Published in final edited form as:

Anesthesiology. 2014 April ; 120(4): 1042–1045. doi:10.1097/ALN.0000000000000106.

Handheld Doppler To Improve Pulse Checks during Resuscitation of Putative Pulseless Electrical Activity Arrest

Robert B. Schonberger, MD, MA,

Department of Anesthesiology; Yale School of Medicine; New Haven, CT

Rachel J. Lampert, MD,

Section of Cardiology; Department of Internal Medicine; Yale School of Medicine; New Haven, CT

Ernest I. Mandel, MD, SM,

Renal Division; Brigham and Women's Hospital; Brookline, MA

Jessica Feinleib, MD, PhD,

Department of Anesthesiology; Yale School of Medicine. and VA Connecticut Healthcare System; West Haven, CT

Zhaodi Gong, MD, PhD, and

Department of Anesthesiology; Yale School of Medicine; New Haven, CT

Shyoko Honiden, MD, MSc

Section of Pulmonary/Critical Care; Department of Internal Medicine; Yale School of Medicine; New Haven, CT

INTRODUCTION

The difficulty of determining pulselessness via manual palpation in simulated cardiopulmonary resuscitation (CPR) has been well-documented in the literature. Prior studies have suggested that trained medical personnel demonstrate a specificity for the manual diagnoses of pulselessness of only 55%.¹ Other research has confirmed the poor diagnostic accuracy of manual pulse checks in a wide spectrum of test subjects - from non-medical personnel to critical care physicians.^{1–4} These data, along with accumulating evidence for the importance of early, high quality chest compression to improve outcomes from out-of-hospital cardiac arrest, have led the American Heart Association to eliminate pulse checks from their algorithm for bystander CPR.^a

In this context, the Advanced Cardiac Life Support (ACLS) algorithm for the treatment of Pulseless Electrical Activity (PEA) arrest presents an interesting dilemma, as the very diagnosis of the PEA condition is predicated, by definition, on the finding of pulselessness. Although unnecessary chest compressions during bystander CPR are considered a relatively benign intervention, the failure to promptly diagnose the return of spontaneous circulation during in-hospital PEA Arrest may delay the institution of more targeted and appropriate care modalities. Ambiguity about the presence of spontaneous circulation during

Corresponding Author: Robert B. Schonberger, MD, MA, TMP-3; Anesthesiology, 333 Cedar Street, New Haven, CT 06520, Tel: 203-785-2802, Fax: 203-785-6664, robert.schonberger@yale.edu.

Meeting Presentation: A portion of this work was presented at the American Society of Anesthesiologists 2013 Journal Symposium; October 15, 2013; San Francisco, CA.

Conflicts of Interest: The authors declare no competing interests.

^aHighlights of the 2010 American Heart Association Guidelines for CPR and ECC. American Heart Association, 2010. (Accessed August 16, 2013, at http://www.heart.org/idc/groups/heart-public/@wcm/@ecc/documents/downloadable/ucm_317350.pdf.)

resuscitation is among many factors that contributes to the challenging task of “running a code.”

Therefore, in order to assess possibilities for improving the detection of the return of spontaneous circulation during in-hospital resuscitation, we conducted a prospective case series (N=8) during which handheld Doppler pulse checks were performed in parallel with standard ACLS procedures during resuscitation of adults with putative PEA arrest or on whom electrocardiogram pads had not yet been placed in an academic tertiary care hospital. The outcomes of interest were: 1) To measure the incidence of Doppler-positive-palpation-negative pulse in patients undergoing resuscitation for putative PEA arrest, and 2) To measure blood pressure in discordant cases of Doppler-positive-palpation-negative putative PEA arrest.

This prospective study was approved by the Yale Human Investigation Committee, including a waiver of informed consent. Investigators applied a portable Doppler (Dopplex Pocket Doppler D900 Vascular Ultrasound with 8MHz probe, Huntleigh, United Kingdom) to an available femoral artery during inhospital resuscitation attempts for putative PEA arrest or in situations of unknown cardiac rhythm prior to electrocardiogram lead placement. The Dopplex D900 with associated probes has been deemed by the Food and Drug Administration to be substantially equivalent to other portable ultrasound devices routinely used for blood flow monitoring. While this technology has been in existence for several decades, the sensitivity and specificity of such devices for detecting pulsatile flow during CPR remain unknown.

For inclusion in the study, a putative PEA rhythm was defined as an organized rhythm in the absence of a manual pulse, excluding ventricular tachycardia and ventricular fibrillation.^b To be included in the case series, subjects also had to meet the following criteria: 1) age > 18 years, 2) ongoing CPR, and 3) availability of a peripheral site for application of a Doppler probe. For included subjects, audible Doppler pulse checks occurred in addition to standard ACLS procedures simultaneously with manual pulse checks. The site of manual pulse checks was not dictated by the research protocol. Doppler pulse checks occurred at an available femoral location that was not being used for the manual pulse check. In the event of a discordant finding of Doppler-positive-palpation-negative pulse, a repeat pulse check and blood pressure measurement were requested, with all management decisions left to the discretion of the code-runner. The cases represent a convenience sample of codes that occurred during times that a study investigator was available to respond. Codes occurred at a tertiary care hospital at which approximately 24 codes are called per month overhead, of which approximately 15% are true cardiac arrests.

