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THE POCUS PULSE CHECK: A CASE SERIES ON A NOVEL METHOD FOR DETERMINING THE PRESENCE OF A PULSE USING POINT-OF-CARE ULTRASOUND

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☐ **Abstract—Background: During cardiopulmonary resuscitation, pulse checks must be rapid and accurate. Despite the importance placed on the detection of a pulse, several studies have shown that health care providers have poor accuracy for detection of central pulses by palpation. To date, the use of point-of-care ultrasound (POCUS) in cardiac arrest has focused on the presence of cardiac standstill and diagnosing reversible causes of the arrest. Objective: This case series highlights a simple, novel approach to determine whether pulses are present or absent by using POCUS compression of the central arteries. Discussion: Using this technique, we found that a POCUS pulse check can be consistently performed in < 5 s and is clearly determinate, even when palpation yields indeterminate results. Conclusions: In this case series, the POCUS pulse check was a valuable adjunct that helped to change management for critically ill patients. Future prospective studies are required to determine the accuracy of this technique and the impact on patient outcomes in a larger cohort. © 2019 Elsevier Inc. All rights reserved.**

☐ **Keywords—ultrasonography; cardiac arrest; pulse check**

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INTRODUCTION

The presence or absence of a pulse is a critical factor when managing critically ill and unresponsive patients, and is used to determine an appropriate resuscitation algorithm in cardiac arrest (1). Despite the importance placed on the detection of a pulse, several studies have shown that health care providers have poor accuracy for the detection of central pulses by palpation (2,3). An incorrect determination of the presence or absence of a pulse can have significant adverse consequences for patients. For example, the incorrect determination that a pulse is present may lead to delays in cardiopulmonary resuscitation (CPR) for patients in cardiac arrest. Conversely, the incorrect determination of an absent pulse may lead to the unnecessary administration of arrest doses of highly potent vasoactive medications.

Recently, point-of-care ultrasound (POCUS) has been described as a useful tool to help differentiate true pulselessness from shock states without a palpable pulse (4). To date, most POCUS cardiac arrest literature has focused on cardiac views for the identification of coordinated cardiac activity and seeking reversible causes of the cardiac arrest, such as pericardial tamponade and signs of massive pulmonary embolism (5). However, adequate

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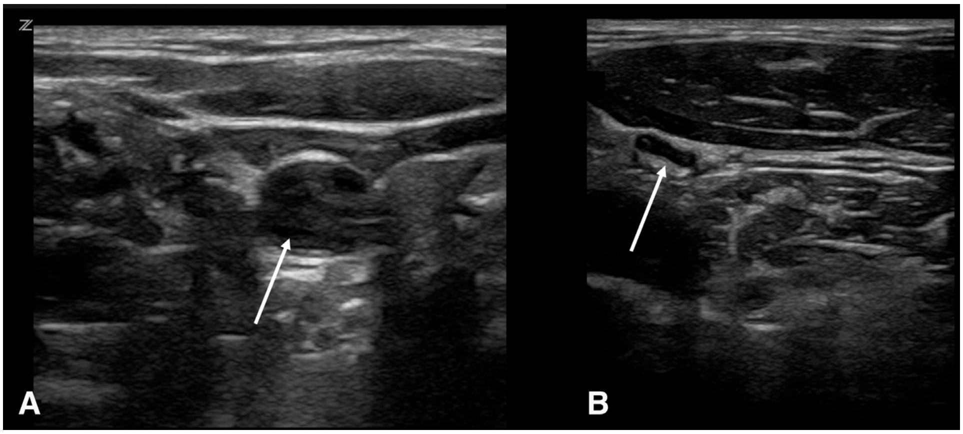

Figure 1. Comparison of a non-collapsible and pulsatile carotid artery (A) with a collapsible non-pulsatile carotid artery (B). Arrows indicate carotid artery.

cardiac views can be difficult to obtain due to patient body habitus, lack of access to the chest during CPR, and insufflation of air into the stomach during bag-valve-mask ventilation (6).

