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

Worksheet author(s)

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Clinical question. BLS 022A

1. In patients with VF (P), will the resumption of chest compressions (I), compared with delayed initiation for rhythm analysis (C), result in better outcomes?

2. Conversely, in patients with VF (P), will delays in initiation of chest compressions for rhythm analysis (I), compared with the resumption of chest compressions (C), result in better outcomes?

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention/therapy
State if this is a proposed new topic or revision of existing worksheet: New topic

Conflict of interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? RB has a potential intellectual COI because of NIH research grant to evaluate this issue, and published studies on this topic.

Search strategy (including electronic databases searched).

Medline, AHA Endnote Library and Cochrane data bases—21 May 2008
Post-shock chest compressions--6 hits
Cardiopulmonary resuscitation and pauses----------------------------20 hits
Chest compressions and pauses--17 hits
Chest compressions and interruptions---------------------------------24 hits
CPR and interruptions --37 hits
Chest compressions and AED---22 hits
Cardiopulmonary resuscitation and AED----------------------------180 hits
Delays in chest compressions---11 hits
Web of Science (for Berg RA, Ann Emerg Med 2003) ------------28 hits

Re-search: ventricular fibrillation AND (chest compressions OR cardiopulmonary resuscitation) **08Mar2009:**
Cochrane Databases (CDSR, CCTR and DARE) search yielded 0 relevant citation (19 hits, Mar 2009)
PubMed search yielded 24 relevant citations (1700 hits [929 through 2000], Mar 2009);
EMBASE (OVID) search yielded 20 relevant citations (630 hits, May 2008)
20Jan2010: PUBMED (120 additional hits, Jan 2010)

- State inclusion and exclusion criteria

Peer-reviewed manuscripts only with any information about post-shock CPR with special focus on outcomes or hemodynamic changes

No reviews included.

- Number of articles/sources meeting criteria for further review: 31 on 21May2008
Additional 4 on 08March2009
Total 35 on 08March2009
Additional 3 on 20Jan2010
Total 38 on 20January2010

Summary of evidence

Evidence Supporting Clinical Question #1

	1	2	3	4	5
Good					*Berg, Resus 2008ABD*
Fair			Rea, Circ 2006 BC Steinmetz, Acta Anaesth Scand,2008 BC	Hess&White, Resus 2005 E	*Yu, Circ 2002ABE* *Berg AEM 2003ABD* *Tang, Circ 2006 ABD* *Walcott, Resus 2009 AB* *Chang Resus 2008 E*
Poor					
	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 #1

	1	2	3	4	5
Good					
Fair		Olasveengen Resus 2009 ABCD			Xanthos, Resus 2007
Poor					
	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 #1

Good	Berdowski Circ Arrhythm 2009 E (epub)				
Fair					*Osorio Circ Arrhythm 2008 E*
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

Evidence Supporting Clinical Question #2

Good					
Fair				Kramer-Johansen, Resus 2007 E (inappropriate shocks)	
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

Evidence Opposing Clinical Question #2

Good					*Berg, Resus 2008ABD*
Fair			Rea, Circ 2006 BC	Hallstrom, Resus 2007ACE Rea, AEM 2005ACE Ko, Resus 2005 Eilervstjonn, Resus 2005E Blouin, AEM 2001BCE Berg MD, Resus 2005BC van Alem, AEM 2003ACE Carpenter, Resus 2003 White, Resus 2002ACDE Herlitz, Resus 1997 Niemann, CCM 2001 Valenzuela, Circ 2005C Eftestol, Circ 2002 Kramer-Johansen, Resus 2007AE	*Yu, Circ 2002ABE* *Berg, AEM 2003ABD* *Tang, Circ 2006ABD* *Li, CCM 2008E* *Walcott, Resus 2009 AB* *Chang Resus 2008 E*
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:

result in worse outcomes.

