WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

Worksheet author(s)

Christoph Eich, MD & Faiqa Qureshi, MD	**Date Submitted for review:**

Clinical question.

"In pediatric patients in clinical cardiac arrest (prehospital [OHCA] or in-hospital [IHCA]) (P), does the use of a focused echocardiogram (I) compared with standard assessment, assist in the diagnosis of reversible causes of cardiac arrest?"

Is this question addressing an intervention/therapy, prognosis or diagnosis?
Diagnosis

State if this is a proposed new topic or revision of existing worksheet:
New worksheet

Conflict of interest specific to this question

No conflict of interest of both authors.

Search strategy (including electronic databases searched).

Dr. Qureshi's search terms

1. Cochrane Library (February 4, 2009): Clinical Trials 2 – both identified in PubMed

2. PubMed (February 2, 2009):
   Text Words:
   - 1st search: Heart arrest AND echocardiography – 328 citations
   - 2nd search: Heart arrest OR resuscitation AND ultrasound AND (child or pediatric) – 192 citations
   - 3rd search: Related Articles for PubMed (18280628) – 104 citations
   - 4th search: Related Articles for PubMed (17822831) – 106 citations
   - 5th search: heart arrest OR resuscitation AND ultrasound Limits: published in the last 5 years, Humans, Clinical trial, Meta-Analysis, Randomized Controlled Trial, Review – 85 citations
   - 6th search: Related Articles for PubMed (15301842) – 120 citations
   - 7th search: Related Articles for PubMed (18248737) – 231 citations
   - 8th search: Related Articles for PubMed (18280628) – 530 citations
   - 9th search: Related Articles for PubMed (11388936) – 198 citations
   - 10th search: Related Articles for PubMed (16032611) – 342 citations
   - 11th search: Related Articles for PubMed (11388934) – 141 citations

   Mesh terms:
   - 1st search: ('Monitoring, Physiologic/methods"[MeSH]) AND ("Heart Arrest" [MeSH]) – 126 citations
   - 2nd search: ('Monitoring, Physiologic/methods"[MeSH] AND ("Cardiopulmonary Resuscitation"[MeSH]) – 50 citations

3. Updated search (September 20, 2009)
   - 7 new relevant citations: 2 review articles, 3 letters, 2 case reports

3. EndNote ECC Master Library 2008 (September 8, 2008 and February 4, 2009): Heart arrest OR resuscitation AND echocardiogram OR ultrasound AND (child OR pediatric) – no additional references found.

Dr. Eich's Search Terms:

1. Cochrane Library as per Aug. 31st 2009 → No systematic Cochrane review found

2. Medline via PubMed as per Aug. 31 1st 2009)
   a) Text words:
      1st search (children only): (heart arrest OR resuscitation) AND (echo* OR ultrasound) AND (child* OR pediatric)
      → 409 citations
      2nd search (all ages): (heart arrest OR resuscitation) AND (echo* OR ultrasound)
      → 2391 citations
   b) MeSH
      1st search (children only): ("Heart Arrest"[Mesh] AND "Ultrasonography"[Mesh]) AND "Child"[Mesh]
      → 83 citations, no additional articles as compared to text word search
      2nd search (all ages): ("Heart Arrest"[Mesh] AND "Ultrasonography"[Mesh]) AND "Child"[Mesh]
      → 622 citations, no additional articles as compared to text word search
      3rd search: "Cardiopulmonary Resuscitation"[Mesh] AND "Ultrasonography"[Mesh]
      → 116 citations, no additional articles as compared to text word search

3. Embase (May 18th 2008 and March 3rd 2009
   (echo* OR pulse*) AND ('resuscitation'/exp OR 'resuscitation') AND child* AND [2000-2008]/py
   → 261 citations, no additional references

4. EndNote ECC Master Library 2008 (Version March 24th 2008): (echo* OR pulse*) AND (resuscitation OR cpr OR arrest)
   → no additional references

5. Worksheets C2005:
   Ped: p.pulsecheck.MF.05Oct04.final.doc (none on echocardiography)
   Adult: a.Echo.hh.1Nov04.P.Medits.dc

6. Cross references from retrieved articles

• **State inclusion and exclusion criteria**

We studied the review articles and obtained their citations/references but did not include them in the final review. There is very limited pediatric data. There is only one study (Tsung, 2008, 264) and one case report (Steiger HV, 2009, 103) which directly address the worksheet topic. We also reviewed relevant adult data on echocardiography during cardiopulmonary resuscitation.

