International Journal of Medical Arts

Volume 4, Issue 7, July 2022

https://ijma.journals.ekb.eg/

Print ISSN: 2636-4174

Online ISSN: 2682-3780

Available online at Journal Website
https://ijma.journals.ekb.eg/
Main Subject [Cardiology]

Review Article

Point of Care Ultrasound [POCUS] in Cardiac Arrest

Muhammad Saad Reihan [1, 2]*, Eman Sobh [3, 4], Ahmed A. Abbas Hassan [5], Gihan Abdelhalim A. Ahmed [2], Mohammed Moanes Mohammed Mohyeldin [6], Mohamad A. Omar [1], Tarek Ahmed Ahmed Dabash [1], Ahmed Mohammed Ahmed Mostafa [1]

[1] Department of Cardiology, Damietta Faculty of Medicine, Al-Azhar University, Damietta, Egypt
[2] Alghad International College of Applied Medical Sciences, Jeddah, Saudi Arabia
[3] Department of Chest Diseases, Faculty of Medicine [for girls], Al-Azhar University, Cairo, Egypt
[4] Department of Respiratory Therapy, College of Medical Rehabilitation Sciences, Taibah University, Medina, Saudi Arabia
[5] Department of Anesthesiology, Theodor Bilharz Research Institute, Ministry of Higher Education and Scientific Research, Cairo, Egypt
[6] Department of Cardiology, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Article information

Received: 10-08-2022

Accepted: 12-09-2022

DOI: 10.21608/IJMA.2022.155497.1493

*Corresponding author

Email: reihancardio@gmail.com

Citation: Reihan MS, Sobh E, Hassan AAA, Ahmed GAA, Mohyeldin MMM, Omar MA, Dabash TAA, Mostafa AMA. Point of Care Ultrasound (POCUS) in Cardiac Arrest. IJMA 2022 July; 4 [7]: 2471-2478. doi: 10.21608/IJMA.2022.155497.1493.

ABSTRACT

Cardiac arrest is a medical emergency affecting many adults around the world. The quality and efficacy of cardiopulmonary resuscitation [CPR] are associated with improved survival. Reported differences in CPR performance and survival among centres have motivated the resuscitation community to develop guidelines and tools to improve CPR outcomes.

Many tools are proposed for the assessment of cardiac arrest aiming for identifying the underlying cause, especially reversible ones, assessing the response of the patient to resuscitation in order to restore the normal circulation. Each of these tools have its own limitations and even failure of improving survival rates.

Point of care ultrasound [POCUS] is increasingly used in the emergency department. The application and utilization of POCUS is still below what is expected. This may be attributed to the fact that ultrasound is operator-dependent. However, in presence of a well-trained expert, POCUS may improve outcomes of cardiopulmonary resuscitation. This review will highlight the role of POCUS in cardiac arrest.

Keywords: POCUS; Point of care ultrasound; Cardiopulmonary resuscitation; Cardiac arrest

This is an open-access article registered under the Creative Commons, ShareAlike 4.0 International license [CC BY-SA 4.0] [https://creativecommons.org/licenses/by-sa/4.0/legalcode.

Introduction

Cardiac arrest is one of the emergency medical conditions affecting more than 290 000 adults each year in the United States [US] with annual incidence rate of seven per each 1000 hospital admissions [1] and ranges from1.5 to 2.8 per 1,000 hospital admissions in Europe with nearly 55 out of hospital cardiac arrests per 100,000 inhabitants [2]. Most patients with in-hospital cardiac arrest do not survive [3]. The quality and effectiveness of cardiopulmonary resuscitation [CPR] have been linked to improved survival. The variations in the performance of CPR and survival reported at different centers motivates the resuscitation community to develop guidelines and tools to improve the outcomes of CPR by improving performance and optimizing the quality [4]. There is a gap between the knowledge of Cardiopulmonary resuscitation quality and proper implementation [4].