DESCRIPTION OF CASES

Summary

A total of 8 subjects underwent the protocol. Discordant Doppler-positive-palpation-negative pulse checks occurred in 5 of 8 cases for an estimated incidence of 62.5% (95% CI 29–96%). In 3 of the 5 discordant cases, manual pulse checks following the finding of Doppler pulsatility resulted in a positive manual pulse check. In 1 of the 5 discordant cases, a radial artery catheter was successfully placed before repeat manual pulse check occurred, confirming pulsatile flow. In the fifth discordant case, repeat manual pulse check was negative followed by a visually confirmed pulse from a bounding carotid artery. Systolic

^b 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Part 7.2: Management of Cardiac Arrest. American Heart Association, 2005. (Accessed August 25, 2013, at http://circ.ahajournals.org/content/112/24_suppl/IV-58.full.)

blood pressures in the discordant group ranged from 58–160mmHg with a mean of 106 mmHg. Diastolic blood pressures ranged from 30–100mmHg with a mean of 56 mmHg. 4 of 5 Doppler positive/manual negative cases survived to intensive care unit (ICU) admission and none of the 3 concordant cases lacking pulsatile flow survived to ICU admission.

Case 1

Investigators applied the Doppler to the femoral artery site of a 45-year-old male undergoing chest compressions for lack of pulse and prior to placement of electrocardiogram leads. During CPR, manual and Doppler pulse checks occurred at both radial and femoral locations without discordance (lack of pulse was found in both locations by both modalities). After placement of electrocardiogram leads, asystole was identified. Despite the continuation of CPR, there was no return of spontaneous circulation, and resuscitation efforts were eventually halted.

Case 2

Investigators applied the Doppler to the femoral artery site of an 82-year-old male undergoing chest compressions for a putative PEA rhythm. At the first Doppler pulse check, there was a concordant finding of pulselessness. At the second Doppler pulse check, there was a discordant Doppler-positive-palpation-negative pulse. Compressions resumed at the direction of the code-runner without a repeat manual pulse check. At the next pulse check, a discordant Doppler-positive-palpation-negative pulse again occurred. A repeat manual pulse check was again negative at which time a member of the code team visually recognized the presence of a pulse in the form of a bounding carotid artery. A non-invasive blood pressure was measured at 160mmHg/100mmHg. The patient survived to ICU admission.

Case 3

Investigators applied the Doppler to the femoral artery site of a 72-year-old male undergoing chest compressions for a putative PEA rhythm. During CPR, manual and Doppler pulse checks found no pulse throughout the code. There was no return of spontaneous circulation, and resuscitation efforts were eventually halted.

Case 4

Investigators applied the Doppler to the femoral artery site of a 79-year-old male undergoing chest compressions for a putative PEA rhythm. At the first Doppler pulse check, there was a discordant Doppler-positive-palpation-negative pulse. Compressions resumed at the direction of the code-runner without a repeat manual pulse check. At the next pulse check, a concordant Doppler-positive-palpation-positive pulse occurred. A non-invasive blood pressure was measured at 58mmHg/30mmHg. Resuscitation efforts continued, including intermittent chest compressions based on manual pulse checks, and the patient survived to ICU admission.

Case 5

Investigators applied the Doppler to the femoral artery site of a 72-year-old female undergoing chest compressions for a putative PEA rhythm that developed during a surgical procedure. At the first Doppler pulse check, there was a concordant finding of pulselessness. At the second Doppler pulse check, there was a discordant Doppler-positive-palpation-negative pulse. A radial artery catheter was placed at this time demonstrating a blood pressure of 80mmHg/50mmHg. In the presence of an arterial line, manual and Doppler pulse checks were no longer performed. The patient eventually expired prior to leaving the operating room.

Case 6

Investigators applied the Doppler to the femoral artery site of a 35-year-old male undergoing chest compressions for a putative PEA rhythm. During CPR, manual and Doppler pulse checks confirmed pulselessness at multiple timepoints without discordance. There was no return of spontaneous circulation, and resuscitation efforts were eventually halted.

Case 7

Investigators applied the Doppler to the femoral artery site of a 54-year-old male undergoing chest compressions for a putative PEA rhythm. At the first Doppler pulse check, there was discordance between a Doppler-positive pulse and an “ambiguous” manual pulse. A repeat manual pulse check was performed, and a pulse was identified. A non-invasive blood pressure was concurrently measured at 102mmHg/54mmHg. The patient survived to ICU admission.