• **Number of articles/sources meeting criteria for further review:** 84.
37 citations selected for detailed review
11 are included in the citation list.

9 citations are clinical trials including the only pediatric study to address the question.
2 articles are case reviews, one involving a pediatric patient and one an adult patient
9 studies are LOE 5, 2 were LOE 4
No studies met criteria for LOE 1, 2 or 3

Summary of evidence

Evidence Supporting Clinical Question

Good					
Fair					
Poor				(Tsung, 2008, 264)[ABC] (Steiger HV, 2009, 103)[A,B,C,D]	(Blaivas, 2001, 616)[A,B] (Menaker, 2007, 99)[ABC] (Niendorff, 2005, 81)[E] (Querellou E, 2009 1211)[A,B,C,D] (Salen, 2001, 610) [B] (Salen, 2005, 459) [ABCD] (Tayal, 2003, 315)[C] (Varriale, 1997, 1717) [B,C]
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Animal studies

Evidence Neutral to Clinical question

Good					
Fair					
Poor					(Pershad, 2004, e667)
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Animal studies

Evidence Opposing Clinical Question

Good					
Fair					
Poor					
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Animal studies

REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

There was only one pediatric study (Tsung, 2008, 264) and one case report (Steiger HV, 2009, 103). The study by Tsung was a case series of 14 children < 19 years old in cardiac arrest. The authors report their data using focused point of care echocardiography and correlating it with a pulse check during resuscitation. They were able to visualize the heart in all patients and correlate it accurately with the presence or absence of a pulse without "prolonged" interruption of chest compressions. Two patients had ROSC and survived to admission. This study is limited by small numbers. There is no randomization or control group and the time needed to do the ECHO that actively interrupted CPR is not reported.

The pediatric case report discusses a 14 year old girl who was felt to have cardiac arrest secondary to cardiac tamponade. The tamponade was diagnosed and treated in the prehospital setting by emergency echiocardiography, resulting in return of spontaneous circulation.

There is one article which discusses the ability of emergency physicians to accurately estimate left ventricular function and inferior vena cava volume in critically ill children in the intensive care unit (Pershad, 2004, e667). They report good agreement between the emergency physician and pediatric echocardiogram. They studied only 31 patients and none were in cardiac arrest.

We also reviewed the results of six clinical trials and two case reports of the use of echocardiography in adult patients undergoing CPR. None were randomized or had control groups, thus they fall in to the category of "poor" methodology. All the adult trials supported the use of echocardiography in predicting resuscitation outcomes in cardiac arrest patients.

Acknowledgements:

Citation list

1. Blaivas M, Fox JC. Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. *Acad Emerg Med.* 2001;8(6):616.

Comments: LOE D5; Methodology Poor; Outcomes A, B; Supportive
Prospective observational study of 169 adult patients presenting to the ED with ongoing CPR who had cardiac ultrasound examinations done during pulse checks. In this study, cardiac standstill on echocardiogram resulted in a positive predictor value of 100% for death in the ED regardless of electrical rhythm. The negative predictor value was 58%. The positive likelihood ration was calculated to be infinity and the negative likelihood ration was 0.17.

Limitations: Small sample size. No formal comparison of echo with clinical assessment or other technical methods. No randomization. Authors did not determine whether bedside ultrasonography interfered with acute resuscitation efforts.

2. Menaker J, Cushman J, Vermillion JM, et al. Ultrasound-diagnosed cardiac tamponade after blunt abdominal trauma-treated with emergent thoracotomy. *J Emerg Med.* 2007;32(1):99.

Comments: LOE D5; Methodology Poor; Outcomes A,B, C; Supportive
This is a single case report which discusses the efficacy of focused ultrasound to detect and treat pericardial effusion with tamponade during cardiac arrest.

3. Niendorff DF, Rassias AJ, Palac R, et al. Rapid cardiac ultrasound of inpatients suffering PEA arrest performed by nonexpert sonographers. *Resuscitation.* 2005;67(1):81.