A potential alternative method for using POCUS to detect a pulse is to examine the central arteries directly. In truly pulseless patients, both the arterial and venous vasculature will be under no-flow states. Thus, both the artery and the vein will easily compress with application of pressure to the skin using a transducer. Conversely, a patient with central perfusion will have a non-compressible artery that has visible pulsations on ultrasound (Figure 1, Video 1). In this case series, we describe a simple, novel technique for rapidly and accurately detecting the presence of a central pulse using POCUS for patients in cardiac arrest.

CASE 1

An 87-year-old male walked into the emergency department (ED) after experiencing dizziness and an irregular heartbeat for the past 2 days. He had a history of atrial fibrillation, and he reported taking multiple doses of flecanide over the previous few days due to increased palpitations. In the ED, the patient had several syncopal episodes and subsequently went unresponsive. He was found to be in ventricular tachycardia and although palpation revealed no pulse, compression of his femoral artery demonstrated clear rapid pulsations (Video 2). Instead of CPR and defibrillation, a synchronized cardioversion was performed, and the patient converted into a narrow complex rhythm, but again no pulse was palpable. A repeat POCUS of the femoral artery was performed showing a pulsatile, non-compressible vessel (Figure 2, Video 3). Instead of CPR, a dopamine infusion was started with return of a palpable pulse several minutes later. He was diagnosed with flecanide toxicity and was discharged from hospital neurologically intact 11 days later.

CASE 2

A 20-year-old male was transported to the ED by ambulance in cardiac arrest after being stabbed several times. The total down time was unclear, and the patient had no palpable pulses in the field. The cardiac monitor showed a narrow complex rhythm and he was transported to hospital with CPR ongoing. The patient arrived to the ED 30 minutes after the original 9-1-1 call. On assessment, the patient was pale, and several stab wounds were noted to the chest, neck, abdomen, and extremities. Cardiac monitor revealed a narrow complex rhythm with a heart rate of 40 beats/min. Manual pulse checks were indeterminate, with some team members reporting that they felt a pulse and others reporting no palpable pulse. A POCUS of the heart was indeterminate; therefore, the transducer was moved to the neck, which revealed a

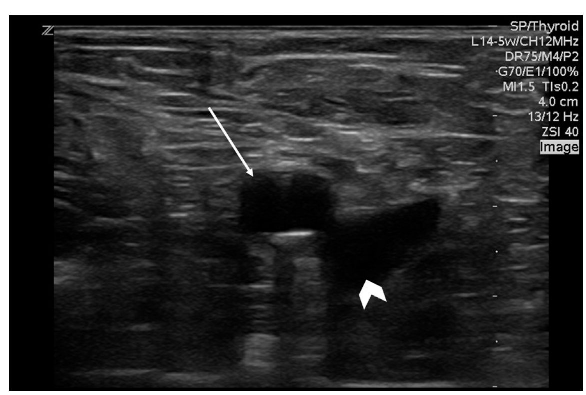

Figure 2. Point-of-care ultrasound of the right femoral artery of a patient with no palpable pulses demonstrating a pulsatile, non-compressible vessel (arrow). The arrowhead indicates the femoral vein.

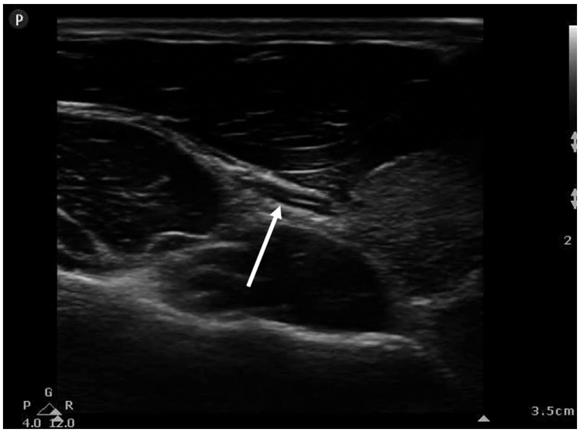

Figure 3. Point-of-care ultrasound of the right carotid artery of a patient with indeterminate pulses by palpation. The carotid artery is completely collapsed with minimal transducer pressure.

