conditions, which in turn can result in a decrease of the time needed for diagnosis, management, and disposition, and therefore improve both the quality and quantity of the service provided in ED.

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### AUTHORS' CONTRIBUTION

All authors passed four criteria for authorship contribution based on recommendations of the International Committee of Medical Journal Editors.

### Conflict OF INTEREST

None declared.

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### REFERENCES

1. Mandavia DP, Aragona J, Chan L, Chan D, Henderson SO. Ultrasound training for emergency physicians—a prospective study. *Acad Emerg Med.* 2000;7(9):1008-14.
2. Murray H, Baakdah H, Bardell T, Tulandi T. Diagnosis and treatment of ectopic pregnancy. *CMAJ.* 2005;173(8):905-12.
3. American College of Emergency Physicians. ACEP emergency ultrasound guidelines-2001. *Ann Emerg Med.* 2001;38(4):470-81.
4. Moore CL, Gregg S, Lambert M. Performance, training, quality assurance, and reimbursement of emergency physician-performed ultrasonography at academic medical centers. *J Ultrasound Med.* 2004;23(4):459-66.
5. Plummer D. Whose turf is it, anyway? Diagnostic ultrasonography in the emergency department. *Acad Emerg Med.* 2000;7(2):186-7.
6. Seyedhosseini J, Nasrelari A, Mohammadrezaei N, Karimialavijeh E. Inter-rater agreement between trained emergency medicine residents and radiologists in the examination of gallbladder and common bile duct by ultrasonography. *Emerg Radiol.* 2017;24(2):171-6.

7. Farahmand S, Safavi S, Shahriarian S, Arbab M, Basirghafoori H, Bagheri-Hariri S. Preferred view and transducer in lumbar ultrasound in overweight and obese patients. *Ultrasound*. 2017;25(1):45-52.
8. Bagheri-Hariri S, Yekesadat M, Farahmand S, Arbab M, Sedaghat M, Shahlafar N, et al. The impact of using RUSH protocol for diagnosing the type of unknown shock in the emergency department. *Emerg Radiol*. 2015;22(5):517-20.
9. Ather MH, Jafri AH, Sulaiman MN. Diagnostic accuracy of ultrasonography compared to unenhanced CT for stone and obstruction in patients with renal failure. *BMC Med Imaging*. 2004;4(1):2.
10. Patlas M, Farkas A, Fisher D, Zaghal I, Hadas-Halpern I. Ultrasound vs CT for the detection of ureteric stones in patients with renal colic. *Br J Radiol*. 2001;74(886):901-4.
11. Atkinson P, McAuley D, Kendall R, Abeyakoon O, Reid C, Connolly J, et al. Abdominal and Cardiac Evaluation with Sonography in Shock (ACES): an approach by emergency physicians for the use of ultrasound in patients with undifferentiated hypotension. *Emerg Med J*. 2009;26(2):87-91.
12. Byrne MW, Hwang JQ. Ultrasound in the critically ill. *Ultrasound Clin*. 2011;6(2):235-59.
13. Dönmez O, Mir S, Özyürek R, Cura A, Kabasakal C. Inferior vena cava indices determine volume load in minimal lesion nephrotic syndrome. *Pediatr Nephrol*. 2001;16(3):251-5.
14. Jones AE, Aborn LS, Kline JA. Severity of emergency department hypotension predicts adverse hospital outcome. *Shock*. 2004;22(5):410-4.
15. 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(8):1703-8.
16. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam: Rapid Ultrasound in SHock in the evaluation of the critically ill. *Emerg Med Clin North Am*. 2010;28(1):29-56.
17. Thomas HA, Beeson MS, Binder LS, Brunett PH, Carter MA, Chisholm CD, et al. The 2005 model of the clinical practice of emergency medicine: the 2007 update. *Acad Emerg Med*. 2008;15(8):776-9.
18. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam 2012: rapid ultrasound in shock in the evaluation of the critically ill patient. *Ultrasound Clin*. 2012;7(2):255-78.
19. Volpicelli G. Usefulness of emergency ultrasound in nontraumatic cardiac arrest. *Am J Emerg Med*. 2011;29(2):216-23.
20. Rose JS, Bair AE, Mandavia D, Kinser DJ. The UHP ultrasound protocol: a novel ultrasound approach to the empiric evaluation of the undifferentiated hypotensive patient. *Am J Emerg Med*. 2001;19(4):299-302.
21. Copetti R, Copetti P, Reissig A. Clinical integrated ultrasound of the thorax including causes of shock in nontraumatic critically ill patients. A practical approach. *Ultrasound Med Biol*. 2012;38(3):349-59.
22. Hernandez C, Shuler K, Hannan H, Sonyika C, Likourezos A, Marshall J. CAUSE: cardiac arrest ultrasound exam—a better approach to managing patients in primary non-arrhythmogenic cardiac arrest. *Resuscitation*. 2008;76(2):198-206.
23. Seif D, Mailhot T, Perera P, Mandavia D. Caval Sonography in Shock. *J Ultrasound Med*. 2012;31(12):1885-90.
24. Hossein-Nejad H, Banaie M, Davarani SS, Mohammadinejad P. Assessment of corrected flow time in carotid artery via point-of-care ultrasonography: Reference values and the influential factors. *J Crit Care*. 2017;40:46-51.
25. Mohammadinejad P, Hossein-Nejad H. Calculation of corrected flow time: Wodey's formula vs. Bazett's formula. *J Crit Care*. 2018;44:154-5.
26. Hossein-Nejad H, Mohammadinejad P, Zeinoddini A, Seyedhosseini-Davarani S, Banaie M. A new modality for the estimation of corrected flow time via electrocardiography as an alternative to Doppler ultrasonography. *Ann Noninvasive Electrocardiol*. 2018;23(1):10.1111/anec.12456.
27. Hossein-Nejad H, Mohammadinejad P, Lessan-Pezeshki M, Davarani SS, Banaie M. Carotid artery corrected flow time measurement via bedside ultrasonography in monitoring volume status. *J Crit Care*. 2015;30(6):1199-203.

