Cardiac Tamponade: A Case for Point-of-Care Ultrasound

Ronald H. Wharton, MD, and Steven A. Greenstein, MD, *Manhasset, New York*

INTRODUCTION

Point-of-care ultrasound (POCUS) is increasingly being used in the evaluation of patients in the hospital. One particularly important use is in the evaluation of a critically ill patient. POCUS allows real-time diagnosis that relies heavily on a high index of clinical suspicion without labs or other modalities of imaging, which have inherent delays in acquisition and interpretation. We describe the importance of POCUS in the assessment of hypotension for a septic patient with a history of renal and heart disease.

CASE PRESENTATION

A 62-year-old man was referred to the hospital after having complained of dyspnea and intermittent chest pain. He had a history of end-stage renal disease on peritoneal dialysis, type 2 diabetes mellitus, and aortic stenosis status post–26 mm transcatheter aortic valve implantation (TAVI) placed 2 months prior. During this hospitalization he was diagnosed with COVID-19. He became anemic and progressively hypoxic and was subsequently intubated and transferred to a tertiary care facility. He was treated by the intensive care unit (ICU) staff for presumed cytokine storm. Cardiology was consulted for assistance with hypotension and evaluation of the recently placed aortic valve prosthesis. Our team arrived without any prior images to review. The patient deteriorated rapidly, becoming hypotensive without a palpable pulse. Advanced cardiac life support was initiated by the ICU team. POCUS with a portable ultrasound device was performed to evaluate the patient's clinical status. A large pericardial effusion was seen on the first image (Video 1, Figure 1). Due to the combination of hypotension and the increased intrathoracic pressure from positive pressure ventilation there was near complete compression of the heart on POCUS consistent with cardiac tamponade. With the POCUS findings and the patient's clinical presentation, we performed an emergent pericardiocentesis using the subcostal approach. In this view the needle and the heart are in different planes, making direct visualization of the needle tip without probe manipulation difficult. Therefore, we maintained the focus on the heart rather than the needle tip for the duration of the procedure. The needle was inserted at a 30° angle to the skin, 1 cm inferior and to the left of the xiphoid aimed at the middle to left clavicle. The needle was advanced while continuously aspirating. We aspirated 60 mL of serous fluid with immediate return of spontaneous circulation. Although hemodynamic improvement was consistent with pericardial drainage,[1] we used a repeat echo rather than agitated saline to confirm that we were not draining pleural or peritoneal fluid and that we were truly in the pericardium. Repeat POCUS demonstrated a decrease in effusion size and expansion of the heart (Video 2, Figure 2). At this point, a guide wire was advanced, and a pigtail was placed using the Seldinger technique for continued drainage. Six hundred fifty milliliters of fluid was drained. A repeat echo was performed showing resolution of pericardial effusion and normal LV function (Video 3, Figure 3).

VIDEO HIGHLIGHTS

Video 1: POCUS obtained in the subcostal view demonstrates a large pericardial effusion with complete compression of both the right atrium and the right ventricle. Pericardiocentesis was performed using this view.

Video 2: Repeat POCUS obtained in the subcostal view after aspiration of 60 mL of fluid demonstrates immediate expansion of the heart and decrease in effusion size. It is important to note the rapid heart rate, marked translation, and unconventional image orientation during the image acquisition, which was necessary to optimize visualization of pericardial effusion and minimize contamination of the procedural field.

Video 3: Repeat POCUS performed in the PLAX view after pericardial drain placement demonstrates resolution of pericardial effusion, TAVI, and normal LV function. A brief view of the RV outflow tract can be seen at the end of the clip. The PLAX view was used to confirm resolution to minimize contamination of the procedural field.

View the video content online at www.cvcasejournal.com.

DISCUSSION

POCUS is a useful tool in cardiac arrest. It is not only helpful in resuscitative efforts, recognizing reversible causes of arrest, but it can also identify the presence or absence of cardiac activity. Sonographic confirmation of cardiac activity leads to shorter pulse check duration while also providing improved ability to prognosticate outcomes correctly. In some Emergency Department studies, cardiac standstill carries a 100% mortality rate.[2] The use of POCUS during cardiac

From the Department of Cardiology, North Shore University Hospital, Zucker School of Medicine at Hofstra/Northwell, Manhasset, New York.