Comments: LOE D5; Methodology Poor; Outcome E; Supportive
This was a feasibility study in 5 adults demonstrating that nonexpert sonographers, in this case senior internal medicine residents, can be trained to perform and interpret cardiac ultrasounds with good accuracy. Four arrests required two pauses in CPR for sonography and 2 arrests required a third pause in CPR. The average total CPR pause related to ultrasound was reported to be19.6 seconds. The authors claim that the focused ultrasound did not interfere with resuscitation in any of the cases.

Limitations: There are too few patients in this study to draw a meaningful conclusion

4. Pershad J, Myers S, Plouman C, et al. Bedside Limited Echocardiography by the Emergency Physician Is Accurate During Evaluation of the Critically Ill Patient. *Pediatrics.* 2004;114(6):e667.

Comments: LOE D4; Methodology Poor; Neutral
Pediatric study done in the intensive care unit to determine the accuracy of protocol-based echo examinations performed by EPs in 31 children (23 d - 16 yrs) compared to readings done by experienced pediatric echocardiographers. The authors report that with focused training, pediatric emergency physicians, can determine fairly accurately inferior vena cava volume and left ventricular function.

Limitations: This is not a clinical trail. There is no comparison with other methods (clinical or technical). This study does not address children with circulatory arrest.

5. Querellou E MD, Petitjean F, Le Dreff P, Maurin O. Ventricular fibrillation diagnosed with trans-thoracic echocardiography. *Resuscitation.* . 2009 Oct;80((10)):1211.

Comments: LOE D5; Methodology Poor; Outcomes A, B, C, D; Supportive
The authors use this case report to support the use of trans thoracic echocardiography during CPR. In this case echocardiography helped to identify VF cardiac arrest when rhythm analysis was not possible because of EKG artifact caused by electrical interference.

Limitations: Case report of a single incident

6. Salen P, Melniker L, Chooljian C, et al. Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients? *The American Journal of Emergency Medicine.* 2005;23(4):459.

Comments: LOE D5; Methodology Poor; Outcomes A, C, B, D; Supportive
70 patients, ages 16-94, 36 in asystole and 34 in PEA were studied. Subjects with asystole on presenting rhythm strip uniformly lacked sonographic existence of myocardial contractions and did not have ROSC. 23 subjects (68%) presenting with PEA had no sonographic evidence of cardiac activity (true EMD) and did not have ROSC. 11 patients with PEA (32%) had sonographically identified cardiac kinetic activity (pseudo EMD), 8 of whom had ROSC. The authors conclude that sonographic evidence of cardiac kinetic motion during CPR is a potential predictor of ROSC (accuracy = 0.95, 95% CI 0.92-1.0).

Limitations: small size in each group. 17 of the 70 subjects did not receive sequential sonographic exam after initial cardiac ultrasound. The results of the ultrasound were not videotaped and not reviewed for accuracy. Possible interference with resuscitation efforts was not mentioned. The authors report that the accuracy of cardiac ultrasound to predict survival to hospital discharge versus death was 0.87, (95% CI, 0.79-0.95). However only 1 patient in the entire cohort survived to hospital discharge.

7. Salen P, O'Connor R, Sierzenski P, et al. Can cardiac sonography and capnography be used independently and in combination to predict resuscitation outcomes? *Acad Emerg Med.* 2001;8(6):610.

COMMENT: LOE D5; Methodology Poor; Outcome B; Supportive
This prospective clinical observational study conducted in 102 adult patients in cardiac arrest sought to determine whether cardiac sonography either alone or in conjunction with capnography in pulseless patients undergoing resuscitation was predictive of survival. Patients with sonographically identified cardiac activity at any time during the resuscitation were more likely to survive to hospital admission (11/41 or 27%) than those without cardiac activity (2/61 or 3%). Two patients (1 PEA, 1 asystole) without sonographically identified contractions survived to admission. The authors state that in their study the ultrasound detection of cardiac activity and $ETCO_2$ levels higher than 16 torr were significantly associated with survival from resuscitation.