Several tools are used in the evaluation of the resuscitation for cardiac arrest, to improve coronary and systemic blood flow and thus improve the likelihood of return of spontaneous circulation [ROSC] [5, 6]. These tools include echocardiography, end tidal CO2 monitoring, however these tools have some limitations, such as the use of Transthoracic echocardiography [TTE] during chest compression, which is limited by transducer movement and position, and interference of providers' hands. Limitations due to transducer movement and position do not exist in Transoesophageal echocardiography [TEE] so it is preferred in advanced CPR for assessing compressions efficacy [7]. TEE can be used to assess the flow or cardiac pump during CPR, it can directly examine the movements of the cardiac walls and valve leaflets which can guide chest compression-decompression forces during CPR [8]. Incorporating the physiologic responses of the patients to CPR can improve survival and save thousands of lives [9]. These include parameters that are closely related to myocardial blood flow as end-tidal carbon dioxide [ETCO2] or diastolic blood pressure [DBP] [10]. However, the studies examining the titration of these physiologic responses in CPR are lacking and a systematic review and metanalysis showed improved ROSC but not survival in the case of clinician-reported use of physiologic monitoring [9]. So, there is a need for a new tool that can overcome these limitations and help in monitoring the quality and effectiveness of CPR.

Point of care ultrasound [POCUS] refers to the use of ultrasonography in the emergency department [ER] to solve clinical problems, narrow differential diagnosis, guide therapy, guide clinical decisions, and shorten the time to reach the diagnosis and optimize management [11]. Its utilization is increasing with the advent of new technologies and portable devices leading to decreased triage time and hence morbidity and mortality [12].

So, the objectives of this review are to highlight the role of POCUS in cardiac arrest and POCUS for diagnosis of cardiac arrest: In CPR, point-of-care ultrasound [POCUS] can be a powerful tool to diagnose reversible causes of cardiac arrests, such as pulmonary embolism, tamponade, tension pneumothorax, and hypo-volemia [5, 6]. It can also differentiate between true asystole and pseudo asystole. However, it requires a trained operator and should take into consideration the need to reduce interruptions during chest compressions. Besides in cases of massive pulmonary embolism, right ventricular dilation should not be used as the sole evidence for diagnosis during cardiac arrest. Furthermore, POCUS should not be used as a sole indicator to terminate CPR [13]. The European Society of Cardiology reported that ultrasound may improve diagnosis and change management throughout the entire course of acute care for patients with cardiac arrest [14].

Role of POCUS in cardiopulmonary resuscitation [CPR]

The American Society of Echocardiography and the American College of Emergency Physicians established a consensus on cardiac ultrasound applications in the emergency department [2010] summarized the goals of focused ultrasound in cardiac arrest into three major categories :[i] distinguish between an organized cardiac rhythm from asystole, true PEA [pulseless electrical activity] and Pseudo-PEA; [ii] searching for reversible causes of cardiac arrest and [iii] performing ultrasound-guided procedures during CPR and then in [ROSC] [15]. And hence its incorporation into cardiac resuscitation guidelines [16, 17]. The values of POCUS in CPR are highlighted below

1. Identification of the cause of cardiac arrest and differentiating different cardiac rhythms: The main benefit of POCUS in cardiac arrest is proposed in non-shockable rhythms [i.e., pulseless electrical activity and asystole], as it can identify reversible causes of cardiac arrests, such as tamponade, pulmonary embolism, hypovolemia, and tension pneumothorax [5, 6]. POCUS is very helpful in differentiating true asystole from fine ventricular fibrillation which seems to be difficult sometimes by rhythm analysis and this is important in the treatment since ventricular fibrillation will benefit from early defibrillation and hence good chances of ROSC and survival [18, 19].

