CLINICAL VIGNETTE

Emerging Use of Point-of-Care Ultrasound in Cardiac Arrest

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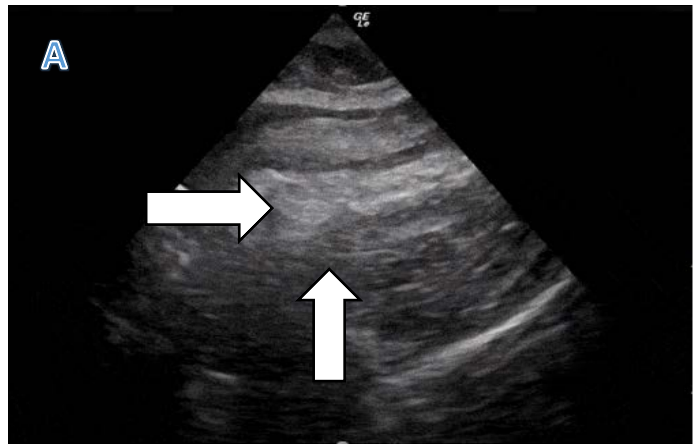
Introduction

Point-of-care ultrasound (POCUS) is a rapidly expanding practice that involves the use of ultrasound at a patient's bedside to provide real-time images to clinicians, allowing direct correlation of findings to signs and symptoms. POCUS has been shown to both improve patient satisfaction and increase diagnostic accuracy for certain medical conditions when used by physicians.[1-3] In cardiac arrest, POCUS is being increasingly used to identify the presence of cardiac activity and potentially reversible causes of arrest.[4]

Case Description

An 87-year-old male with advanced Alzheimer's dementia was witnessed to have sudden onset dyspnea while eating in the dining room of an inpatient dementia-care unit. Nursing staff assessed the patient and noted he was visibly choking and unable to talk. The nurses immediately activated a Rapid Response Emergency while initiating Heimlich maneuver abdominal thrusts. When the Rapid Response team arrived, the patient was unconscious with agonal breathing. No foreign object had been expelled. The patient had a palpable pulse on initial assessment. He was placed in a supine position and further abdominal thrusts were performed. His oropharynx was explored but no removable obstruction was visualized. At this juncture, the patient appeared to lose his palpable pulse and nursing staff informed the team that his code status was Do-Not-Resuscitate. More aggressive efforts to remove a potential foreign object were not aligned with the patient's previously stated goals of care. The patient continued agonal breathing and there was uncertainty whether he was truly pulseless. A portable ultrasound machine was used to obtain a bedside subxiphoid 4-chamber cardiac view, which demonstrated coagulated blood within motionless cardiac chambers (see Figure 1A). After the Rapid Response team leader reviewed this image, the code was discontinued, and the patient was pronounced dead.



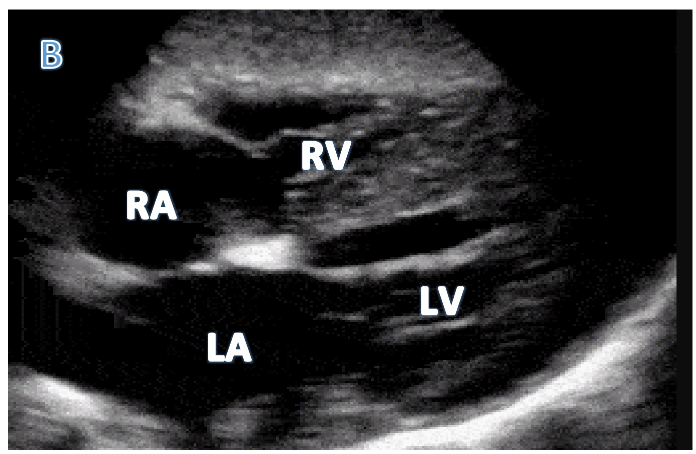


Figure 1. Comparison of ultrasonographic subxiphoid images. Figure 1A represents an image similar to our case and Figure 1B represents a normal image in a healthy patient (RV=right ventricle, RA=right atrium, LV=left ventricle, LA=left atrium). Note the presence of anechoic/black chambers in Figure 1B which represents normal perfusing blood, whereas the isoechoic and hyperechoic areas in Figure 1A (arrows) denote coagulated blood and clot.

Note. Figure 1A and 1B are still images (with arrows and abbreviations added for reference) taken from short clip recordings in "The Pocus Atlas", Figure 1A is from a clip recording by Josiane Almeida (https://www.thepocusatlas.com/echocardiography/cardiac-tamponade-in-pea, accessed 2/10/2022). Figure 1B is from a clip recording by Shahad Al Chalaby (https://www.thepocusatlas.com/normal-anatomy, accessed 2/10/2022).