Limitations: The study protocol recommended that cardiac sonography should be performed in the 10 seconds and that it should not interfere with ACLS mandated interventions. However the actual time involved in doing the ultrasound was not reported in the results. The authors simply stated that “clinicians did not report any instances in which cardiac sonography appeared to interfere with resuscitation.”

8. Steiger HV RK, Müller E, Breitkreutz R. Focused emergency echocardiography: lifesaving tool for a 14-year-old girl
suffering out-of-hospital pulseless electrical activity arrest because of cardiac
tamponade. *Eur J Emerg Med.* . 2009;16(Apr;(2)):103.

Comments: LOE D4; Methodology Poor; Outcomes A, B, C, D; Supportive
The main observation of this case report was that emergency echocardiography in a prehospital case scenerio of cardiac arrest led to the detection and treatment of pericardial tamponade thereby aiding in successful resuscitation of the child.

Limitations: This is a case report involving a single patient.

9. Tayal VS, Kline JA. Emergency echocardiography to detect pericardial effusion in patients in PEA and near-PEA states. *Resuscitation.* 2003;59(3):315.

Comments: LOE D5; Methodology Poor; Outcome C; Supportive
Observational prospective series of 20 adult patients with nontraumatic hemodynamic collapse of whom 8/20 (40%) had no cardiac kinetic motion on echo and were refractory to the usual ACLS measures. 12/20 (60%) had cardiac kinetic motion observed on echo and 8 of these patients had pericardial effusion detected on echo. Three patients had tamponade necessitating emergency pericardial drainage or surgery. Additionally in those with cardiac activity without effusion the echo assisted in resuscitation of 2 patients by detection of transcutaneous pacer capture and early restoration of spontaneous circulation (ROSC) respectively. The authors conclude that emergency physicians were able to detect pericardial effusion with correctable etiologies versus true PEA with ventricular standstill in patients presenting with PEA or near PEA status, thereby improving resuscitation outcome. Seven of eight patients with pericardial effusion survived to hospital discharge.

Limitiations: Very small numbers. The authors state that theirs was a highly select group of adult patients who may have had a high pretest probability for pericardial effusion or pathology, so the results would be difficult to generalize to all patient presenting in cardiac arrest.

10. Tsung JW, Blaivas M. Feasibility of correlating the pulse check with focused point-of-care echocardiography during pediatric cardiac arrest: A case series. *Resuscitation.* 2008;77(2):264.

Comments: LOE D4; Methology Poor; Outcomes A, B, C; Supportive
The only pediatric study that I found, this was a case series of 14 children < 19 years old in cardiac arrest. The authors describe clinical observations using focused point of care echocardiography done concurrently with a pulse check during the resuscitation. They report that they were able to visualize the heart in all patients and were able to correlate cardiac activity with the presence or absence of a pulse without prolonged interruption of chest compressions. They postulate that echocardiography is a potentially valuable tool to assess the effect of resuscitative interventions in critically ill or injured pediatric patients.

Limitations: Small number of patients of whom only 2 had ROSC. Thus it is difficult to quantify magnitude of effect of the intervention. The length of time that chest compressions were interrupted to do the echo is not reported.

11. Varriale P, Maldonado JM. Echocardiographic observations during inhospital cardiopulmonary resuscitation. *Critical Care Medicine.* 1997;25(10):1717.

Comments: LOE D5; Methodology Poor; Outcomes B, C; Supportive
Prospective observational study. Twenty patients (60-93 years of age) were studied during CPR, only 16 of whom had transthorascic probe examination. Initial echocardiography imaging demonstrated

mechanical a systole in 18 of 20 patients. In 4 of the patients with initial mechanical asystole return of ventricular contractions was observed during CPR. This return of mechanical activity was not accompanied by an apparent pulse or blood pressure and prompted use of inotropic agents. These 4 patients survived resuscitation, however only 1 patient survived to hospital discharge. A gel like coalescent echo contrast within the cardiac chambers 20-30 minutes after CPR in patients with cardiac arrest was uniformly associated with a bad outcome. The authors suggest that echocardiography imaging during CPR may detect reversible causes of cardiac arrest such as hypovolemia, cardiac tamponade or pulmonary embolism and provide useful information for management.

Limitations: Too few patients to draw any definite conclusions.