2. Assessment of the effectiveness of CPR: The effectiveness of the chest compressions is of supreme importance in CPR since ROSC and survival are associated with adequate chest compression. In advanced CPR. It can provide instantaneous monitoring of squeezing and relaxation of the heart chambers. Several studies have shown that the maximal compressions zone when pressing the chest several times results in non-pumping in a large proportion of patients, as it is compressed primarily on the ascending aorta, aortic root, or left ventricular outflow tract, but not on the left ventricle [20, 21]. Therefore, POCUS may be helpful to adjust the applied forces and the position of the hand to improve chest compressions [7]. There are still arguments about the use of POCUS in resuscitation of out-of-hospital cardiac arrests. Some authors claim that it may prolong CPR intervals due to difficulties in obtaining and interpreting images during the 10-seconds CPR pause and hence adversely affect the outcomes of CPR [22, 23]. While others proposed that cardiac arrest sonographic assessment [CASA] can be performed rapidly using the phased array transducer to examine for pericardial effusion, presence of right heart strain pattern as an indicator for pulmonary embolism, and cardiac activity. Thus, diagnosing of the reversible causes [cardiac tamponade and pulmonary embolism] rapidly which improves prognosis [24]. Using POCUS for the diagnosis of reversible causes of cardiac arrest widely improves the diagnosis as these causes [pericardial tamponade, pneumothorax, pulmonary embolism, and hypovolemia] can also cause false pulseless electrical activity [PEA]. Distinguishing between false and true PEA using ultrasound can contribute positively to patient outcomes if POCUS does not interfere with CPR [25].

3. Guided diagnostic/therapeutic interventions during CPR: POCUS-guided pericardiocentesis, needle decompression, thrombolysis, and fluid challenges can all be performed during CPR [7, 26]. Thus, the use of POCUS in CPR can improve management in many patients [7, 26, 27].

Precautions for POCUS

1. **Probe and views:** a phased array cardiac transducer for the echocardiographic examination, and all images should be recorded for review [24]. The curvilinear [abdominal] probe may also be used if the phased array is not available [14]. The subcostal, apical, and parasternal long axis views, have been designated in the cardiac arrest literature, but usually any one view is satisfactory if it provides the operator with all the answers he is looking for [7, 14]. The initial cardiac evaluation often utilizes the subxiphoid view because cardiac compressions make the anterior chest difficult to access. The parasternal long-axis may also be used, but the scanning gel should be removed from the chest after each echocardiographic evaluation. Leaving the gel on the chest may impair cardiac compression and stick defibrillation pads. The best view of the heart depends on the internal pathology of the patient. Patients with chronic lung disease [e.g., COPD] are often best imaged from the subxiphoid view, but the location of the heart can vary widely. Having only one view per pause is recommended [24]. Also, a quick view of the lungs can be obtained while checking the pulse again to look for absent lung sliding in case of tension pneumothorax [28].

2. **POCUS should not delay chest compressions:** The early use of POCUS in cardiac resuscitation gives higher chances of survival if potentially reversible causes of arrest were identified and addressed early. Although the use of ultrasound in arrest is strongly encouraged, users should be aware of potential harm if not applied properly. Most importantly, the application of ultrasound in the event of cardiac arrest should not interrupt or interfere with chest compressions [14, 16]. Increased time of pulse check and chest compressions during CPR have been confirmed in previous studies to be increased with the use of POCUS but they did not advise against the use of POCUS rather than advised for proper training and optimal performance [22, 23].

3. **Level of competency:** a certain level of competence should be present for ER personnel who will perform CPR using POCUS. Training to obtain different cardiac windows, analysis of various cardiac diseases as well as training to

integrate POCUS screening into advanced life support process without delaying chest compressions. But no recent guidelines recommending specific hours of training [14, 16]. One study advised for six-months training allowed for efficient use of bedside ultrasound [29].

4. Timing of POCUS: some authors recommend performing focused echocardio-graphy in the evaluation of resuscitation [FEER] after five cycles of high-quality CPR [7]. Or early once high-quality chest compressions are achieved and then repeating it prior to termination of CPR to assess if the patient is having a cardiac standstill. Ultrasound also plays a major role after ROSC has been achieved. Causes of reversible shock that are usually not evident during CPR can be easily identified using ultrasound - e.g., wall motion abnormalities in patients with acute myocardial infarction. Ultrasound can also guide fluid administration during ROSC by scanning the inferior vena cava and reassessing the lungs for the development of pulmonary oedema [30].

5. Improved image acquisition: In order to improve image acquisition, the heart window can be acquired while CPR is in progress prior to checking the pulse [30].

