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The Use Of Echocardiography In Prehospital Resuscitation

Abstract

Ultrasound equipment has rapidly become more affordable and portable with its use expanding almost as rapidly. Recent studies have shown that with minimal training and augmented protocols, echocardiography can improve resuscitative efforts outside the hospital in prehospital care.

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Introduction

Bedside point of care ultrasound (POCUS) has rapidly become a critical tool for emergency medicine (EM) providers in the emergency department (ED) to aid in diagnosis and procedures. One of the most common uses in EM is the evaluation of the heart by ultrasound, echocardiography. The use of electrocardiography (ECG) has been incorporated into widely utilized protocols for the rapid diagnosis and treatment of critically ill patients with potential cardiac arrhythmias. The well-known and widely accepted standards of care in Advanced Cardiac Life Support (ACLS), promoted by the American Heart Association[1] include guidelines for the immediate treatment of critically ill patients. Prehospital providers, primarily paramedics, are taught to recognize ECG arrhythmias that require rapid treatment and reversal of these arrhythmias has been linked to improved outcomes.[2]

More recently, authors of several studies [3-5] have proposed the incorporation of echocardiography into a systematic approach and algorithms in conjunction with standard ACLS measure and ECG interpretation. This is akin to the adoption of POCUS into recommended guidelines by the American College of Surgeons' Advanced Trauma Life Support (ATLS). In ATLS, bedside ultrasound is used to assess for intra-abdominal hemorrhage, a potentially "hidden" life threatening condition. A potential delay in recognition and intervention is avoided by utilizing POCUS, rather than other imaging modalities such as Computed Tomography (CT) scanning. Similarly, POCUS has been shown to aid in the early detection of life-threatening cardiac conditions outside of ECG findings with one study reporting "Echocardiographic findings altered management in 78% of cases."[6]

Benefits of early echocardiography

The addition of direct visualization of the heart through bedside echocardiography in cardiac arrest or pulselessness has been shown to add further benefit by identifying immediate life threats even during standard ACLS resuscitation.[7] There are mechanical causes of pulselessness or arrest including fluid or blood within the pericardial sac (pericardial effusion or hemorrhage) compressing the heart preventing adequate filling (cardiac tamponade). This can easily be identified by POCUS which could possibly improve outcomes by facilitating early intervention (drainage of blood or fluid in pericardial sac) and thus a return of normal cardiac function.

Another potential cause of pulselessness or severe hypotension that can be seen with echocardiography is an abnormally high pressure in the pulmonary system altering normal cardiac contractions leading to signs of elevated right heart pressure that can indicate a massive pulmonary embolism (PE), another cause of hypo perfusion, hypotension, or arrest. Again early identification could lead to more rapid treatment and better outcomes.

Both of these conditions, pericardial tamponade and massive PE, fall into the category of "reversible causes" of pulselessness or pulseless electrical activity (PEA) within the ACLS guidelines which encourage early correction (Table 1).

Table 1 Adaptation of the list of reversible causes of cardiac arrest within ACLS algorithms

Reversible condition	Detection aided by POCUS
Hypovolemia Tension Pneumothorax Cardiac Tamponade Pulmonary Embolism Myocardial Infarction	Yes
Hypoxia Severe acidosis Hypoglycemia Hypokalemia Hyperkalemia Toxins	No

Already incorporated into these algorithms is the use of ECG to identify unstable cardiac arrhythmias. This is possible in the prehospital setting, of course, because of use of ECG machines by paramedics and other pre-hospital personnel. This required widespread, routine purchase and stocking of ECG machines on ambulances, as well as instruction in the use of the machines and interpretation of the ECG readings. Similar adaptation and expansion by purchasing and using ultrasound equipment in the field likely faces the same arguments against the use of pre-hospital ECG interpretation many years ago.

Limitations of pre-hospital echocardiography

As with any new technology, pre-hospital personnel must be trained in the use and interpretation of echocardiogram images to

correctly identify important findings while ignoring other findings or abandoning attempts to ultrasound if other critical interventions are being delayed. Therein lies the biggest danger in introducing ultrasound to the pre-hospital setting as the inappropriate use of ultrasound could delay critical interventions such as chest compressions in cardiac arrest. One important study[8] showed in-hospital delays during pulse checks took longer than the recommended 10 second during CPR when echocardiogram was being attempted.

The potential financial burden of providing and maintaining ultrasound machines as well as the cost of training per-hospital personnel remain another major hurdle in adoption of echocardiography by EMTs and paramedics. The cost of large-scale purchasing of portable ultrasound machines and training first responders in the appropriate use of the technology. Upkeep, maintenance, and troubleshooting would also add a recurring cost. Of course, this would not be the first time new technology has been added to the skill set of pre-hospital workers as was seen with ECG and now dozens of other technologies from mechanical chest compressors, end-tidal carbon dioxide detectors, pulse oximetry, glucose testing, and more.

The future of pre-hospital echocardiography

The use of POCUS in the hospital has expanded dramatically over the last decade proving to be valuable, and rapid in diagnosis, and has become standard of care for visualizing subcutaneous structures during procedures such as placing central intravenous (IV) catheters. With the portability of ultrasound machines now the size of a smartphone or tablet, and the cost no longer prohibitive, it is without doubt that the next ten years will see a rapid rise in the use of pre-hospital POCUS by paramedics and other physician extenders. The key remains incorporating POCUS into proven pre-hospital protocols in a way that does not delay essential care. It is likely that more studies will show that this is feasible and improves outcomes. Further demonstration that the core skills of POCUS can be taught in EMS training efficiently without adding an excessive or prohibitive number of hours will be needed for approval and implementation within long-standing, widely used protocols.

At this juncture in time, it is not a matter of if ultrasound will be used by EMS but how it will be employed. Already there are cautionary studies showing detrimental results when attempts to ultrasound delay critical care interventions such as chest compression. Prudent early adopters should focus on a narrow scope of indications with easy to interpret ultrasound findings that lead to immediate change in treatment of life threats rather than opening Pandora's box and likely wasting time and resources to needlessly "look around" with the ultrasound rather than providing good, timely pre-hospital critical care.

Conclusion

The routine use of echocardiography within in-hospital care of the critically ill in the emergency department is rapidly expanding, and bedside ultrasound is becoming standard-of-care for trauma patients and for guidance in many emergency procedures. Today's ultrasound machines capable of providing clear images of the heart while remaining portable and affordable have contributed to this expanding trend. Protocols have been developed and tested incorporating ultrasound use into the evaluation and management of cardiac arrest,[3,9] undifferentiated hypotension,[10,11] and respiratory distress.[12] There are no hurdles that other technologies which have been added to the armamentarium of pre-hospital providers have not overcome including cost, training, and implementation of validated protocols. With this in mind, it is not a matter of if but of when echocardiography will become a staple of the evaluation and management of critically ill patients in the field.

Acknowledgments

Author Bio: Adam Broughton, PA-C started his career in medicine as an emergency medicine technician and proceeded to get a master's degree in physician assistant studies at Northeastern University Physician Assistant Program where he is now an assistant professor. .

Conflicts of interest

No conflicts of interest.

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