28. Ghafouri H, Zare M, Bazrafshan A, Modirian E, Farahmand S, Abazarian N. Diagnostic accuracy of emergency-performed focused assessment with sonography for trauma (FAST) in blunt abdominal trauma. *Electron Physician*. 2016;8(9):2950-3.
29. Baratloo A, Banaei M, Mirbaha S. The strengths and weaknesses of ultrasound in trauma. *Sonography in Emergency Department*. Tehran: RazNahan Publisher; 2017. p. 9.
30. Brooks A, Davies B, Smethhurst M, Connolly J. Emergency ultrasound in the acute assessment of haemothorax. *Emerg Med J*. 2004;21(1):44-6.
31. Stengel D, Bauwens K, Rademacher G, Mutze S, Ekkernkamp A. Association between compliance with methodological standards of diagnostic research and reported test accuracy: meta-analysis of focused assessment of US for trauma. *Radiology*. 2005;236(1):102-11.
32. Byhahn C, Bingold TM, Zwissler B, Maier M, Walcher F. Prehospital ultrasound detects pericardial tamponade in a pregnant victim of stabbing assault. *Resuscitation*. 2008;76(1):146-8.
33. Walcher F, Weinlich M, Conrad G, Schweigkofler U, Breitskreutz R, Kirschning T, et al. Prehospital ultrasound imaging improves management of abdominal trauma. *Br J Surg*. 2006;93(2):238-42.
34. Byhahn C, Müller E, Walcher F, Seeger FH, Breitskreutz R. Prehospital echocardiography in pulseless electrical activity victims. *Anesthesiology*. 2006;105:A1735.
35. Walcher F, Kortüm S, Kirschning T, Weihgold N, Marzi I. Optimized management of polytraumatized patients by prehospital ultrasound. *Der Unfallchirurg*. 2002;105(11):986-94.
36. Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by emergency physicians. *Ann Emerg Med*. 2001;38(4):377-82.
37. Spodick DH. Acute cardiac tamponade. *N Engl J Med*. 2003;349(7):684-90.
38. Balestreri M, Czosnyka M, Hutchinson P, Steiner LA, Hiler M, Smielewski P, et al. Impact of intracranial pressure and cerebral perfusion pressure on severe disability and mortality after head injury. *Neurocrit Care*. 2006;4(1):8-13.
39. Badri S, Chen J, Barber J, Temkin NR, Dikmen SS, Chesnut RM, et al. Mortality and long-term functional outcome associated with intracranial pressure after traumatic brain injury. *Intensive Care Med*. 2012;38(11):1800-9.
40. Chesnut RM, Temkin N, Carney N, Dikmen S, Rondina C, Videtta W, et al. A trial of intracranial-pressure monitoring in traumatic brain injury. *N Engl J Med*. 2012;367(26):2471-81.
41. Bauer DF, Razdan SN, Bartolucci AA, Markert JM. Meta-analysis of hemorrhagic complications from ventriculostomy placement by neurosurgeons. *Neurosurgery*. 2011;69(2):255-60.
42. Binz DD, Toussaint LG, Friedman JA. Hemorrhagic complications of ventriculostomy placement: a meta-analysis. *Neurocrit Care*. 2009;10(2):253-6.
43. Carney N, Totten AM, O'reilly C, Ullman JS, Hawryluk GW, Bell MJ, et al. Guidelines for the management of severe traumatic brain injury. *Neurosurgery*. 2017;80(1):6-15.
44. Robba C, Cardim D, Tajsic T, Pietersen J, Bulman M, Donnelly J, et al. Ultrasound non-invasive measurement of intracranial pressure in neurointensive care: A prospective observational study. *PLoS Med*. 2017;14(7):e1002356.
45. Berdon WE, Slovis TL. Where we are since ALARA and the series of articles on CT dose in children and risk of long-term cancers: what has changed? *Pediatr Radiol*. 2002;32(10):699.
46. Brenner DJ, Elliston CD, Hall EJ, Berdon WE. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol*. 2001;176(2):289-96.
47. Hall EJ. Lessons we have learned from our children: cancer risks from diagnostic radiology. *Pediatr Radiol*. 2002;32(10):700-6.
48. Davis J, Czerniski B, Au A, Adhikari S, Farrell I, Fields JM. Diagnostic accuracy of ultrasonography in retained soft tissue foreign bodies: a systematic review and meta-analysis. *Acad Emerg Med*. 2015;22(7):777-87.