Cardiac Arrest Sonographic Assessment [CASA] exam protocol

This protocol has been published in 2018 by **Gardner *et al.*** [24] The CASA protocol is composed of a three-step ultrasound-guided evaluation of patients in cardiac arrest. Acquisition of primary images focuses on excluding cardiac tamponade. The second image attempts to exclude right ventricular strain secondary to pulmonary embolism. The third presentation is the last step of the protocol and is performed at the end of resuscitation to determine cardiac standstill [24]. The protocol is simple and can be easily trained. There was a reduction in pulse check interruptions when tested making it an attractive tool to be integrated into CPR [30, 31].

The cardiac activity can be recorded while checking the pulse and reviewing it when CPR is resumed. This can be repeated on the next pulse check if a suitable image is not obtained the first time. In the absence of cardiac activity, M-mode can be used to confirm the presence or absence of any cardiac activity [30]. Also, a specific team member is set to say the "countdown" out loud during the scan to reduce delays between compressions. The operator performing the scan can also keep towels and tissues ready to remove the chest gel immediately before resuming compression [30].

Scanning goals

1. Identification of reversible causes of cardiac arrest

The C.A.U.S.E. protocol [Cardiac Arrest Ultra-Sound Exam] is a systematic algorithm to identify the four most important causes of cardiac arrest [28]. These reversible causes include right ventricular dilatation in pulmonary embolism, pericardial fluid in pericardial tamponade, ventricular collapse in hypo-volemia, and absent lung sliding in tension pneumothorax. The authors also suggested additional views that could be obtained in the case of hypovolemia such as the IVC to confirm the 'empty reservoir', as well as the abdominal aorta to evaluate aneurysms as the cause of hypovolemia [28]. The 2010 American Society of Echocardiography and American College of Emergency Physicians guidelines recommend the use of POCUS only in pulseless electrical activity [PEA] or asystole and inhibit its use in a shockable rhythm. Their justification is reasonable because identification of ventricular fibrillation or pulseless ventricular tachycardia should be followed by immediate shock delivery and resumption of chest compressions. Screening for pathologies such as wall motion abnormalities or hypertrophic cardiomyopathy is unlikely to affect management during CPR, but should be determined after ROSC. However, **Hussein *et al*.** believed that there are exceptions where ultrasound may be valuable in such scenarios, especially if ventricular fibrillation is refractory to treatment [30]. Cardiac arrest due to pulmonary embolism presenting with ventricular fibrillation can occur in 5% of cases. In such a case, ultrasound may prompt the doctor to administer thrombolytic agents. Refractory ventricular fibrillation and wall motion abnormality as shown by ultrasound may benefit from coronary intervention even with continuous CPR [31].

2. Right ventricular heart strain in cardiac arrest

Many studies use POCUS to search for right ventricular dilatation in cases of cardiac arrest due to pulmonary embolism [15, 28]. However, increasing evidence indicates that this may be an ineffective method of judgment in the diagnosis. The presence of a pulmonary embolus can certainly lead to right heart strain which can manifest as right ventricular dilation, however, there are other factors that have also been shown to produce similar right-sided enlargement during cardiac arrest, such as hypovolemia, hyperkalaemia, primary arrhythmia, and pre-existing chronic right ventricular strain [32, 33]. Indeed, an interesting aspect to consider is the phenomenon that some degree of RV dilatation may occur normally during resuscitation of cardiac arrest. **Wardi *et al*.** [34] reported that RV strain and dilatation were more pronounced with increasing time in resuscitation. The European Society of Cardiology - ESC 2019 - guidelines on pulmonary embolism addressed the precision of RV dilatation in pulmonary embolism. Although RV dilatation plays a vital predictive role in stable patients with pulmonary embolism, it has a rather poor positive predictive value for pulmonary embolism-related mortality. This relative insensitivity is due in part to the inherent difficulty in standardizing ultrasound for any study [35].

In view of the occurrence of such false positives when imaging the right side of the heart during cardiac arrest, the diagnosis of pulmonary embolism and any following intervention dependent on this should be increased by factors other than the isolated right heart strain on POCUS. Old details of pre-arrest signs and symptoms, as well as potential assessments during a cardiac arrest for DVT in high-risk patients, could prove useful measures for the diagnosis and treatment of pulmonary embolism during cardiac arrest. Also, the increasing presence of false-positive results late in resuscitation is prompting consideration of incorporating ultrasound assessments early into cardiac arrest procedures [36].

