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

Worksheet author(s)  
Robert Berg  
Date Submitted for review: 20 January 2010

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

<table>
<thead>
<tr>
<th>Good</th>
<th>Rea, Circ 2006 BC</th>
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<tr>
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<td>Steinmetz, Acta Anaesth Scand, 2008 BC</td>
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<table>
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<tr>
<th>Fair</th>
<th>Hess &amp; White, Resus 2005 E</th>
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<tr>
<td></td>
<td>Yu, Circ 2002 ABE</td>
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<td></td>
<td>Berg AEM 2003 ABD</td>
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### 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 Neutral to Clinical Question #1

<table>
<thead>
<tr>
<th>Good</th>
<th>Olasveengen Resus 2009 ABCD</th>
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| Fair    | Xanthos, Resus 2007 |

### Evidence Opposing Clinical Question #1

<table>
<thead>
<tr>
<th>Good</th>
<th>Berdowski Circ Arrhythm 2009 E (epub)</th>
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| Fair    | Osorio Circ Arrhythm 2008 E |

| Poor    |                          |

### Level of evidence

- **A** = Return of spontaneous circulation
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**Evidence Supporting Clinical Question #2**

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Kramer-Johansen, Resus 2007

E (inappropriate shocks)

**Evidence Opposing Clinical Question #2**

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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

Berg, Resus 2008ABD

Yu, Circ 2002ABE
Berg, AEM 2003ABD
Tang, Circ 2006ABD
Li, CCM 2008E
Walcott, Resus 2009
AB
Chang Resus 2008 E

**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 rate and 16% vs 8% 30-day survival rate, P<0.001). In contrast, Olasveengen 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 et al (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 (i.e., 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


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.


Background information


LOE 5, Fair, Supports Q1 and Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 5, Good, Supports Q1 and Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 4, Fair, Opposes Q2


Background

LOE 5, Fair, Supports Q1 and Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 4, Fair, Support Q1


Background


Level 4, Fair, Oppose Q2

Level 4, Fair, Opposes and Supports Q2


LOE 4, Fair, Opposes Q2


LOE 2, Fair, Neutral Q1


LOE 5, Fair, Opposes Q1


LOE 4, Fair, Opposes Q2


LOE 3, Fair, Supports Q1 and Opposes Q2


LOE 3, Fair, Supports Q1


LOE 5, Good, Supports Q1 and Opposes Q2


LOE 5, Good, Supports Q1 and Opposes Q2

LOE 4, Fair, Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 4, Fair, Opposes Q2


LOE 5, Fair, Neutral Q1 and Q2


Background


LOE 5, Fair, Supports Q1 and Opposes Q2