Keywords: Cardiac tamponade, Point-of-care ultrasound (POCUS), Pericardiocentesis

Conflicts of Interest: None.

Correspondence: Steven A. Greenstein, MD, North Shore University Hospital, Zucker School of Medicine at Hofstra/Northwell, Department of Cardiology, 300 Community Drive, Manhasset, New York 11030. (E-mail: *Sgreenstein2@northwell.edu*).

2468-6441
https://doi.org/10.1016/j.case.2022.05.003

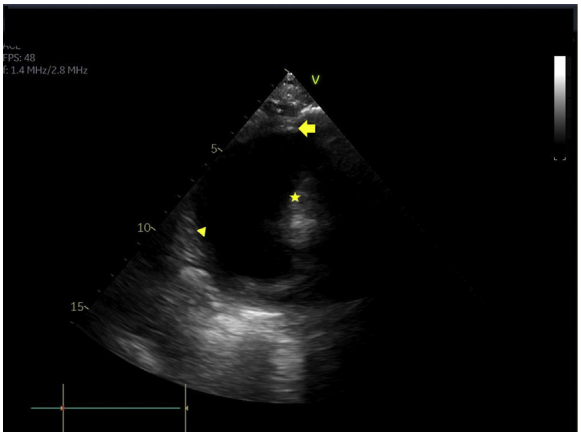

Figure 1 Two-dimensional POCUS subcostal view demonstrating a large pericardial effusion, causing compression of the right ventricle. The *yellow arrow* indicates the pericardium, the *yellow arrowhead* indicates the large pericardial effusion, and the *yellow star* indicates the compressed right ventricle.

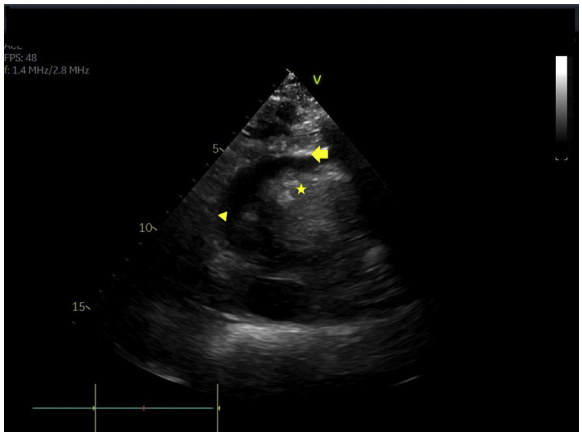

Figure 2 Two-dimensional POCUS subcostal view after removal of 60 mL of fluid demonstrating smaller pericardial effusion and expansion of the heart. The *yellow arrow* indicates the pericardium, the *yellow arrowhead* indicates the smaller pericardial effusion, and the *yellow star* indicates the right ventricle.

arrest has also changed our approach to pulseless electrical activity. Patients with organized activity are not necessarily in cardiac arrest; rather, they may be profoundly hypotensive, representing a new phase colloquially referred to as pseudo-pulseless electrical activity.[3] Identifying these patients is important because the presence of organized cardiac activity has been associated with increased survival.[4] Not only have we identified a functioning heart, but POCUS may help shift the resuscitative efforts from chest compressions to targeted therapies in profoundly hypotensive patients.

It is classically taught that cardiac tamponade can be identified at bedside using Beck's triad of muffled heart sounds, hypotension, and distended neck veins. However, this is rarely seen in practice and is undoubtedly of limited utility when a patient is in shock.[5] Beck's triad was identified in a surgical population who developed cardiac tamponade immediately due to hemorrhage or trauma. However, medical patients comprise a population that develops cardiac tamponade more slowly. In these cases, the sensitivity can be as low as 20% and the triad may not be seen at all. As clinical exam findings are insufficiently sensitive, two-dimensional echocardiography should be performed.[6] Particularly, when time is of the essence, the need for quick diagnosis has made the ubiquity of POCUS a pivotal component in the care of critically ill patients.[7]

Our case demonstrates the utility of POCUS in making a swift diagnosis leading to pericardiocentesis in a patient with hypotension and cardiac tamponade. The advantage of a handheld POCUS is its small size, portability, ease of use, and rapid image acquisition.

