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

Worksheet author(s)

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Clinical question.

In adult and pediatric patients with cardiac arrest (prehospital or in-hospital) (P), does the minimization of hands off time for rhythm analysis including frequency and duration of checks (I) as opposed to standard care (according to treatment algorithm) (C), improve outcome (O) (eg. ROSC, survival)?

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

Conflict of interest specific to this question

Author of one of the studies assessed in this worksheet.
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Search strategy (including electronic databases searched).

Search parameters:
Medline and Cochrane via OvidSP: 1302 hits (28 hits in Cochrane, 1274 hits in Medline) on 9/23/2009
(cardiopulmonary resuscitation[MESH/keyword] OR basic life support[keyword] OR advanced life support[keyword] OR advanced cardiac life support[keyword] OR chest compression*[keyword] OR cardiac massage[keyword]) AND (no-flow[keyword] OR hands-off[keyword] OR rhythm analysis[keyword] OR pulse check[keyword] OR pause[keyword] OR time without[keyword] OR flow fraction OR delay*[keyword] OR interrupt*[keyword])

Medline and EMBASE via EMBASE: 1536 hits on 9/23/2009
'cardiopulmonary resuscitation'/de OR 'basic life support' OR 'advanced life support' OR 'advanced cardiac life support'/exp OR 'chest compressions' OR 'cardiac massage'/exp AND ('no-flow' OR 'hands-off' OR 'rhythm analysis' OR 'pulse check' OR pause OR 'time without' OR 'flow fraction' OR delay* OR interrupt*)
AHA EndNote Master library. Forward search using Web of Science. Review of references from articles

- State inclusion and exclusion criteria

The following studies were excluded: abstract only studies, non-peer reviewed articles, studies comparing chest compression only CPR with conventional CPR (unless hands-off time was specifically evaluated), and studies that did not directly answer the question. Specifically, we omitted studies of compression to ventilation ratio because they did not evaluate pauses independent of ventilations.

Clinical studies as well as animal models included.

- Number of articles/sources meeting criteria for further review: 1710 articles were identified by initial searching, of which 29 met criteria for further review. Of those, 6 were subsequently rejected after careful review, leaving 23 which are addressed below.

Summary of evidence

Evidence Supporting Clinical Question

Good		Edelson, 2006, E4 Gundersen, 2009, E3			*Sato, 1997, A,E1,E2* *Steen, 2003, A* *Yu, 2002, A* *Chang, 2008, A,E5* *Walcott (1), 2009, E6*
Fair		Eilevstjønn 2007, A Christenson, 2009, A,C Eftestol, 2002, E3	Rea, 2006, B, C		*Berg, 2003, A,D,E1* *Berg, 2008, A,D,E1,E2*
Poor		Bobrow (2), 2008, A,B,C	Kellum, 2006, C,D Bobrow(1), 2008, C Garza, 2009, A,C, D		
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
E3 = Higher pROSC
C = Survival to hospital discharge
D = Intact neurological survival
E4 = Successful defibrillation
E1 = 24hr survival
E2 = 48hr survival
E5 = 72hr survival

E6 = 4hr survival *Italics = Animal studies*

Evidence Neutral to Clinical question

Good		Edelson, 2006, A			*Ristagno, 2008, A,E5*
Fair		Kramer-Johansen, 2006, E7	Rea, 2006, D Olasveengen, 2009, C		*Walcott (2), 2009, E6*
Poor		Valenzuela, 2005, A Abella, 2005, A Wik, 2005, C	Olasveengen, 2007, B, C Bobrow(1), 2008, A,B		
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
E3 = Higher pROSC
E6 = 4hr survival
C = Survival to hospital discharge
D = Intact neurological survival
E4 = Successful defibrillation
E7 =survival to hospital admission
E1 = 24hr survival
E2 = 48hr survival
E5 = 72hr survival
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
E3 = Higher pROSC
E6 = 4hr survival
C = Survival to hospital discharge
D = Intact neurological survival
E4 = Successful defibrillation
Italics = Animal studies
E1 = 24hr survival
E2 = 48hr survival
E5 = 72hr survival

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

Evidence from six adult studies of IHCA and/or OOHCA (three LOE 2, one LOE 3, and two LOE 4) with support from seven animal studies (LOE 5) suggest that minimizing hands-off time, specifically in the pre- and post-defibrillation time frame for patients in VF, may improve patient outcomes.