Discussion

Use of POCUS has already evolved to become a standard of care in settings such as the emergency department and with bedside procedures. Use of POCUS during cardiac arrest has gained momentum because it can help guide real-time management during such events. In cardiac arrest, the ability to identify the presence or absence of a pulse as quickly as possible is essential, because the cardiac arrest algorithm relies heavily on this determination and because prolonged pauses in cardiopulmonary resuscitation (CPR) have been shown to be negatively associated with survival.[5,6] The American Heart Association has ingrained the following phrase into the training of all healthcare providers: "minimize pauses in chest compressions during cardiopulmonary resuscitation." Despite this emphasis, manual pulse checks are well known to be unreliable and time-consuming. In an observational study of 105 student healthcare providers, only 38% correctly identified a pulse within 10 seconds using a computerized manikin.[7] Even amongst healthcare professionals, pulse detection is slower than desired with one study demonstrating that 43% of participating Emergency Medicine and Critical Care doctors and nurses required more than 5 seconds to palpate a carotid pulse on healthy patient volunteers.[8] The absence of a pulse causes further delay in assessment. Eberle et al.[9] studied the evaluations of first responders on patients undergoing coronary artery bypass grafting during non-pulsatile cardiopulmonary bypass and during spontaneous circulation. When no carotid pulse was present, there was a significantly longer delay in establishing the diagnosis of pulselessness, taking 30 seconds, as compared to 15 seconds when a pulse was present and identified. Only 1 out of 59 (2%) correctly identified pulselessness within 10 seconds.

Many healthcare providers have encountered scenarios where the presence of a pulse is unclear in a cardiac arrest or in a rapidly deteriorating patient. Real-time emergency and cardiac arrest situations would likely reveal slower and less accurate assessments than demonstrated in the aforementioned studies due to the high-stress environments and poorer-perfusion states of patients involved. In our case, there was uncertainty about whether the patient was pulseless and without a perfusing rhythm. This dilemma was resolved with the use of POCUS which confirmed the absence of cardiac activity in several seconds. While there are other methods that can help assess the presence or absence of a perfusing rhythm including arterial line monitoring and end-tidal carbon dioxide monitoring, these methods are often not available nor practical as they require more time and skill to establish in a cardiac arrest situation compared to a POCUS assessment.

Point-of-care ultrasound can be used with a high degree of accuracy and efficiency to identify a central pulse or a perfusing rhythm. In cardiac arrests, POCUS has historically been used by Emergency Medicine physicians to identify possible reversible causes cardiac tamponade and right heart strain suggestive of massive pulmonary embolus and to assist with prognostication based on the presence of any ultrasonographic cardiac activity. The Reason-1 trial[10] demonstrated that the lack of any ultrasonographic cardiac activity during cardiac arrest was associated with a poorer prognosis. Of the 793 patients enrolled in this observational study who presented in cardiac arrest with pulseless electrical activity or asystole, 263 patients (33%) demonstrated cardiac activity on initial ultrasound assessment by an Emergency Medicine physician, whereas 530 (67%) had no cardiac activity on initial ultrasound. Ten of the 263 patients (3.8%) with initial cardiac activity survived to hospital discharge, whereas only 3 of the 530 patients (0.6%) without initial cardiac activity survived to hospital discharge. Cardiac activity was defined as any visible movement of the myocardium—this is sometimes termed a "cardiac quiver" and is distinguishable from a full cardiac contraction that generates a pulse. In contrast, the absence of any ultrasonographic cardiac activity is often termed "cardiac standstill." Initial cardiac activity on ultrasound was associated with increased survival to hospital discharge (OR 5.7: 1.5-21.9). The existing literature associates POCUS with a prognostic role during cardiac arrest, supporting its use by many Emergency Medicine physicians to shorten code resuscitation times after excluding reversible causes and confirming the presence of cardiac standstill.[11] More recently, POCUS has also demonstrated efficacy when assessing the carotid pulse, with healthcare providers able to consistently identify a carotid pulse in less than 5 seconds after attending a 15-minute focused ultrasound workshop.[8]

While the emphasis of this vignette is to demonstrate the utility of POCUS in cardiac arrest, a unique aspect of our specific case relates to a defining characteristic in the ultrasonographic image that we visualized. Generally, in cardiac arrest code situations where POCUS is used to identify possible cardiac activity or a perfusing rhythm, the image obtained will be similar to that displayed in Figure 1B. Movement of the cardiac chambers (full contraction vs quiver vs. standstill) will denote the effective-ness of each contraction while anechoic (black) areas within the heart chambers reveal the degree to which blood is circulated out of the chamber. In our case, the patient was deemed to be in cardiac standstill when we assessed via the subxiphoid view. Interestingly, the cardiac chambers were largely hyperechoic and isoechoic (instead of anechoic; see arrows in Figure 1A), demonstrating complete clot burden within the chambers. This is hypothesized to be secondary to post-mortem hemostasis which suggests the patient in this case was likely pulseless for at least several minutes prior to POCUS assessment. Ultrasonographic findings of complete intracardiac hemostasis are unlikely to be found during cardiac arrest code scenarios, because chest compressions during CPR will produce blood flow through the cardiac chambers which inhibits hemostasis. It is also important to emphasize this unique finding because this image could be easily mistaken for another organ or tissue due to the echogenicity of the material in the cardiac chambers.