Myocardial and cerebral blood flows during CPR for VF (and during CPR after defibrillation into a non-perfusing rhythm) depend on effective chest compressions. During interruptions in chest compressions, cardiac output, coronary perfusion and cerebral perfusion approach zero. In addition, the aortic diastolic pressure decreases substantially during the interruptions, and slowly increases after re-institution of chest compressions (Berg Circ 2001; Kern Circ 2002). Not surprisingly, interruptions, or pauses, in chest compressions can result in worse outcomes (Yu, Circ 2002; Eftestol Circ 2002; Berg AEM 2003; Kern Circ 2002). Defibrillation, termination of VF, is necessary for successful resuscitation from VF cardiac arrest. When prompt defibrillation is provided soon after the induction of VF in a cath lab the rates of successful defibrillation and survival approach 100% (van Camp, JAMA 1986). When automated external defibrillators are used within 3 minutes of witnessed VF in casinos, long-term survival occurs in ~75% (Valenzuela, NEJM 2000). However, out-of-hospital VF cardiac arrests are typically prolonged before paramedical personnel and defibrillators are available at the scene. Continued active metabolism by the myocardium during VF progressively depletes high-energy phosphate. Changes in the VF morphology over time (from “coarse,” high amplitude VF to “fine,” low amplitude VF) correlate with these changes in myocardial bioenergetics during VF. As a result of progressive physiologic changes, defibrillation from prolonged VF typically results in a non-perfusing rhythm of asystole or pulseless electrical activity (Blouin AEM 2001; Berg Resus 2005; van Alem AEM 2003; Carpenter Resus 2003; Niemann CCM 2001; White Resus 2002; Herlitz Resus 1997; Valenzuela, Circ 2005). Therefore, clinical observational studies show that either pre-shock CPR or post-shock CPR is generally necessary to attain return of spontaneous circulation from this so-called Circulatory Phase of VF (Weisfeldt JAMA 2002).

Several animal studies and two before-after clinical studies showed that minimizing interruptions in chest compressions for better perfusion before and after defibrillation is associated with better rates of survival (Berg AEM 2003; Yu Circ 2002; Tang Circ 2006; Rea Circ 2006; Steinmetz Acta Anaesth scand 2008). In contrast, one before-after clinical study did not show significant differences with minimizing interruptions after Guidelines 2005 versus Guidelines 2000 (Olasveengen Resus 2009). Two animal studies (LOE 5) have specifically compared prompt post-shock chest compressions with delayed initiation of chest compressions for rhythm analysis and “human factors,” with no other changes in the resuscitation protocol (Berg, Resus 2008; Walcott Resus 2009). In one animal study (Berg Resus 2008), the outcomes were substantially better with prompt post-shock chest compressions, as manifested by higher rates of survival to 48-hours post-arrest (9/18 vs 3/18, $P<0.05$). All of the survivors had favorable neurological outcomes. The other animal study (Walcott Resus 2009), showed that 4-hour survival was more likely when 90 seconds of immediate post-shock were provided after 7 minutes of VF compared with a 20 second pause and 70 seconds followed by 70 seconds of post-shock CPR (5/12 vs 0/12, $P<0.05$). Another animal study (LOE 5), 24-hour survival and favorable neurological outcomes were substantially better with relatively prompt post-shock chest compressions after manual defibrillation compared with delayed initiation of chest compressions for rhythm analysis and “human factors” associated with AED use (Berg, AEM 2003). All three animal studies modeled out-of-hospital VF. Rea and colleagues also demonstrated in a before-after clinical investigation that outcomes from VF arrest improved after a change in EMS protocol emphasizing a single shock rather than stacked shocks and prompt post-shock chest compressions (survival to discharge of 46% vs 33%, adj OR 1.75; 95%CI 1.14-2.69; $P=0.008$) (Rea Circ 2006). The survival improvement corresponded to a decrease in the interval from shock to onset of CPR (median, 28 versus 7 seconds, $P<0.05$) and an increase in the duration of CPR between rhythm analyses (median, 28 versus 7 seconds, $P<0.05$) (Rea Circ 2006). Steinmetz also showed that outcomes were better with this 2005 Guideline approach of a single shock and prompt post-shock chest compressions: 16% vs 8% survival to hospital discharge ragte and 16% vs 8% 30-day survival rate, P<0.001). In contrast, OIasveengen and colleagues showed no difference comparing Guidelines 2000 care with Guidelines 2005 care (with single shocks and immediate post-shock CPR): 11% survival to discharge vs 13% survival to discharge (P=0.287).

In theory, chest compressions could cause harm by inducing VF/VT (i.e., commotio cordis). However, Hess and White have shown that chest compressions do not appear to precipitate VF/VT (i.e., increase the rate of recurrent VF/VT) (Hess, Resus 2005). More recently, Berdowski etal (Circulation Arrhythmia and Electrophysiology 2010) showed a hazard ratio for VF in the first 2 seconds of CPR was 15.5 (95%CI, 5.63-57.7) compared with prior to CPR resumption, consistent with recent animal data also indicating that VF may be induced by chest compressions (Osorio, Circulation Arrhythmia and Electrophysiology 2008). However, neither of these studies evaluated any adverse effects on outcome.