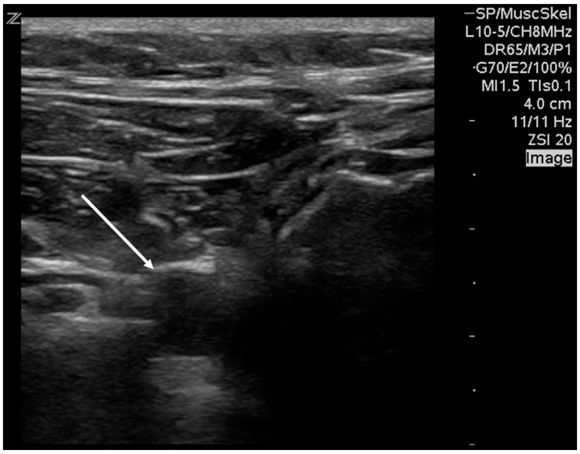

Figure 4. Point-of-care ultrasound of the right carotid artery of a patient with no palpable pulses, demonstrating a non-compressible pulsatile vessel (arrow).

completely collapsed carotid artery with no pulsations (Figure 3, Video 4). Based on the prolonged down time and absence of carotid pulse on ultrasound, the resuscitation was terminated.

CASE 3

A 63-year-old female was found by her personal support worker to be lethargic and confused. She had a history of obstructive sleep apnea, type 2 diabetes, hypertension, and congestive heart failure. Shortly after arriving to the ED, the patient was found unresponsive with no palpable pulse. CPR was initiated and 1 mg epinephrine was given intravenously. After 2 minutes, no palpable pulse was detected, but a POCUS was performed (Figure 4, Video 5), which revealed a non-compressible pulsatile carotid artery. CPR was discontinued and the patient was found to have a noninvasive blood pressure of 61/20 mm Hg and a heart rate of 80 beats/min. She was started on a norepinephrine infusion, which led to the improvement of her blood pressure and the return of a palpable pulse. The cause of the cardiac arrest was severe hypercapneic respiratory failure with a pCO_2 of 130 mm Hg. She underwent targeted temperature management in the intensive care unit (ICU) for 3 days. An electroencephalogram and magnetic resonance imaging scan showed severe anoxic-ischemic encephalopathy. The family decided to transition the patient to comfort measures and she died 9 days after her cardiac arrest.

CASE 4

A 78-year-old male with known atherosclerotic heart disease was found unresponsive at home. Paramedics arrived to find him in pulseless electrical activity (PEA). CPR was initiated, he was intubated, and given 1 mg epinephrine via intravenous line. While en route to the hospital, there was a return of spontaneous circulation. Within minutes of arrival in the ED, he once again had no palpable pulse, however, carotid POCUS showed a pulsatile, non-compressible vessel. CPR was not restarted but push-dose epinephrine was administered in 2- to 4-μg aliquots every 30 seconds. The carotid pulse was checked continuously with POCUS, and after 15 μg epinephrine, the patient had regained a mean arterial pressure of 65 mm Hg and palpable peripheral pulses. He was admitted to the ICU and discharged home neurologically intact 16 days later.

DISCUSSION

Cardiac arrest algorithms rely on the presence or absence of a pulse to determine the appropriate treatment pathway (1). Unfortunately, several studies have shown that health care providers are inaccurate at detecting pulses, and often take longer than the maximum of 10 seconds recommended by Advanced Cardiac Life Support guidelines (2,3,7,8). One study of first responders showed that only 2% of participants could recognize true pulselessness in 10 seconds (2). Other studies found that between 50% and 62% of health care providers were incorrect at detecting pulses when assessing simulated pulseless patients (3,9). Incorrect identification of a pulse can lead to delays in chest compressions, unnecessary chest compressions, or incorrect medication administration. In addition, uncertainty surrounding the presence of a pulse prolongs pauses in chest compressions, leading to reduced coronary perfusion pressure for patients in true cardiac arrest. We found similar inaccuracies in this case series, where in several cases there was uncertainty or inaccurate findings using manual pulse checks.