Conclusion

Point-of-care ultrasound is being increasingly utilized in cardiac arrest. During cardiac arrest, ultrasonography can assist with the identification of a pulse or perfusing rhythm, provide prognostic information, and evaluate potentially reversible causes of arrest. While POCUS is frequently used in Emergency department and Intensive Care Unit settings, increasing exposure to POCUS and basic ultrasound concepts will allow many more healthcare providers to use this tool in the management of cardiac arrest.

REFERENCES

1. **Brennan JM, Blair JE, Goonewardena S, Ronan A, Shah D, Vasaiwala S, Brooks E, Levy A, Kirkpatrick JN, Spencer KT**. A comparison by medicine residents of physical examination versus hand-carried ultrasound for estimation of right atrial pressure. *Am J Cardiol*. 2007 Jun 1;99(11):1614-6. doi: 10.1016/j.amjcard.2007.01.037. Epub 2007 Apr 18. PMID: 17531592.
2. **Filopei J, Siedenburg H, Rattner P, Fukaya E, Kory P**. Impact of pocket ultrasound use by internal medicine housestaff in the diagnosis of dyspnea. *J Hosp Med*. 2014 Sep;9(9):594-7. doi: 10.1002/jhm.2219. Epub 2014 Jun 3. PMID: 24891227.
3. **Howard ZD, Noble VE, Marill KA, Sajed D, Rodrigues M, Bertuzzi B, Liteplo AS**. Bedside ultrasound maximizes patient satisfaction. *J Emerg Med*. 2014 Jan;46(1):46-53. doi: 10.1016/j.jemermed.2013.05.044. Epub 2013 Aug 12. PMID: 23942153.
4. **Labovitz AJ, Noble VE, Bierig M, Goldstein SA, Jones R, Kort S, Porter TR, Spencer KT, Tayal VS, Wei K**. 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. PMID: 21111923.
5. **Link MS, Berkow LC, Kudenchuk PJ, Halperin HR, Hess EP, Moitra VK, Neumar RW, O'Neil BJ, Paxton JH, Silvers SM, White RD, Yannopoulos D, Donnino MW**. 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. Erratum in: *Circulation*. 2015 Dec 15;132(24):e385. PMID: 26472995.
6. **Brouwer TF, Walker RG, Chapman FW, Koster RW**. Association Between Chest Compression Interruptions and Clinical Outcomes of Ventricular Fibrillation Out-of-Hospital Cardiac Arrest. *Circulation*. 2015 Sep 15;132(11):1030-7. doi: 10.1161/CIRCULATIONAHA. 115.014016. Epub 2015 Aug 7. PMID: 26253757.
7. **Moule P**. Checking the carotid pulse: diagnostic accuracy in students of the healthcare professions. *Resuscitation*. 2000 May;44(3):195-201. doi: 10.1016/s0300-9572(00)00139-8. PMID: 10825620.
8. **Badra K, Coutin A, Simard R, Pinto R, Lee JS, Chenkin J**. The POCUS pulse check: A randomized controlled crossover study comparing pulse detection by palpation versus by point-of-care ultrasound. *Resuscitation*. 2019 Jun;139:17-23. doi: 10.1016/ j.resuscitation.2019.03.009. Epub 2019 Mar 20. PMID: 30902687.
9. **Eberle B, Dick WF, Schneider T, Wisser G, Doetsch S, Tzanova I**. Checking the carotid pulse check: diagnostic accuracy of first responders in patients with and without a pulse. *Resuscitation*. 1996 Dec;33(2):107-16. doi: 10.1016/s0300-9572(96)01016-7. PMID: 9025126.
10. **Gaspari R, Weekes A, Adhikari S, Noble VE, Nomura JT, Theodoro D, Woo M, Atkinson P, Blehar D, Brown SM, Caffery T, Douglass E, Fraser J, Haines C, Lam S, Lanspa M, Lewis M, Liebmann O, Limkakeng A, Lopez F, Platz E, Mendoza M, Minnigan H, Moore C, Novik J, Rang L, Scruggs W, Raio C**. 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. Epub 2016 Sep 28. PMID: 27693280.
11. **Shoenberger JM, Massopust K, Henderson SO**. The use of bedside ultrasound in cardiac arrest. *Cal J Emerg Med*. 2007 May;8(2):47-50. PMID: 20440400; PMCID: PMC2860421.