Importantly, numerous animal and clinical studies suggest that post-shock analysis of rhythm after out-of-hospital VF is not very productive and the resultant delay in chest compressions is probably harmful (Blouin AEM 2001; Berg Resus 2005; van Alem AEM 2003; Carpenter Resus 2003; Niemann CCM 2001; White Resus 2002; Herlitz Resus 1997; Valenzuela, Circ 2005; Berg Resus 2008). More than 80% of patients in VF/VT attain termination of fibrillation to asystole or pulseless electrical activity with the first shock. In these circumstances, perfusion of the myocardium and cerebrum is necessary for successful resuscitation. Delays for pulse check and rhythm analysis generally waste precious time before potentially life-saving myocardial and cerebral blood flows can be provided. In addition, outcomes are quite poor for the sub-group of patients with out-of-hospital arrests who convert from a non-perfusing rhythm to VF/VT, suggesting that the potential gain from repeated rhythm analyses and shocks are limited (Hallstrom Resus 2007). Interestingly, new automated rhythm detection systems may obviate the need for interrupting chest compressions in order to determine a shockable rhythm (Li, CCM 2008).

The studies reviewed mostly focus on out-of-hospital prolonged VF. In contrast, in-hospital VF/VT is typically short duration at the time of the first shock (Chan, NEJM 2008). Nevertheless, data from the AHA National Registry of CPR indicate that the first shock is not delivered within 2 minutes for ~30% of arrests and that outcomes were worse when the first shock was delivered greater than 2 minutes after onset of VF arrest compared with less than 2 minutes (Chan, NEJM 2008). Presumably provision of excellent perfusion is important for these in-hospital arrests also. Importantly, manual defibrillators are most commonly used for in-hospital VF and the post-shock delays for rhythm detection are not as long as with AED usage (Kramer-Johansen Resus 2007; Pytte Resus 2007). However, Kramer-Johansen also showed that the proportion of inappropriate shocks (ie, for asystole or PEA) was greater with manual defibrillator than AEDs (33% vs 21%; OR 1.9 [1.3-2.7], P=0,001).

Acknowledgements:

Citation List

Berdowski J, Tijssen JG, Koster RW. (2009) "Chest Compressions Cause Recurrence of Ventricular Fibrillation after the First Successful Conversion by Defibrillation in Out-of-Hospital Cardiac Arrest." Circ Arrhythm Electrophysiol. Dec 30. [Epub ahead of print]

LOE 1, good study, opposing question #1; however, only looks at the interim outcome that prompt post-shock CPR increases the risk of re-fibrillation. No important outcome data.

Berg, R. A., A. B. Sanders, et al. (2001). "Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest." Circulation **104**(20): 2465-2470.

Background information

Berg, R. A., R. W. Hilwig, et al. (2003). "Automated external defibrillation versus manual defibrillation for prolonged ventricular fibrillation: lethal delays of chest compressions before and after countershocks." Ann Emerg Med **42**(4): 458-467.

LOE 5, Fair, Supports Q1 and Opposes Q2

Berg, M. D., L. L. Clark, et al. (2005). "Post-shock chest compression delays with automated external defibrillator use." Resuscitation **64**(3): 287-291.

LOE 4, Fair, Opposes Q2

Berg RA, Hilwig RW, etal (2008). "Immediate post-shock chest compressions improve outcome from prolonged ventricular fibrillation." Resuscitation. 78(1):71-6

LOE 5, Good, Supports Q1 and Opposes Q2

Blouin, D., C. Topping, et al. (2001). "Out-of-hospital defibrillation with automated external defibrillators: postshock analysis should be delayed." Ann Emerg Med **38**(3): 256-261.

LOE 4, Fair, Opposes Q2

Carpenter, J., T. D. Rea, et al. (2003). "Defibrillation waveform and post-shock rhythm in out-of-hospital ventricular fibrillation cardiac arrest." Resuscitation **59**(2): 189-196.

LOE 4, Fair, Opposes Q2

Chan PS, Krumholz HM, etal (2008) "Delayed time to defibrillation after in-hospital cardiac arrest." N Engl J Med. 358(1):9-17.

Background

Chang YT, Tang W, etal. (2008) “Exclusion of a patient assessment interval and extension of the CPR interval both mitigate post-resuscitation myocardial dysfunction in a swine model of cardiac arrest.” Resuscitation. 76(2):285-90.

LOE 5, Fair, Supports Q1 and Opposes Q2

Eftestol, T., K. Sunde, et al. (2002). "Effects of interrupting precordial compressions on the calculated probability of defibrillation success during out-of-hospital cardiac arrest." Circulation **105**(19): 2270-2273.

LOE 4, Fair, Opposes Q2

Eilevstjønn J, Kramer-Johansen J, etal (2005) Reducing no flow times during automated external defibrillation. Resuscitation. 67(1):95-101.

LOE 4, Fair, Opposes Q2

Hallstrom, A., T. D. Rea, et al. (2007). "The relationship between shocks and survival in out-of-hospital cardiac arrest patients initially found in PEA or asystole." Resuscitation **74**(3): 418-426.