Rea et al conducted a historically controlled, interventional trial of the 2005 guidelines in bystander-witnessed OOHVF. (Rea, 2006, 2760). The intervention was a single shock algorithm, no post shock rhythm check, and decreased frequency of rhythm checks from 1-2 minutes. ROSC on hospital arrival increased from 59.6% in the 2002-4 control period to 73.9% in the 2005-6 intervention period ($p<0.05$). In addition, survival to discharge increased from 32.8% to 45.5% ($p<0.05$) and percent of patients discharged to home increased from 25.6% to 36.6% ($p<0.05$).There was a trend toward increased neurologically intact survival. These results correlated with an increased median CPR duration between shocks of 54 (25, 100) vs 91 (71, 125) and a decrease in the post-shock pause from 28 (20, 41) to 7 (5, 9) s. This data is supportive of minimizing post-shock pauses and 2 minutes of uninterrupted CPR between rhythm checks. Limitations: confounders are not adjusted for.

Christenson and colleagues conducted a concurrently controlled sub-analysis of the ROC data in OOHVF/VT on the effects of chest compression fraction (CCF) before the first shock (Christenson 2009, 1241). There was a notable increase in both ROSC and survival when CCF increased from 0-20% to 21-40%, and lesser increases beyond 40%, although it is not clear whether there was a significant difference between the categories themselves. An adjusted regression model demonstrated an 11% increase in odds of survival associated with each 10% increase in CCF, however, this assumes a linear relationship which the data are not. Nevertheless, these data support reducing the no-flow fraction during CPR prior to defibrillation.
Limitations: Study only looked at the interval before initial defibrillation without adjusting for the variability in the amount of time included per patient. Of less importance, 79% of the data came from only two ROC sites.

Eilevstjønn et al utilized data from a prospective study of IH- and OOHVF, evaluating the effect of pre-shock pause duration on shock outcome, among other things (Eilevstjønn 2007, 60). In an analysis of 598 shocks, there was significant decrease in median pre-shock pause between those shocks resulting in ROSC and those without (15s vs 18s; p0.008). These data also support minimizing pre-shock pauses. Limitations: cofounders are not adjusted for.

Eftestol and colleagues conducted an observational study of VF characteristics in OOHCA during hands-off segments of up to 20 seconds. (Eftestol, 2002, 2270) A total of 634 segments were evaluated and pROSC calculated in 4-second intervals. There was a trend of decreasing pROSC over time in both the high and middle tertiles of baseline pROSC starting at 5 seconds of pause time. There was no difference in the lowest tertile. Limitations: no adjustment made for nonindependence of data and pROSC was validated in same data set. Recently, Gundersen and colleagues (Gundersen, 2009, 6) demonstrated that analyzing the pROSC values 10 seconds into each segment, rather than using the initial values dramatically changes the established relationship. In this follow-up paper, 911 ECG intervals without chest compressions were identified and divided into 2-second segments (5138 analysis windows in total). The logarithm of the mean-slope of each analysis window was used as a predictor of pROSC. Cases with pROSC values of .035, 0.1 and 0.5 three seconds into the pause had pROSC values of 0.26(0.24-0.29), 0.077 (0.070 – 0.085) and 0.040 (0.036 – 0.045), respectively, at 27 seconds (95% confidence interval in parenthesis). These results demonstrated a 23% relative decrease in pROSC from the 3 to 27 seconds mark during pre-shock pauses.

Edelson and colleagues conducted an observational study of 60 IH and OOH VF arrests evaluating the impact of pre-shock pause. (Edelson, 2006, 137). Pre-shock pauses of less than 10s, 10.1-20s, 20.1-30s and more than 30s had respective shock successes of 94%, 72%, 60% and 38%. Adjusted OR for shock success was 1.86 for every 5s decrease (95%CI 1.10-3.15) in the pre-shock pause. Limitations: Small sample. No significant correlation with ROSC.

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Citation List

Included

Abella, B. S., J. P. Alvarado, et al. (2005). "Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest." JAMA 293(3): 305-310.