49. Cross KP, Warkentine FH, Kim IK, Gracely E, Paul RI. Bedside ultrasound diagnosis of clavicle fractures in the pediatric emergency department. *Acad Emerg Med.* 2010;17(7):687-93.
50. Hübner U, Schlicht W, Outzen S, Barthel M, Halsband H. Ultrasound in the diagnosis of fractures in children. *J Bone Joint Surg Br.* 2000;82(8):1170-3.
51. Marshburn TH, Legome E, Sargsyan A, Li SMJ, Noble VA, Dulchavsky SA, et al. Goal-directed ultrasound in the detection of long-bone fractures. *J Trauma.* 2004;57(2):329-32.
52. Farahmand S, Arshadi A, Bagheri-Hariri S, Shahriarian S, Arbab M, Sedaghat M. Extremity Fracture Diagnosis Using Bedside Ultrasound in Pediatric Trauma Patients Referring to Emergency Department; A Diagnostic Study. *Int J Pediatr.* 2017;5(10):5959-64.
53. Hurley ME, Keye GD, Hamilton S. Is ultrasound really helpful in the detection of rib fractures? *Injury.* 2004;35(6):562-6.
54. Siris ES, Miller PD, Barrett-Connor E, Faulkner KG, Wehren LE, Abbott TA, et al. Identification and fracture outcomes of undiagnosed low bone mineral density in postmenopausal women: results from the National Osteoporosis Risk Assessment. *JAMA.* 2001;286(22):2815-22.
55. Turk F, Kurt AB, Saglam S. Evaluation by ultrasound of traumatic rib fractures missed by radiography. *Emerg Radiol.* 2010;17(6):473-7.
56. Seyedhosseini J, Saaidian J, Taheri AH, Vahidi E. Accuracy of point-of-care ultrasound using low frequency curvilinear transducer in the diagnosis of shoulder dislocation and confirmation of appropriate reduction. *Turk J Emerg Med.* 2017;17(4):132-5.
57. Mohammadrezaei N, Seyedhosseini J, Vahidi E. Validity of ultrasound in diagnosis of tendon injuries in penetrating extremity trauma. *Am J Emerg Med.* 2017;35(7):945-8.
58. Ivanišević M, Bojić L, Eterović D. Epidemiological study of nontraumatic phakic rhegmatogenous retinal detachment. *Ophthalmic Res.* 2000;32(5):237-9.
59. Group BRRDS. Incidence and epidemiological characteristics of rhegmatogenous retinal detachment in Beijing, China. *Ophthalmology.* 2003;110(12):2413-7.
60. Yoonessi R, Hussain A, Jang TB. Bedside ocular ultrasound for the detection of retinal detachment in the emergency department. *Acad Emerg Med.* 2010;17(9):913-7.
61. Blaivas M, Theodoro D, Sierzenski PR. A study of bedside ocular ultrasonography in the emergency department. *Acad Emerg Med.* 2002;9(8):791-9.
62. Elia J, Borger R. Diagnosis of retinal detachment in the ED with ultrasonography. *J Emerg Med.* 2009;37(4):415-6.
63. Rabinowitz R, Yagev R, Shoham A, Lifshitz T. Comparison between clinical and ultrasound findings in patients with vitreous hemorrhage. *Eye (Lond).* 2004;18(3):253-6
64. Blaivas M. Bedside emergency department ultrasonography in the evaluation of ocular pathology. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine.* 2000;7(8):947-50.
65. Chugh J, Verma M. Role of ultrasonography in ocular trauma. *Indian J Radiol Imaging.* 2001;11(2):75-9.
66. Baratloo A, Banaei M, Mirbaha S. *Eye. Sonography in Emergency Department.* Tehran: RazNahan Publisher; 2017. p. 24.
67. Price DD, Wilson SR. Ultrasound-Guided Procedures. *Clinical Emergency Radiology.* 2017:284.
68. Kharat AT, Shah AA. Role of high resolution ultrasound in evaluation of soft tissue foreign bodies. *Med J DY Patil Univ.* 2015;8(5):582-4.
69. Orlinsky M, Knittel P, Feit T, Chan L, Mandavia D. The comparative accuracy of radiolucent foreign body detection using ultrasonography. *Am J Emerg Med.* 2000;18(4):401-3.
70. Newman AB, Arnold AM, Burke GL, O'Leary DH, Manolio TA. Cardiovascular disease and mortality in older adults with small abdominal aortic aneurysms detected by ultrasonography: the cardiovascular health study. *Ann Intern Med.* 2001;134(3):182-90.