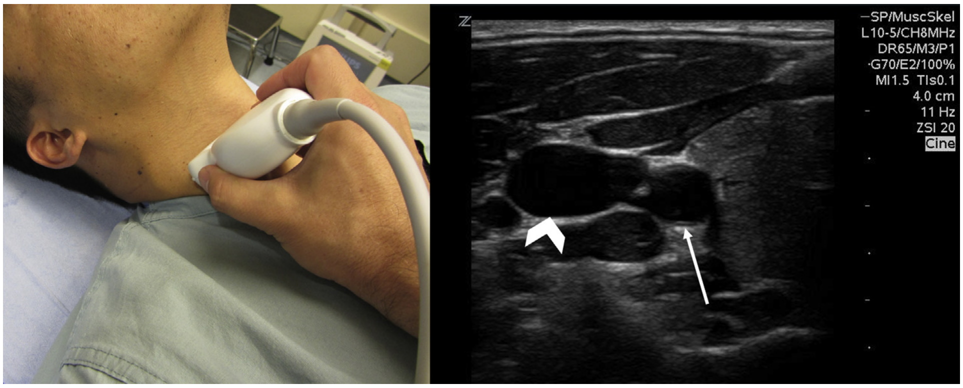

Figure 5. Transducer placement for the carotid artery. The transducer is placed in the transverse orientation lateral to the trachea with the indicator facing the operator's left. The carotid artery (arrow) is usually located medial to the internal jugular vein (arrowhead).

An easy-to-use, noninvasive method to accurately detect pulses would be of great benefit in cardiac arrest. POCUS is widely available in most hospital resuscitation environments and is commonly used to guide resuscitations. Previous studies have evaluated its use in resuscitation to help identify cardiac standstill, as well as reversible causes for shock and cardiac arrest (7,10). In this case series, we demonstrated how a novel technique using simple compression of the carotid or femoral artery can quickly and clearly demonstrate the presence or absence of pulses in cases where palpation was either indeterminate or incorrect.

The use of compression POCUS for detection of central pulses can be performed rapidly during pauses in CPR for rhythm checks. Either the carotid artery or the femoral artery may be used, depending on access to the patient. In general, the carotid artery is preferred due to its superficial anatomic location and ease of identification. A high-frequency linear array transducer should be used due to its higher resolution, however, a curvilinear or phased array transducer may be used for larger patients when evaluating the femoral artery. The transducer should be placed in a transverse orientation, with the indicator pointing toward the operator's left side. In this orientation, the artery will appear as a black circle. The carotid artery generally lies medial to the internal jugular vein (Figure 5). The common femoral artery generally lies lateral to the common femoral vein (Figure 6). Gentle compression of the artery with the transducer will reveal whether the artery collapses, and whether pulsations are present.

The use of POCUS of the central arteries has several potential advantages over cardiac POCUS during cardiac arrest. Recent studies have found an association between the use of cardiac POCUS and prolonged pulse checks beyond the recommended 10 seconds (11). This is likely due to the difficulty in visualizing the heart in this patient population from gas in the stomach or overlying soft tissues. Prior studies of intubated patients have found that up to 55% of cardiac views were inconclusive due to