A prospective observational study of CPR quality in relation to the published guidelines during resuscitations examining chest compression rate and depth, ventilation rate and no-flow fraction. Study includes an unadjusted comparison of no-flow ratio by ROSC. LOE 2, quality poor, neutral.

Berg, R. A., R. W. Hilwig, et al. (2008). "Immediate post-shock chest compressions improve outcome from prolonged ventricular fibrillation." Resuscitation 78(1): 71-76.

A randomized control trial in a porcine model examining the effect of immediate post-shock chest compressions showing increased return of spontaneous circulation, 24hr survival, 48hr survival and neurological outcomes for those animals versus those assigned to simulated pre-hospital AED care . LOE 5, quality fair, supportive.

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.

A randomized control trial in a porcine model examining the effect automatic external defibrillator use versus manual defibrillator use on 24hr survival and neurological outcomes, showing better outcomes for manually defibrillated animals. LOE 5, quality fair, supportive.

Bobrow, B. J., L. L. Clark, et al. (2008). "Minimally interrupted cardiac resuscitation by emergency medical services for out-of-hospital cardiac arrest.[see comment]." JAMA 299(10): 1158-65.

1) A prospective study of out-of-hospital cardiac arrest before and after minimally interrupted CPR training implemented, showing increased survival to hospital discharge following rescuer training. LOE 3, quality poor, supportive/neutral.
2) A comparison of patients receiving minimally interrupted CPR versus standard advance life support showing increased ROSC, survival, and survival to hospital discharge. LOE 2, quality poor, supportive.
In both, the specific impact of minimizing pauses is not isolated, hence the quality with respect to this question is poor.

Chang, Y.-T., W. Tang, et al. (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.

A randomized control trial in a porcine model examining the effects of exclusion of a 30s post –shock assessment interval prior to CPR and extended CPR intervals (180s versus 90s). Demonstrated that removing the post-shock pause decreased time to ROSC and ST segment elevation at 5 minutes while there was no difference in outcomes associated with 90s vs 180s continuous compressions following the shock or pause. LOE 5, Quality good, supportive

Christenson, J., D. Andrusiek, et al. (2009). "Chest Compression Fraction Determines Survival in Patients With Out-of-Hospital Ventricular Fibrillation." Circulation.

A prospective study analyzing the effect of the chest compression fraction during out-of-hospital arrests with an initial rhythm of VF/VT on survival to hospital discharge and ROSC, demonstrating a weak trend of increasing chest compression fractions correlating to increased survival to hospital discharge and ROSC. LOE2, fair, supportive

Edelson, D. P., B. S. Abella, et al. (2006). "Effects of compression depth and pre-shock pauses predict defibrillation failure during cardiac arrest." Resuscitation 71(2): 137-45.

A prospective study of pre-shock pause times demonstrating that shorter pre-shock pauses prior to defibrillation increase the chance of shock success but not ROSC. LOE 2, quality good, supportive/neutral.

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.

A study of the effect of pre-shock pause length on the probability of ROSC demonstrating a reduction in the probability of ROSC with increasing pause time. LOE 2, quality fair, supportive. Some methodologic concerns that were corrected in a subsequent paper by the authers (Gunderson, 2009, 6)

Eilevstjønn, J., J. Kramer-Johansen, et al. (2007). "Shock outcome is related to prior rhythm and duration of ventricular fibrillation." Resuscitation 75(1): 60-7.

A study on the effects of the duration of VF, from onset to shock delivery, on ROSC. Demonstrated a shorter median pre-shock pause (15s versus 18s) in cases with ROSC versus no-ROSC. LOE 2, fair, supportive

Garza, A. G., M. C. Gratton, et al. (2009). "Improved patient survival using a modified resuscitation protocol for out-of-hospital cardiac arrest.[see comment]." Circulation 119(19): 2597-605.

A before and after study of minimally interrupted CPR training in out-of-hospital witnessed VF showing increased ROSC, and survival to discharge after rescuer retraining. Unfortunately there is not data to show how well the protocol was followed (specifically with respect to hands-off time between the two study periods), therefore it is impossible to isolate the effects of minimizing pauses. LOE 3, quality poor, supportive.