71. Blanchard JF, Armenian HK, Friesen PP. Risk factors for abdominal aortic aneurysm: results of a case-control study. *Am J Epidemiol.* 2000;151(6):575-83.
72. Kuhn M, Bonnin RL, Davey MJ, Rowland JL, Langlois SLP. Emergency department ultrasound scanning for abdominal aortic aneurysm: accessible, accurate, and advantageous. *Ann Emerg Med.* 2000;36(3):219-23.
73. Hayter RG, Rhea JT, Small A, Tafazoli FS, Novelline RA. Suspected aortic dissection and other aortic disorders: multi-detector row CT in 373 cases in the emergency setting. *Radiology.* 2006;238(3):841-52.
74. Nienaber CA, Fattori R. Aortic diseases-do we need MR techniques? *Herz.* 2000;25(4):331-41.
75. Koschyk DH, Meinertz T, Hofmann T, Kodolitsch YV, Dieckmann C, Wolf W, et al. Value of Intravascular Ultrasound for Endovascular Stent-Graft Placement in Aortic Dissection and Aneurysm. *J Card Surg.* 2003;18(5):471-7.
76. Robert-Ebadi H, Righini M. Management of distal deep vein thrombosis. *Thromb Res.* 2017;149:48-55.
77. Lapidus L, De Bri E, Ponzer S, Elvin A, Norén A, Rosfors S. High sensitivity with color duplex sonography in thrombosis screening after ankle fracture surgery. *J Thromb Haemost.* 2006;4(4):807-12.
78. Lichtenstein DA. The BLUE-Protocol, Venous Part: Deep Venous Thrombosis in the Critically Ill. Technique and Results for the Diagnosis of Acute Pulmonary Embolism. *Lung Ultrasound in the Critically Ill: Springer;* 2016. p. 123-42.
79. Katz DS, Hon M. Current DVT imaging. *Tech Vasc Interv Radiol.* 2004;7(2):55-62.
80. Farahmand S, Farnia M, Shahriaran S, Khashayar P. The accuracy of limited B-mode compression technique in diagnosing deep venous thrombosis in lower extremities. *Am J Emerg Med.* 2011;29(6):687-90.
81. Cibinel GA, Casoli G, Elia F, Padoan M, Pivetta E, Lupia E, et al. Diagnostic accuracy and reproducibility of pleural and lung ultrasound in discriminating cardiogenic causes of acute dyspnea in the emergency department. *Intern Emerg Med.* 2012;7(1):65-70.
82. Seyedhosseini J, Bashizadeh-fakhar G, Farzaneh S, Momeni M, Karimialavijeh E. The impact of the BLUE protocol ultrasonography on the time taken to treat acute respiratory distress in the emergency department. *Am J Emerg Med.* 2017;35(12):1815-8.
83. Vitturi N, Soattin M, Allemand E, Simoni F, Realdi G. Thoracic ultrasonography: a new method for the work-up of patients with dyspnea. *J Ultrasound.* 2011;14(3):147-51.
84. Zanobetti M, Poggioni C, Pini R. Can chest ultrasonography replace standard chest radiography for evaluation of acute dyspnea in the ED? *Chest.* 2011;139(5):1140-7.
85. Frassi F, Gargani L, Tesorio P, Raciti M, Mottola G, Picano E. Prognostic value of extravascular lung water assessed with ultrasound lung comets by chest sonography in patients with dyspnea and/or chest pain. *J Card Fail.* 2007;13(10):830-5.
86. Dick EA, Varma D, Kashef E, Curtis J. Use of advanced imaging techniques during visits to emergency departments—implications, costs, patient benefits/risks. *Br J Radiol.* 2016;89(1061):20150819.
87. Birnbaum BA, Wilson SR. Appendicitis at the millennium. *Radiology.* 2000;215(2):337-48.
88. Paulson EK, Kalady MF, Pappas TN. Suspected appendicitis. *N Engl J Med.* 2003;348(3):236-42.
89. Rumack CM, Wilson SR, Charboneau JW. *Diagnostic ultrasound vol 1: London: Mosby, 2005; 2005.*
90. Zielke A, Sitter H, Rampp T, Bohrer T, Rothmund M. Clinical decision-making, ultrasonography, and scores for evaluation of suspected acute appendicitis. *World J Surg.* 2001;25(5):578-84.
91. Karimi E, Aminianfar M, Zarafshani K, Safaie A. The Accuracy of Emergency Physicians in Ultrasonographic Screening of Acute Appendicitis; a Cross Sectional Study. *Emergency.* 2017;5(1):e22.
92. Sammalkorpi H. Diagnosis of acute appendicitis: Diagnostic scoring and significance of preoperative delay. 2017.
93. Strohmaier WL. Diagnostic imaging in pediatric urolithiasis. *J Pediatr Biochem.* 2014;4(2):81-8.
94. Abdel-Gawad M, Kadasne R, Anjekar C, Elsobky E. Value of color doppler ultrasound, kub and urinalysis in diagnosis of renal colic due to ureteral stones. *International braz j urol.* 2014;40(4):513-9.