Case 8

Investigators applied the Doppler to the femoral artery site of a 59-year-old male undergoing chest compressions who had been shocked from pulseless ventricular tachycardia into a putative PEA rhythm. At the first Doppler pulse check, there was a discordant Doppler-positive-palpation-negative pulse. A repeat manual pulse check was performed, and a pulse was identified. A non-invasive blood pressure was measured at 127mmHg/42mmHg. The patient survived to ICU admission.

DISCUSSION

The present case-series suggests that during attempts at in-hospital resuscitation, standard manual pulse checks frequently lag behind the Doppler recognition of the return of spontaneous circulation. The failure to identify a pulse on manual palpation may occur across a wide range of blood pressures, including in the presence of significant systemic hypertension.

Prior studies have documented the difficulty of determining pulselessness via manual palpation. In one study for example, investigators used a cardiopulmonary bypass model of pulselessness in a group of 206 emergency medical technician and paramedic trainees and practitioners.¹ They brought subjects into a cardiac operating room and asked them to determine the presence or absence of a pulse by palpation of the carotid artery without knowing the cardiopulmonary bypass status of the patient before them. The median time to diagnosis of pulselessness among study subjects was 30 seconds. When asked to evaluate the group of patients who were not on cardiopulmonary bypass, 45% of study subjects made an incorrect diagnosis of pulselessness despite systolic pressures > 80mmHg. Conversely, when patients were on bypass, 10% of participants diagnosed a positive carotid pulse despite the absence of pulsatile flow. When pulsatile flow was found, it took a median of 15 seconds to make this determination.

A second group of investigators inserted aortic pressure catheters in patients undergoing CPR. They found that of 94 patients who were diagnosed clinically with electro-mechanical dissociation (since re-named PEA), 41% were found to have measurable aortic pulsations. Two of these patients were found to have systolic pressures greater than 90mmHg.⁵

In the present case-series, the observation that 3 of 5 discordant cases were subsequently found to have a manually palpable pulse suggests that the addition of a portable Doppler to resuscitation efforts may enhance the accuracy of manual pulse checks. The portable Doppler pulse check is a practical and easily performed intervention that may help to

address the difficulty of assessing pulsatility in a reliable and timely fashion. However several limitations of the present case series should be highlighted. Most importantly, the effects on patient-outcomes of increasing the sensitivity of pulse checks during CPR are not known. Given the small convenience sample reported in the present case series, the benefits of Doppler pulse checks remain speculative. Among the potential benefits includes the possibility that the addition of Doppler pulse checks could prevent premature abandonment of the resuscitation effort based on an incorrectly negative manual pulse check. Supporting this notion, recent evidence has described significant differences in resuscitation times between hospitals, with more favorable outcomes associated with institutions that continue resuscitation for longer periods.⁶ It is also possible that of the 3 concordant cases, some may have had spontaneous circulation that was missed by both pulse-check modalities which, if true, could imply that Doppler pulse checks are not sufficiently sensitive to prevent premature abandonment of resuscitation efforts. Further study is needed to investigate whether Doppler pulse checks may prove a useful addition to future in-hospital resuscitation algorithms.

Acknowledgments

Funding: This research was funded in part by resources from the Department of Anesthesiology; Yale School of Medicine; New Haven, CT, and the National Institutes of Health (Bethesda, MD) Grant T32 GM086287, Principal Investigator. Laura E Niklason

References

1. Dick W, Eberle B, Wisser G, Schneider. The carotid pulse check revisited: What if there is no pulse? *Crit Care Med.* 2000; 28:N183–5. [PubMed: 11098941]
2. Bahr J, Klingler H, Panzer W, Rode H, Kettler D. Skills of lay people in checking the carotid pulse. *Resuscitation.* 1997; 35:23–6. [PubMed: 9259056]
3. Eberle B, Dick W, 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; 33:107–16. [PubMed: 9025126]
4. Lapostolle F, Le Toumelin P, Agostinucci J, Catineau J, Adnet F. Basic cardiac life support providers checking the carotid pulse: Performance, degree of conviction, and influencing factors. *Acad Emerg Med.* 2004; 11:878–80. [PubMed: 15289196]
5. Paradis N, Martin G, Goetting M, Rivers E, Feingold M, Nowak R. Aortic pressure during human cardiac arrest. Identification of pseudo-electromechanical dissociation. *Chest.* 1992; 101:123–8. [PubMed: 1729058]
6. Goldberger ZD, Chan PS, Berg RA, Kronick SL, Cooke CR, Lu M, Banerjee M, Hayward RA, Krumholz HM, Nallamothu BK. Duration of resuscitation efforts and survival after in-hospital cardiac arrest: An observational study. *Lancet.* 2012; 380:1473–81. [PubMed: 22958912]