Gundersen, K., J. T. Kvaloy, et al. (2009). "Development of the probability of return of spontaneous circulation in intervals without chest compressions during out-of-hospital cardiac arrest: an observational study." BMC medicine 7: 6.

A retrospective study looking at the probability of ROSC over increasing pause durations (using each pause as it's own control), demonstrating a 23% decrease in pROSC from 3 to 27 seconds of no-flow time. LOE 2, good, supportive.

Kellum, M. J., K. W. Kennedy, et al. (2006). "Cardiocerebral resuscitation improves survival of patients with out-of-hospital cardiac arrest." American Journal of Medicine 119(4): 335-40.

A retrospective comparison of a CPR protocol, including minimization of pauses in chest compressions and elimination of post-shock pauses, to an older protocol. The newly implemented protocol increased both survival and neurologically intact survival. LOE 3, quality poor, supportive.

Kramer-Johansen, J., H. Myklebust, et al. (2006). "Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: A prospective interventional study." Resuscitation 71(3): 283-292.

A study of the effect of audiovisual feedback on CPR quality demonstrating improvements in chest compression depth, and compression rate with no significant difference in survival to discharge. This study is historically controlled and is LOE3 on the question of feedback. However, with respect to pauses in CPR, there was a logistic regression analysis for the outcome of survival to hospital admission across both cohorts which the authors indicate was not significant with respect to no-flow ratio (NFR), p=0.6. LOE 2, quality fair, neutral.

Olasveengen, T. M., E. Vik, et al. (2009). "Effect of implementation of new resuscitation guidelines on quality of cardiopulmonary resuscitation and survival." Resuscitation 80(4): 407-411.

A prospective study of out-of-hospital cardiac arrest before and after the implementation of new resuscitation guidelines emphasizing uninterrupted chest compressions, demonstrating a weak trend towards increasing survival to hospital discharge. LOE 3, quality fair, neutral

Olasveengen, T. M., L. Wik, et al. (2007). "Is CPR quality improving? A retrospective study of out-of-hospital cardiac arrest." Resuscitation 75(2): 260-6.

A retrospective study of measuring the effect of CPR guideline changes on CPR quality administered for out-of-hospital cardiac arrest. Hands-off time and hyperventilation were significantly reduced in the period following the 2005 guideline publication. LOE 3, quality poor, neutral.

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.[see comment]." Circulation 114(25): 2760-5.

An interventional study implementing reduced pause times and eliminating stack shocks. The interventional cohort saw 46% survival to discharge compared to the control period of 33% which corresponded to a decrease in the interval from shock to start to chest compressions. There was not a significant difference in neurologically intact survival. LOE3, fair, supportive/neutral.

Ristagno, G., W. Tang, et al. (2008). "Minimal interruption of cardiopulmonary resuscitation for a single shock as mandated by automated external defibrillations does not compromise outcomes in a porcine model of cardiac arrest and resuscitation." Critical care medicine 36(11): 3048-3053.

A randomized control study in a porcine model comparing the effects of CPR duration and pre-defibrillation pauses on ROSC and 72hr survival, demonstrating no adverse effects of pre-shock interruptions. LOE 5, quality good, neutral.

Sato, Y., M. H. Weil, et al. (1997). "Adverse effects of interrupting precordial compression during cardiopulmonary resuscitation." Crit Care Med 25(5): 733-736.

Randomized controlled trial in a rodent model of increasing pre-shock pause from 0 to 40 seconds demonstrating decreasing rates of ROSC, 24hr and 48 hr survival. LOE 5, quality good, supportive.

Steen, S., Q. Liao, et al. (2003). "The critical importance of minimal delay between chest compressions and subsequent defibrillation: a haemodynamic explanation." Resuscitation 58(3): 249-258.

Randomized control study in swine model demonstrating the how CPR before and during defibrillation improves the likelihood of ROSC. ROSC was seen 83% of the time in the experimental group that received mCPR for 3.5min prior and during defibrillation compared to 0% ROSC with defibrillation only. LOE 5, Good quality, supportive.

Valenzuela, T. D., K. B. Kern, et al. (2005). "Interruptions of chest compressions during emergency medical systems resuscitation." Circulation 112(9): 1259-65.