95. Marx J, Walls R, Hockberger R. Rosen's Emergency Medicine-Concepts and Clinical Practice E-Book: Elsevier Health Sciences; 2013.
96. Butler K. Incision and drainage. In: Roberts J, Hedges J, editors. Clinical Procedures in Emergency Medicine. 4 ed. Philadelphia: PA : Saunders; 2004. p. 717-26.
97. Chao H-C, Lin S-J, Huang Y-C, Lin T-Y. Sonographic evaluation of cellulitis in children. *J Ultrasound Med.* 2000;19(11):743-9.
98. Squire BT, Fox JC, Anderson C. ABCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. *Acad Emerg Med.* 2005;12(7):601-6.
99. Chandwani D, Shih R, Cochrane D. Bedside emergency ultrasonography in the evaluation of a perirectal abscess. *Am J Emerg Med.* 2004;22(4):315.
100. Blaivas M. Ultrasound-guided Breast Abscess Aspiration in a Difficult Case. *Acad Emerg Med.* 2001;8(4):398-401.
101. Page-Wills C, Simon BC, Christy D, Levitt MA. Utility of ultrasonography on emergency department management of suspected cutaneous abscess. *Acad Emerg Med.* 2000;7(5):493.
102. Lyon M, Blaivas M. Intraoral ultrasound in the diagnosis and treatment of suspected peritonsillar abscess in the emergency department. *Acad Emerg Med.* 2005;12(1):85-8.
103. Abrahams M, Aziz M, Fu R, Horn J-L. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block: a systematic review and meta-analysis of randomized controlled trials. *Br J Anaesth.* 2009;102(3):408-17.
104. Oberndorfer U, Marhofer P, Bösenberg A, Willschke H, Felfernig M, Weintraud M, et al. Ultrasonographic guidance for sciatic and femoral nerve blocks in children. *Br J Anaesth.* 2007;98(6):797-801.
105. Domingo-Triadó V, Selfa S, Martínez F, Sánchez-Contreras D, Reche M, Tecles J, et al. Ultrasound guidance for lateral midfemoral sciatic nerve block: a prospective, comparative, randomized study. *Anesth Analg.* 2007;104(5):1270-4.
106. Macaire P, Singelyn F, Narchi P, Paqueron X. Ultrasound-or nerve stimulation-guided wrist blocks for carpal tunnel release: a randomized prospective comparative study. *Reg Anesth Pain Med.* 2008;33(4):363-8.
107. Sauter AR, Dodgson MS, Stubhaug A, Halstensen AM, Klaastad Ø. Electrical nerve stimulation or ultrasound guidance for lateral sagittal infraclavicular blocks: a randomized, controlled, observer-blinded, comparative study. *Anesth Analg.* 2008;106(6):1910-5.
108. Casati A, Danelli G, Baciarello M, Corradi M, Leone S, Di Cianni S, et al. A prospective, randomized comparison between ultrasound and nerve stimulation guidance for multiple injection axillary brachial plexus block. *Anesthesiology.* 2007;106(5):992-6.
109. Marhofer P, Sitzwohl C, Greher M, Kapral S. Ultrasound guidance for infraclavicular brachial plexus anaesthesia in children. *Anaesthesia.* 2004;59(7):642-6.
110. Chan VW. Applying ultrasound imaging to interscalene brachial plexus block. *Reg Anesth Pain Med.* 2003;28(4):340-3.
111. Casati A, Baciarello M, Cianni SD, Danelli G, De Marco G, Leone S, et al. Effects of ultrasound guidance on the minimum effective anaesthetic volume required to block the femoral nerve. *Br J Anaesth.* 2007;98(6):823-7.
112. Eichenberger U, Greher M, Kirchmair La, Curatolo M, Moriggl B. Ultrasound-guided blocks of the ilioinguinal and iliohypogastric nerve: accuracy of a selective new technique confirmed by anatomical dissection. *Br J Anaesth.* 2006;97(2):238-43.
113. Costantino TG, Fojtik JP. Success rate of peripheral IV catheter insertion by emergency physicians using ultrasound guidance. *Acad Emerg Med.* 2003;10(5):487.