Multimodality imaging in suspected cardiac tamponade has been used for over 20 years and has now become the standard of care when available.[6] Pericardiocentesis guided by echocardiography can be successfully performed over 95% of the time and may reduce both the "door to pericardiocentesis time" and hospital length of stay.[8-10] Despite various success rates, the "blind" approach remains common, especially in emergency situations. Computed tomography models estimate the success rate of the blind approach can be as high as 87% using the subxiphoid approach but much lower (~60%) using the apical approach.[11] Intuitively, when performed under echo visualization, major complication rates are likely significantly reduced.

Cardiac tamponade can be identified when there is clinical suspicion and echocardiographic evidence. POCUS machines were designed to be portable and have therefore sacrificed some capabilities such as electrocardiographic gating and image-processing power to achieve a smaller and more maneuverable machine. As technology advances, probe costs have decreased. Handheld systems are now available that use silicon chip array microsensors instead of piezoelectric crystals. This allows a single probe to be used for multiple types of exams such as cardiac and vascular. A major limitation of POCUS is image quality as the machines are inherently less powerful and the operators have less experience than full-time sonographers. Furthermore, POCUS machines are more susceptible to damage when not maintained appropriately. This can lead to electromagnetic and acoustic interference and grayscale artifacts that can significantly hinder image interpretation.

There are several structured protocols that have been studied for sonographic assessment during cardiac arrest. One such protocol is the Cardiac Arrest Sonographic Assessment (CASA) exam.[12] This protocol consists of 4 steps conducted at sequential pulse checks and has been shown to decrease pulse check duration.[13]

POCUS findings of cardiac tamponade are largely made using two-dimensional and M-mode imaging. Doppler assessment is possible but often limited. When the pretest probability is high for cardiac tamponade, the provider should start with the subcostal view. This can be used to identify anterior or circumferential pericardial effusions and right heart collapse. A combination of either atrial or ventricular collapse can be seen in up to 90% of cases of cardiac tamponade.[14] It is important to note that in this view, pleural, peritoneal, and right ventricular (RV) epicardial fat can present as mimickers of pericardial effusions. They should be identified as extracardiac and outside the pericardium, which can be seen as a bright echogenic stripe (Figure 1). The probe can be quickly rotated and rocked upward to identify the inferior vena cava. In over 90% of patients the inferior vena cava will be enlarged with minimal respiratory variation. This yield is higher than physical exam markers for right atrial pressure, which are estimated to be absent in approximately 30% of patients. Additionally, the subcostal view can be obtained while chest compressions are ongoing, making it particularly helpful for our patient, who was in cardiac arrest at the time of the POCUS. Accordingly, we started with the subcostal view for our patient, and images were taken while compressions were being performed to minimize interruptions.

In our patient the etiology of cardiac arrest was immediately apparent. The parasternal long axis (PLAX) can also identify RV

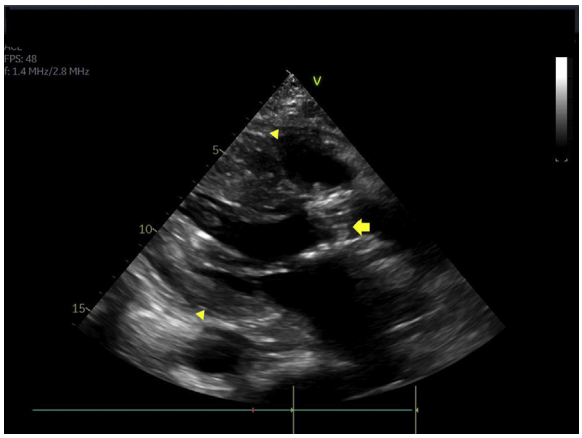

Figure 3 POCUS taken in the PLAX view after pericardial drain placement and removal of 650 mL of pericardial fluid. The TAVI valve (*yellow arrow*) is in the appropriate position, and there is complete resolution of the pericardial effusion (*yellow arrowheads*). The PLAX view was used to confirm resolution to minimize contamination of the procedural field.

dysfunction, pleural effusions, pericardial effusions, and many type A aortic dissections. Additionally, the PLAX gives a view of the anterior and posterior mitral valve leaflets, and the two-dimensional left atrial size in combination with color Doppler can be invaluable in the assessment of mitral regurgitation. In this view, the M-mode cursor can be placed through the RV free wall and the mitral valve leaflets. This can identify diastolic collapse of the right ventricle. This technique can be difficult on POCUS machines that do not have electrocardiographic gating. If the machine does not have this function, timing the RV free wall movement and mitral leaflet opening (diastole) in the M mode can be used to identify diastolic collapse. The parasternal short axis can be helpful for overall assessment of biventricular function, RV size, and septal motion. The apical views can be helpful to identify valvular pathology and biventricular function and allow for assessment of regional wall motion.