3. Identification of cardiac standstill

Cardiac standstill or true asystole is defined as the complete absence of any cardiac motion including the ventricles, atria, and valves [30, 37]. Patients who are identified in a standstill with accompanying electrical activity on the monitor are often described as having true PEA. Pseudo-PEA is the presence of ventricular contractility imaged by ultrasound with electrical activity but no perceptible pulse [15].

The M-mode option on ultrasound detects any motion along a given line against time. If any movement is identified that part of the heart will look hazy like “sand on a beach”. When there is a complete absence of cardiac contractility, the image will resemble a “barcode” appearance. The determination of true PEA or cardiac standstill on ultrasound has important prognostic value [30].

A large prospective study examining cardiac arrest conducted by **Blaivas and colleagues** [38] reported out of 169 patients enrolled, 136 patients were found to be at a cardiac standstill with a zero percent survival rate irrespective of the electrical rhythm detected at presentation. On the other hand, 20 out of 33 patients with cardiac activity on initial ultrasound survived. The average patient age in this study was 71 years, which may represent a greater number of elderly people than is usually found in other centres. The significant limitation of the study was that it only included out-of-hospital arrests where the survival rate is lower than in-hospital arrests. No data on survival to discharge from hospital or neurological outcomes were provided [38]. Similar findings were reported in previous studies [37, 39]. However, in the former study, 2 out of 59 patients with no cardiac activity survived.

In 2010, one of the highest survival rates for patients without wall motion was described by **Breitkreutz *et al*.** [7] as five [10%] out of 50 patients without cardiac activity survived. His results also established that the presence of wall motion could predict a much higher survival rate [n = 30/75, 40%].

The findings of these studies indicate that cardiac standstill at initial POCUS is a poor prognostic factor and may be an indicator of certain mortality [38].

4. BLUE protocol for emergency ultrasound

This protocol was described by **Lichtenstein** [40] for the detection of causes of acute dyspnoea in ER. It involves scanning of 3 areas of each lung and takes three minutes. The sensitivity and specificity of lung ultrasound for the diagnosis of pneumothorax are very high. Pneumothorax can be seen as absent lung sliding on M-mode plus the presence of multiple A-lines with the absence of B-lines “the stratosphere sign” with 100% specificity. In addition, the presence of “lung point” sign is pathognomonic for pneumothorax. The presence of "A profile" associated with DVT has a high specificity for pulmonary embolism. Pulmonary oedema can be seen as increased B lines "lung Rockets". it can differentiate cardiogenic from non-cardiogenic pulmonary oedema, diagnose pneumonia, and atelectasis. However, this protocol needs high skills in performance during cardiac arrest and CPR.

The future role of POCUS

Point-of-care ultrasound is a rapidly expanding science with new applications being published every year. POCUS can be practical to chest compression quality by directly visualizing left ventricular contraction and modulating hand position [30]. Ultrasound may also be applied to check the pulse between CPR cycles. Some studies in the past have shown that manual pulse checks have poor sensitivity and specificity, with some studies showing that pulse check accuracy is as low as 15% when limited to the allowed ten seconds [30]. Ultrasound certainly provides more reliable answers regarding cardiac output through direct visualization of ventricular contractility. Finally, there is increasing evidence supporting the use of TEE in cardiac arrest. TEE can provide the team with live feedback about the heart's condition throughout the entire resuscitation process. It provides better image resolution, is applicable to all body habitus, and may limit pauses in chest compressions because image acquisition is much faster compared to TTE [30].

Conclusion

During CPR, POCUS is useful in identifying reversible sources of cardiac arrest; separating between true and false asystole along with observing the total procedure of CPR. Visualization of cardiac motion on ultrasound during CPR is the best predictor of survival; while a cardiac standstill is associated with the worst prognosis. However, ultrasound alone can't be utilized to decide the termination of resuscitation. Finally, the effectiveness of chest compressions is a promising concern that can be assessed using POCUS, especially TEE.