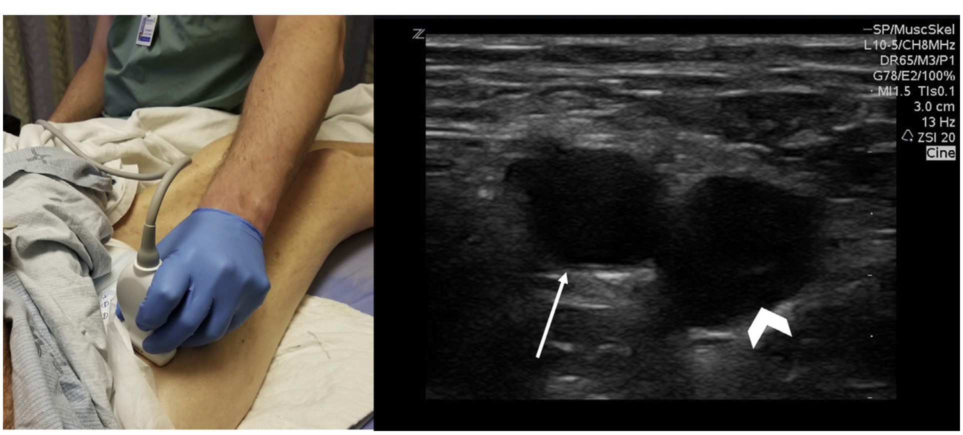

Figure 6. Transducer placement for the femoral artery. The transducer is placed in the transverse orientation in the inguinal crease with the indicator facing the operator's left. The common femoral artery (arrow) is usually located lateral to the common femoral vein (arrowhead).

poor imaging quality (6). Unlike the heart, the carotid and femoral arteries are superficial structures that are very easy to recognize, even during chest compressions, making the scan time very fast. The arteries are out of the way of the chest, allowing chest compressions to continue uninterrupted while the transducer is held in position during the 2-minute compression cycle. In all cases in this case series, the time to complete a pulse check with POCUS never exceeded 5 seconds.

Another concern with the use of cardiac POCUS for patients in cardiac arrest is the lack of agreement on what constitutes cardiac standstill. A recent study found only moderate agreement ($\alpha = 0.47$) between physician sonographers on the presence of cardiac activity, which can lead to uncertainty in decision-making and delays in chest compressions (12). It can be difficult to determine whether a poorly beating heart is generating any perfusion. One of the potential advantages of POCUS of the central arteries is that the operator can directly determine whether the cardiac contractions are sufficient to generate flow through the artery, which may be more important physiologically during a cardiac arrest.

There are potential harms to administering chest compressions to a patient who has pulses that are too weak to be palpated. First, by continuing CPR, the team resources are directed toward chest compressions instead of focusing on identifying and treating the underlying cause of shock. Second, the administration of full-dose vasopressors has been associated with worse neurologic outcomes and, therefore, should be reserved for patients in true cardiac arrest without any perfusion (13). A recent multicenter study of 793 patients found that 54.3% of patients thought to be in PEA actually had cardiac activity without palpable pulses, often referred to as "pseudo-PEA" (14). In our case series, 3 patients had pseudo-PEA that was only detected by POCUS compression of the arteries, and their profound shock states were successfully treated with immediate administration of lower-dose vasopressor infusions.

While POCUS for pulse checks appears to be a promising new technique, it does have some important limitations. It takes time to bring an ultrasound machine to the patient's bedside, power up, and prepare for scanning. During the first few minutes of a resuscitation, it is likely more feasible to perform manual pulse checks while the ultrasound machine is being prepared. However, once the ultrasound is at the bedside, we found that it was as fast as, or faster than, manual pulse checks. There is a lack of evidence on the time and training required to perform this technique, however, in our experience, it can be learned and performed quickly by any practitioner with basic ultrasound skills. POCUS of the central arteries does not provide information as to the cause of the arrest. It is not designed to replace cardiac POCUS, but it may provide a faster and potentially more reliable alternative for practitioners who are less experienced with ultrasound, or for patients with difficult sonographic windows. Whenever possible, the POCUS pulse check should be combined with a comprehensive protocol to evaluate the patient for life-threatening conditions, such as the RUSH (rapid ultrasonography for shock and hypotension) protocol (15). This case series is a preliminary proof-of-concept study, and further studies are required to determine the impact of this technique on patient-oriented outcomes, such as neurologically intact survival.

CONCLUSIONS

This case series highlights four cases where a simple, efficient, and novel POCUS pulse check technique was very effective for rapidly differentiating true cardiac arrest from occult shock states. In these cases, identification of the compressibility and pulsatility of the femoral or carotid artery impacted patient management and reduced uncertainty. Future prospective studies are needed to determine the accuracy of the POCUS pulse check for the detection of cardiac arrest and impact on patient outcomes.

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SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jemermed.2019.02.013.

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