Not only does POCUS confirm the diagnosis, but echocardiography also offers the unique advantage of identifying the best window for safely draining the effusion. In our patient, we successfully identified a large effusion anterior to the right ventricle amenable to pericardiocentesis from the subcostal window while chest compressions were being performed. This minimized any interruptions during cardiopulmonary resuscitation while preparing our equipment to optimize outcomes. Additionally, we were able to estimate the depth of the effusion and the needle length needed to safely reach the effusion without damaging the heart.

Our case demonstrates the utility of a focused cardiac ultrasound, which was appropriate in this critically ill patient with hypotension.

CONCLUSION

This case highlights the importance of POCUS as an adjunct to a patient's clinical exam, leading to a rapid diagnosis and directing an intervention that led to a quick return of spontaneous circulation.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.case.2022.05.003.

REFERENCES

1. Iskandrian AS. Practical considerations in pericardiocentesis. Cathet Cardiovasc Diagn 1989;16:24.
2. Hussein L, Rehman MA, Sajid R, Annajjar F, Al-Janabi T. Bedside ultrasound in cardiac standstill: a clinical review. Ultrasound J 2019;11:35.
3. Rabjohns J, Quan T, Boniface K, Pourmand A. Pseudo-pulseless electrical activity in the emergency department: an evidence based approach. Am J Emerg Med 2020;38:371-5.
4. Gaspari R, Weekes A, Adhikari S, Noble V, Nomura JT, Theodoro D, et al. A retrospective study of pulseless electrical activity, bedside ultrasound identifies interventions during resuscitation associated with improved survival to hospital admission. A REASON study. Resuscitation 2017;120:103-7.
5. Simel DL, Roy CL, Minor MA, Brookhart M, Choudhry NK. Cardiac tamponade. In: Simel DL, Rennie D, editors. The Rational Clinical Examination: Evidence-Based Clinical Diagnosis. New York: McGraw Hill. Available at: https://jamaevidence.mhmedical.com/content.aspx?bookid=845&sectionid=61357633. Accessed March 9, 2022.
6. Klein AL, Abbara S, Agler DA, Appleton CP, Asher CR, Hoit B, et al. American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography. J Am Soc Echocardiogr 2013;26:965-101215.
7. Kobal SL, Liel-Cohen N, Shimony S, Neuman Y, Konstantino Y, Dray EM, et al. Impact of point-of-care ultrasound examination on triage of patients with suspected cardiac disease. Am J Cardiol 2016;118:1583-7.
8. Maggiolini S, Gentile G, Farina A, De Carlini CC, Lenatti L, Meles E, et al. safety, efficacy, and complications of pericardiocentesis by real-time echo-monitored procedure. Am J Cardiol 2016;117:1369-74.
9. Hanson MG, Chan B. The role of point-of-care ultrasound in the diagnosis of pericardial effusion: a single academic center retrospective study. Ultrasound J 2021;13:2.
10. Alpert EA, Amit U, Guranda L, Mahagna R, Grossman SA, Bentancur A. Emergency department point-of-care ultrasonography improves time to pericardiocentesis for clinically significant effusions. Clin Exp Emerg Med 2017;4:128-32.
11. Petri N, Ertel B, Gassenmaier T, Lengenfelder B, Bley TA, Voelker W. "Blind" pericardiocentesis: a comparison of different puncture directions. Catheter Cardiovasc Interv 2018;92:E327-32.
12. 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;36:729-31.
13. Clattenburg EJ, Wroe PC, Gardner K, Schultz C, Gelber J, Singh A, et al. Implementation of the Cardiac Arrest Sonographic Assessment (CASA) protocol for patients with cardiac arrest is associated with shorter CPR pulse checks. Resuscitation 2018;131:69-73.
14. Mercé J, Sagristà-Sauleda J, Permanyer-Miralda G, Evangelista A, Soler-Soler J. Correlation between clinical and Doppler echocardiographic findings in patients with moderate and large pericardial effusion: implications for the diagnosis of cardiac tamponade. Am Heart J 1999;138(4 Pt 1):759-64.