REFERENCES

1. Andersen LW, Holmberg MJ, Berg KM, Donnino MW, Granfeldt A. In-Hospital Cardiac Arrest: A Review. JAMA. 2019 Mar 26;321[12]:1200-1210. doi: 10.1001/jama.2019.1696.
2. Gräsner JT, Herlitz J, Tjelmeland IBM, Wnent J, Masterson S, Lilja G, *et al*. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe. Resuscitation. 2021 Apr;161:61-79. doi: 10.1016/j.resuscitation.2021.02.007.
3. Girotra S, Nallamothu BK, Spertus JA, Li Y, Krumholz HM, Chan PS; American Heart Association Get with the Guidelines–Resuscitation Investigators. Trends in survival after in-hospital cardiac arrest. N Engl J Med. 2012 Nov 15;367[20]:1912-20. doi: 10.1056/NEJMoa1109148.
4. Meaney PA, Bobrow BJ, Mancini ME, Christenson J, de Caen AR, Bhanji F, *et al.*; CPR Quality Summit Investigators, the American Heart Association Emergency Cardiovascular Care Committee, and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Cardiopulmonary resuscitation quality: [corrected] improving cardiac resuscitation outcomes both inside and outside the hospital: a consensus statement from the American Heart Association. Circulation. 2013 Jul 23;128[4]:417-35. doi: 10.1161/CIR.0b013e31829d8654.
5. Soar J, Böttiger BW, Carli P, Couper K, Deakin CD, Djärv T, *et al.* European Resuscitation Council Guidelines 2021: Adult advanced life support. Resuscitation. 2021 Apr;161:115-151. doi: 10.1016/j. resuscitation.2021.02.010..
6. Link MS, Berkow LC, Kudenchuk PJ, Halperin HR, Hess EP, Moitra VK, *et al*. Part 7: Adult Advanced Cardiovascular Life Support: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015 Nov 3;132[18 Suppl 2]:S444-64. doi: 10.1161/CIR.0000000000000261.
7. Breitkreutz R, Walcher F, Seeger FH. Focused echocardiographic evaluation in resuscitation management: concept of an advanced life support-conformed algorithm. Crit Care Med. 2007 May;35[5 Suppl]:S150-61. doi: 10.1097/01.CCM.0000260626.23848.FC.
8. Catena E, Colombo R, Volontè A, Borghi B, Bergomi P, Ottolina D, *et al*. Transesophageal echocardiography in patients with cardiac arrest: from high-quality chest compression to effective resuscitation. J Echocardiogr. 2021 Mar;19[1]: 28-36. doi: 10.1007/s12574-020-00492-8.
9. Sutton RM, French B, Meaney PA, Topjian AA, Parshuram CS, Edelson DP, *et al.*; American Heart Association's Get With The Guidelines–Resuscitation Investigators. Physiologic

monitoring of CPR quality during adult cardiac arrest: A propensity-matched cohort study. Resuscitation. 2016 Sep;106:76-82. doi: 10.1016/ j.resuscitation.2016.06.018.

10. Halperin HR, Lee K, Zviman M, Illindala U, Lardo A, Kolandaivelu A, Paradis NA. Outcomes from low versus high-flow cardiopulmonary resuscitation in a swine model of cardiac arrest. Am J Emerg Med. 2010 Feb;28[2]:195-202. doi: 10.1016/j.ajem.2009.10.006.

11. Melgarejo S, Schaub A, Noble VE. Point of care ultrasound: an overview. American College of Cardiology [Internet]. [cited 2022 Apr 13]. Available from: https://www.acc.org/latest-in-cardiology/articles/ 2017/10/31/09/57/point-of-care-ultrasound

12. Rooney KD, Schilling UM. Point-of-care testing in the overcrowded emergency department--can it make a difference? Crit Care. 2014 Dec 8;18[6]:692. doi: 10.1186/s13054-014-0692-9.

13. Reynolds JC, Del Rios M. Point-of-care cardiac ultrasound during cardiac arrest: a reliable tool for termination of resuscitation? Curr Opin Crit Care. 2020 Dec;26[6]:603-611. doi: 10.1097/MCC.0000000000000766.