114. Costantino TG, Parikh AK, Satz WA, Fojtik JP. Ultrasonography-Guided Peripheral Intravenous Access Versus Traditional Approaches in Patients With Difficult Intravenous Access. *Ann Emerg Med.* 2005;46(5):456-61.
115. Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. *Acad Emerg Med.* 2002;9(8):800-5.
116. Chiang VW, Baskin MN. Uses and complications of central venous catheters inserted in a pediatric emergency department. *Pediatr Emerg Care.* 2000;16(4):230-2.
117. Dunning J, Williamson J. Ultrasonic guidance and the complications of central line placement in the emergency department. *Emerg Med J.* 2003;20(6):551-2.
118. Stein J, George B, River G, Hebig A, McDermott D. Ultrasonographically Guided Peripheral Intravenous Cannulation in Emergency Department Patients With Difficult Intravenous Access: A Randomized Trial. *Ann Emerg Med.* 2009;54(1):33-40.
119. Brannam L, Blaivas M, Lyon M, Flake M. Emergency Nurses' Utilization of Ultrasound Guidance for Placement of Peripheral Intravenous Lines in Difficult-access Patients. *Acad Emerg Med.* 2004;11(12):1361-3.
120. Doniger SJ, Ishimine P, Fox JC, Kanegaye JT. Randomized Controlled Trial of Ultrasound-Guided Peripheral Intravenous Catheter Placement Versus Traditional Techniques in Difficult-Access Pediatric Patients. *Pediatr Emerg Care.* 2009;25(3):154-9.
121. Calvert N, Hind D, McWilliams R, Thomas S, Beverley C, Davidson A. The effectiveness and cost-effectiveness of ultrasound locating devices for central venous access: a systematic review and economic evaluation. *Health Technol Assess.* 2003;7(12):1-84.
122. Karakitsos D, Labropoulos N, De Groot E, Patrianakos AP, Kouraklis G, Poularas J, et al. Real-time ultrasound-guided catheterisation of the internal jugular vein: a prospective comparison with the landmark technique in critical care patients. *Crit Care.* 2006;10(6):R162.
123. Kusminsky RE. Complications of central venous catheterization. *J Am Coll Surg.* 2007;204(4):681-96.
124. Seyedhosseini J, Abdollahi A, Karimialavijeh E. Using real time ultrasound to correct a misplaced central venous catheter. *Visual J Emerg Med.* 2017;8:37-8.
125. Lamperti M, Bodenham AR, Pittiruti M, Blaivas M, Augoustides JG, Elbarbary M, et al. International evidence-based recommendations on ultrasound-guided vascular access. *Intensive Care Med.* 2012;38(7):1105-17.
126. Milling Jr TJ, Rose J, Briggs WM, Birkhahn R, Gaeta TJ, Bove JJ, et al. Randomized, controlled clinical trial of point-of-care limited ultrasonography assistance of central venous cannulation: the Third Sonography Outcomes Assessment Program (SOAP-3) Trial. *Crit Care Med.* 2005;33(8):1764-9.
127. Baratloo A, Banaei M, Mirbaha S. Ultrasound guided lumbar puncture. *Sonography in Emergency Department.* Tehran: RazNahan Publisher; 2017. p. 99.
128. Coley BD, Shiels li WE, Hogan MJ. Diagnostic and interventional ultrasonography in neonatal and infant lumbar puncture. *Pediatr Radiol.* 2001;31(6):399-402.
129. Nomura JT, Leech SJ, Shenbagamurthi S, Sierzenski PR, O'Connor RE, Bollinger M, et al. A Randomized Controlled Trial of Ultrasound-Assisted Lumbar Puncture. *J Ultrasound Med.* 2007;26(10):1341-8.
130. Baratloo A, Banaei M, Mirbaha S. Confirmation of Endotracheal tube by ultrasound. *Sonography in Emergency Department* Tehran: RazNahan Publisher; 2017. p. 95.
131. Kim HM, So BH, Jeong WJ, Choi SM, Park KN. The effectiveness of ultrasonography in verifying the placement of a nasogastric tube in patients with low consciousness at an emergency center. *Scand J Trauma Resusc Emerg Med.* 2012;20:38.
132. Grmec Š. Comparison of three different methods to confirm tracheal tube placement in emergency intubation. *Intensive Care Med.* 2002;28(6):701-4.