LOE 4, Fair, Opposes Q2

Herlitz, J., A. Bang, et al. (1997). "Rhythm changes during resuscitation from ventricular fibrillation in relation to delay until defibrillation, number of shocks delivered and survival." Resuscitation **34**(1): 17-22.

LOE 4, Fair, Opposes Q2

Hess EP, White RD. (2005) “Ventricular fibrillation is not provoked by chest compression during post-shock organized rhythms in out-of-hospital cardiac arrest.”Resuscitation. 66(1):7-11.

LOE 4, Fair, Support Q1

Kern, K. B., R. W. Hilwig, et al. (2002). "Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario." Circulation **105**(5): 645-649.

Background

Ko, P. C., W. J. Chen, et al. (2005). "Evaluating the quality of prehospital cardiopulmonary resuscitation by reviewing automated external defibrillator records and survival for out-of-hospital witnessed arrests." Resuscitation **64**(2): 163-169.

Level 4, Fair, Oppose Q2

Kramer-Johansen J, Edelson DP, etal. (2007) “Pauses in chest compression and inappropriate shocks: a comparison of manual and semi-automatic defibrillation attempts.” Resuscitation. 73(2):212-20.

Level 4, Fair, Opposes and Supports Q2

Niemann JT, Stratton SJ, etal (2002) Outcome of out-of-hospital postcountershock asystole and pulseless electrical activity versus primary asystole and pulseless electrical activity. Crit Care Med 30(1):245.

LOE 4, Fair, Opposes Q2

Olasveengen TM, Lund-Kordahl I, etal.(2009) "Out-of hospital advanced life support with or without a physician: effects on quality of CPR and outcome." Resuscitation. 80(11):1248-52

LOE 2, Fair, Neutral Q1

Osorio J, Dosdall DJ, etal (2008) "In a swine model, chest compressions cause ventricular capture and, by means of a long-short sequence, ventricular fibrillation." Circ Arrhythm Electrophysiol. 1(4):282-9.

LOE 5, Fair, Opposes Q1

Rea, T. D., S. Shah, et al. (2005). "Automated external defibrillators: to what extent does the algorithm delay CPR?" Ann Emerg Med **46**(2): 132-141.

LOE4, Fair, Opposes Q2

Rea, T. D., M. Helbock, et al. (2006). "Increasing use of cardiopulmonary resuscitation during out-of-hospital ventricular fibrillation arrest: survival implications of guideline changes." Circulation **114**(25): 2760-2765.

LOE 3, Fair, Supports Q1 and Opposes Q2

Steinmetz, J., S. Barnung, et al. (2008). "Improved survival after an out-of-hospital cardiac arrest using new guidelines." Acta Anaesthesiol Scand **52**(7): 908-913.

LOE 3, Fair, Supports Q1

Tang, W., D. Snyder, et al. (2006). "One-shock versus three-shock defibrillation protocol significantly improves outcome in a porcine model of prolonged ventricular fibrillation cardiac arrest." Circulation **113**(23): 2683-2689.

LOE 5, Good, Supports Q1 and Opposes Q2

Walcott GP, Melnick SB, etal (2009) Effect of timing and duration of a single chest compression pause on short-term survival following prolonged ventricular fibrillation. Resuscitation. 80(4):458-62.

LOE 5, Good, Supports Q1 and Opposes Q2

Valenzuela, T. D., K. B. Kern, et al. (2005). "Interruptions of chest compressions during emergency medical systems resuscitation." Circulation **112**(9): 1259-1265.

LOE 4, Fair, Opposes Q2

van Alem AP, Sanou BT, Koster RW. **(**2003) “Interruption of cardiopulmonary resuscitation with the use of the automated external defibrillator in out-of-hospital cardiac arrest.” Ann Emerg Med. 42(4):449-57.

LOE 4, Fair, Opposes Q2

White, R. D. and J. K. Russell (2002). "Refibrillation, resuscitation and survival in out-of-hospital sudden cardiac arrest victims treated with biphasic automated external defibrillators." Resuscitation **55**(1): 17-23.

LOE 4, Fair, Opposes Q2

Xanthos T, Tsirikos-Karapanos N, etal ((2007) “Resuscitation outcomes comparing year 2000 with year 2005 ALS guidelines in a pig model of cardiac arrest.” Resuscitation. 73(3):459-66.

LOE 5, Fair, Neutral Q1 and Q2

Yakaitis, R. W., G. A. Ewy, et al. (1980). "Influence of time and therapy on ventricular defibrillation in dogs." Crit Care Med **8**(3): 157-163.

Background

Yu, T., M. H. Weil, et al. (2002). "Adverse outcomes of interrupted precordial compression during automated defibrillation." Circulation **106**(3): 368-372.

LOE 5, Fair, Supports Q1 and Opposes Q2