14. Maconochie IK, Bingham R, Eich C, López-Herce J, Rodríguez-Núñez A, Rajka T, *et al.*; Paediatric life support section Collaborators. European Resuscitation Council Guidelines for Resuscitation 2015: Section 6. Paediatric life support. Resuscitation. 2015 Oct;95:223-48. doi: 10.1016/j.resuscitation.2015.07.028.

15. Labovitz AJ, Noble VE, Bierig M, Goldstein SA, Jones R, Kort S, *et al*. Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. J Am Soc Echocardiogr. 2010 Dec;23[12]:1225-30. doi: 10.1016/j.echo.2010.10.005.

16. Truhlář A, Deakin CD, Soar J, Khalifa GE, Alfonzo A, Bierens JJ, *et al.*; Cardiac arrest in special circumstances section Collaborators. European Resuscitation Council Guidelines for Resuscitation 2015: Section 4. Cardiac arrest in special circumstances. Resuscitation. 2015 Oct;95:148-201. doi: 10.1016/j.resuscitation. 2015.07.017.

17. Perkins GD, Graesner JT, Semeraro F, Olasveengen T, Soar J, Lott C, *et al.*; European Resuscitation Council Guideline Collaborators. European Resuscitation Council Guidelines 2021: Executive summary. Resuscitation. 2021 Apr; 161:1-60. doi: 10.1016/j.resuscitation.2021.02. 003.

18. Amaya SC, Langsam A. Ultrasound detection of ventricular fibrillation disguised as asystole. Ann Emerg Med. 1999 Mar;33[3]:344-6. doi: 10.1016/s0196-0644[99]70372-0.

19. Querellou E, Meyran D, Petitjean F, Le Dreff P, Maurin O. Ventricular fibrillation diagnosed with trans-thoracic echocardiography. Resuscitation. 2009 Oct;80[10]:1211-3. doi: 10.1016/j. resuscitation.2009.06.033.

20. Hwang SO, Zhao PG, Choi HJ, Park KH, Cha KC, Park SM, *et al*. Compression of the left ventricular outflow tract during cardiopulmonary resuscitation. Acad Emerg Med. 2009 Oct;16 [10]:928-33. doi: 10.1111/j.1553-2712.2009. 00497.x.

21. Shin J, Rhee JE, Kim K. Is the inter-nipple line the correct hand position for effective chest compression in adult cardiopulmonary resuscitation? Resuscitation. 2007 Nov;75[2]: 305-10. doi: 10.1016/j.resuscitation.2007.05.003.

22. Clattenburg EJ, Wroe P, Brown S, Gardner K, Losonczy L, Singh A, Nagdev A. Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study. Resuscitation. 2018 Jan;122:65-68. doi: 10.1016/ j.resuscitation.2017.11.056.

23. Huis In 't Veld MA, Allison MG, Bostick DS, Fisher KR, Goloubeva OG, Witting MD, Winters ME. Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions. Resuscitation. 2017 Oct;119:95-98. doi: 10.1016/j.resuscitation.2017.07.021.

24. Gardner KF, Clattenburg EJ, Wroe P, Singh A, Mantuani D, Nagdev A. The Cardiac Arrest Sonographic Assessment [CASA] exam - A standardized approach to the use of ultrasound in PEA. Am J Emerg Med. 2018 Apr;36[4]:729-731. doi: 10.1016/j.ajem.2017.08.052.

25. Zengin S, Gümüşboğa H, Sabak M, Eren ŞH, Altunbas G, Al B. Comparison of manual pulse palpation, cardiac ultrasonography and Doppler ultrasonography to check the pulse in cardiopulmonary arrest patients. Resuscitation. 2018 Dec;133:59-64. doi: 10.1016/j.resuscitation. 2018.09.018.

26. Gaspari R, Weekes A, Adhikari S, Noble VE, Nomura JT, Theodoro D, *et al.* Emergency department point-of-care ultrasound in out-of-hospital and in-ED cardiac arrest. Resuscitation. 2016 Dec;109:33-39. doi: 10.1016/j.resuscitation. 2016.09.018.