133. Milling TJ, Jones M, Khan T, Tad-y D, Melniker LA, Bove J, et al. Transtracheal 2-d ultrasound for identification of esophageal intubation. *J Emerg Med.* 2007;32(4):409-14.
134. Weaver B, Lyon M, Blaivas M. Confirmation of endotracheal tube placement after intubation using the ultrasound sliding lung sign. *Acad Emerg Med.* 2006;13(3):239-44.
135. Cunningham J, Kirkpatrick AW, Nicolaou S, Liu D, Hamilton DR, Lawless B, et al. Enhanced recognition of "lung sliding" with power color Doppler imaging in the diagnosis of pneumothorax. *JTrauma*;2002;52(4):769-71.
136. Tanigawa K, Takeda T, Goto E, Tanaka K. Accuracy and reliability of the self-inflating bulb to verify tracheal intubation in out-of-hospital cardiac arrest patients. *Anesthesiology.* 2000;93(6):1432-6.
137. Tanigawa K, Takeda T, Goto E, Tanaka K. The efficacy of esophageal detector devices in verifying tracheal tube placement: a randomized cross-over study of out-of-hospital cardiac arrest patients. *Anesth Analg.* 2001;92(2):375-8.
138. Hossein-nejad H. ETCO2 and ultrasound fail to directly confirm the depth of ETT placement. *Am J Emerg Med.* 2014;32(3):279.