A retrospective study of interruptions in chest compressions in OOH cardiac arrests. This study included a separate analysis of patients in the intervention cohort alone, comparing those who were successfully resuscitated with those patients that were not. The result was a non-significant increase in CC% in those not resuscitated (49% vs 34%, p=0.09). LOE 2, Poor quality. Neutral.

Walcott, G. P., S. B. Melnick, et al. (2009). "Effect of timing and duration of a single chest compression pause on short-term survival following prolonged ventricular fibrillation." Resuscitation 80(4): 458-462.

1) A randomized control study of cardiac arrest in a porcine model looking at the effects of peri-shock pause timing and duration on 4 hr survival. Demonstrated reduced 4hr survival in animals with a 20s post-shock pause plus 20 sec pre-shock pause, compared to the 3 other randomized groups which had no post-shock pause but varying timing and duration of the pre-shock pause. LOE 5, quality good, supportive for avoiding post-shock pauses in compressions.
2) An additional non-randomized concurrent control group was added to assess the impact of removing the pre-shock pause entirely and demonstrated no change in outcome when compared to the three subgroups from part one that did not have a post-shock pause. LOE 5, quality fair, neutral.

Wik, L., J. Kramer-Johansen, et al. (2005). "Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest." JAMA 293(3): 299-304.

Observational study of adherence to CPR guidelines.The authors included a concurrently-controlled comparison of NFR between those that survived to discharge and those patients that did not, demonstrating a non-significant decrease in NFR in survivors (40% v 49%, p=0.34). LOE 2, Poor quality. Neutral.

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

Randomized control study in swine model of increasing AED pre-shock pauses from 3 to 20 seconds demonstrating decreased CPR outcome with pulse checks greater than 15 seconds. Stack charges not relevant. LOE 5, Good quality, Supportive.

Excluded

Babbs, C. F., A. E. Kemeny, et al. (2008). "A new paradigm for human resuscitation research using intelligent devices." Resuscitation 77(3): 306-315.

A retrospective analysis of the effect of delayed defibrillation and compression depth on both defibrillation success and return of spontaneous circulation. Excluded because it did not address the question directly.

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

A randomized control trial in a porcine model examining the effect of chest-compressions-only (CC) versus chest compressions and rescue breathing resuscitation (CC+RB) on coronary perfusion pressure, blood oxygen content, myocardial oxygen delivery, 24hr survival and neurological outcomes. While the CPP was higher for the CC group, blood oxygen content as higher for the CC+RB group such that myocardial oxygen delivery was the same for both groups. 24hr survival and neurological outcomes were the same for both groups. Excluded because the study compares chest compression only CPR with standard CPR without specifically evaluating hands off time.

Hostler, D., J. C. Rittenberger, et al. (2007). "Increased chest compression to ventilation ratio improves delivery of CPR." Resuscitation 74(3): 446-452.

A prospective study before and after CPR training emphasizing continuous chest compressions and a 30:2 C:V ratio demonstrating an increased number of chest compressions delivered and fewer patients going into asystole. Excluded because it compares intervals of continuous chest compressions delivery during different C:V ratyios rather than evaluating hands off time.

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.

A randomized trial in a porcine cardiac arrest model comparing the effects of chest compressions with interruptions for ventilations versus continuous chest compressions on 24hr survival with normal neurological functions. Demonstrated elevated survival for the chest compression only cases. Excluded because study compares chest compression only versus conventional CPR without specifically analyzing the hands off time.

Lloyd, M. S., B. Heeke, et al. (2008). "Hands-On Defibrillation: An Analysis of Electrical Current Flow Through Rescuers in Direct Contact With Patients During Biphasic External Defibrillation." Circulation 117(19): 2510-2514.

A study of the level of current running through a rescuer with gloved hands placed on the patient and a thigh electrode connecting to the patient's shoulder. Measure leakage currents were found to be less than recommended safety standards. Excluded because it did not address the question directly.

Rea, T. D., S. Shah, et al. (2005). "Automated external defibrillators: to what extent does the algorithm delay CPR?" Ann Emerg Med 46(2): 132-41.

A retrospective study of out-of-hopsital cardiac arrests looking at the probability of ROSC during rhythm checks following initial and stacked shocks. Excluded because it did not address the question directly.