27. Chardoli M, Heidari F, Rabiee H, Sharif-Alhoseini M, Shokoohi H, Rahimi-Movaghar V.

Echocardiography integrated ACLS protocol versus conventional cardiopulmonary resuscitation in patients with pulseless electrical activity cardiac arrest. Chin J Traumatol. 2012;15[5]:284-7. PMID: 23069099.

28. Hernandez C, Shuler K, Hannan H, Sonyika C, Likourezos A, Marshall J. C.A.U.S.E.: Cardiac arrest ultra-sound exam--a better approach to managing patients in primary non-arrhythmogenic cardiac arrest. Resuscitation. 2008 Feb;76[2]:198-206. doi: 10.1016/j. resuscitation.2007.06. 033.

29. Lien WC, Hsu SH, Chong KM, Sim SS, Wu MC, Chang WT, *et al*. US-CAB protocol for ultra-sonographic evaluation during cardiopulmonary resuscitation: Validation and potential impact. Resuscitation. 2018 Jun;127:125-131. doi: 10.1016/j.resuscitation.2018.01.051.

30. Hussein L, Rehman MA, Sajid R, Annajjar F, Al-Janabi T. Bedside ultrasound in cardiac standstill: a clinical review. Ultrasound J. 2019 Dec 30;11[1]:35. doi: 10.1186/s13089-019-0150-7.

31. Clattenburg EJ, Wroe PC, Gardner K, Schultz C, Gelber J, Singh A, Nagdev A. Implementation of the Cardiac Arrest Sonographic Assessment [CASA] protocol for patients with cardiac arrest is associated with shorter CPR pulse checks. Resuscitation. 2018 Oct;131:69-73. doi: 10.1016/ j.resuscitation.2018.07.030.

32. Aagaard R, Granfeldt A, Bøtker MT, Mygind-Klausen T, Kirkegaard H, Løfgren B. The Right Ventricle Is Dilated During Resuscitation From Cardiac Arrest Caused by Hypovolemia: A Porcine Ultrasound Study. Crit Care Med. 2017 Sep;45[9]:e963-e970. doi: 10.1097/CCM.00000-00000002464.

33. Andrus P, Dean A. Focused cardiac ultrasound. Glob Heart. 2013 Dec;8[4]:299-303. doi: 10.1016/j.gheart.2013.12.003.

34. Wardi G, Blanchard D, Dittrich T, Kaushal K, Sell R. Right ventricle dysfunction and echocardiographic parameters in the first 24h following resuscitation in the post-cardiac arrest patient: A retrospective cohort study. Resuscitation. 2016;103:71-74. doi: 10.1016/j. resuscitation.2016.03.009.

35. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, *et al.*; The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology [ESC]. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society [ERS]: The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology [ESC]. Eur Respir J. 2019 Oct 9;54[3]:1901647. doi: 10.1183/13993003.01647-2019.

36. Blanco P, Martínez Buendía C. Point-of-care ultrasound in cardiopulmonary resuscitation: a concise review. J Ultrasound. 2017 Jul 31;20[3]: 193-198. doi: 10.1007/s40477-017-0256-3.

37. Salen P, Melniker L, Chooljian C, Rose JS, Alteveer J, Reed J, Heller M. Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients? Am J Emerg Med. 2005 Jul;23 [4]:459-62. doi: 10.1016/j.ajem.2004.11.007.

38. Blaivas M, Fox JC. Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. Acad Emerg Med. 2001 Jun;8[6]:616-21. doi: 10.1111/j.1553-2712.2001.tb00174.x.

39. Salen P, Sierzenski P, Pancu D, O'Connor R, Passarello B, Langsam A, Amadio T, Heller M. Cardiac ultrasound evaluation of pulseless patients in the emergency department. Ann Emerg Med. 1999;4[34]:S75. doi: 10.1016/ S0196-0644[99]80376-X

40. Lichtenstein DA. Lung ultrasound in the critically ill. Ann Intensive Care. 2014 Jan 9;4[1]:1. doi: 10. 1186/2110-5820-4-1.

International Journal

https://ijma.journals.ekb.eg/
Print ISSN: 2636-4174
Online ISSN: 2682-3780

# of Medical Arts