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

Worksheet author(s)

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Clinical question.

BLS-034A.R2: In adult and pediatric patients with cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific rate for external chest compressions (I) compared with standard care (i.e. approximately 100/min) (C), improve outcome (e.g., ROSC, survival) (O)?

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

Conflict of interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? Co-author of one cited article

Search strategy (including electronic databases searched).

- PubMed (NLM) (Dec 12, 2004 – November 9, 2009)
- Ovid Medline (Dec 12, 2004 – November 9, 2009)

Query: "chest compression* rate"[All Fields]
Query: "rate*[All Fields] AND heart massage [MeSH Terms] AND cardiopulmonary resuscitation/methods[MeSH Terms]" – ***113 hits***

- State inclusion and exclusion criteria

Inclusion: human, surrogate (manikin), animal and mathematical model studies.

Exclusion: Article did not address chest compression rate, C:V ratio studies, alternative method for CPR (abdominal compression, active compression-decompression (ACD), impedance threshold valve (ITV), etc.), mechanical models that did not test different rates of chest compression, not English language, or review articles.

91 articles excluded

- Number of articles/sources meeting criteria for further review:

22 articles

Summary of evidence

Evidence Supporting Clinical Question

Use a chest compression rate of 100/min and/or deliver at least 70 – 90 compressions/min

Good				**Christenson J Circulation 2009 C** **Abella BS. Circulation 2005 A**	
Fair			**Kellum MJ. Am J Med 2006 D**	**Fletcher D Resuscitation 2008 C**	
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

Use a chest compression rate of 100/min and/or deliver at least 70 – 90 compressions/min

Good				Kramer-Johansen J. Resusc 2006 C Abella BS. Resusc 2007 C Losert H. Arch Int Med 2006 E Abella BS. JAMA 2005 E Wik L. JAMA 2005 E	Perkins GD Resusc 2004 E Beckers SK Resusc 2007 E Dias JA Resusc 2007 E Dawkins Resusc 2008 E Devries, Handley Resusc 2007 E Roppolo L, et al. Resusc 2007 E Deschilder K, et al. Resusc 2007E Heidenreich JW. Acad Emerg Med 2006 E Brown TB. Resusc 2006 E Lynch B. Resusc 2005 E Trowbridge C. BioMed Central Nursing 2009E
Fair					Deakin CD, Resusc 2007 E Williamson LI. Emerg Med J. 2005 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 Opposing Clinical Question

Use a chest compression rate of 100/min and/or deliver at least 70 – 90 compressions/min

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

<u>Excerpted From C2005 Worksheet W167B – Gabrielli/Fenici:</u>

Determine class of recommendation:
Hypothesis E: Chest compression rate (speed of compression)

- Speed of chest compression should be maintained at least 100/min and not more than 130/min (Class IIb).

Reviewer's comments and assessment of benefit/risk:
Recent theoretical, animal and human data reflect the importance of limiting ventilation rates in order to maximize vital organ blood flow (see C:V ratio AHA worksheet by Fenici/Gabrielli/Lurie available on the AHA Consensus 2005 website). It is now accepted that during cardiac arrest mixed venous blood gases reflect tissue oxygenation and acid-base state more accurately. Therefore, a minute ventilation that is considerably less than that required in the presence of a normal cardiac output, may produce normal arterial blood gases and provide adequate exchange of alveolar gas during CPR. Moreover, maneuvers aimed to increase proficiency of ventilation usually decrease the speed of chest compression. ***[Thomas, 1993]***.

Animal investigations have reported that stroke volume remained relatively constant during chest compression. As a result left ventricular dimensions decreases minimally at higher manual compression rates. and cardiac output increases significantly at higher compression rate, generally up to 130 compression /min ***[Maier, 1984]***; the hemodynamic advantage of higher compression rate is generally not dependent on alteration in the duty cycle ***[Feneley, 1988]***.

Halperin et al ***[Halperin, 1986]*** demonstrated an increase of cerebral and coronary blood flow by keeping the duty cycle at 50% and progressively increasing the rate of compression from 60 to 150 /min. In this model cerebral and coronary blood flow was quantified using a microsphere technique.

A faster rate (120 /min) is associated with better neurological outcome in animals at 24h, and improvement of ETCO2 in humans during cardiac arrest ***[Kern, 1992]***.

High-fidelity hemodynamic recordings of aortic and right atrial pressures and the coronary perfusion gradient (the difference between aortic and right atrial pressure) made in nine patients during cardiopulmonary resuscitation (CPR) suggested there is a theoretical advantage to perform faster compressions using a *high-impulse* and a C:V ratio less than 50% ***[Swenson, 1988]***.

While the optimal compression: ventilation ratio is not known, the speed of compression reflects the current C:V recommendation in adults. (see C:V ratio AHA worksheet by Fenici/Gabrielli/Lourie available on the AHA Consensus 2005 website). Mathematical, animal and human data to be extrapolated from the C:V ratio literature are still too speculative and the potential advantage of compression-only CPR is affected by the presence of an endotracheal tube while performing CPR making general use of this technique uncertain. With the current C:V recommendation of 15:2 in adults and the limitations provided by the extensive time required to provide mouth-to-mouth ventilation and early (one minute) onset of rescuer fatigue, maintaining the speed of chest compression at a minimum of 100 /min is reasonable.

Preliminary draft outline/bullet points of guidelines revision:

- Cardiac output, cerebral and coronary blood flow and 24-hour neurological outcome increases significantly at higher compression rate, generally up to 130 compression /min; the hemodynamic advantage of higher compression rates is not dependent on alteration in duty cycle ***(LOE 6)***.

- The hemodynamic gain from higher compression rate during CPR is maintained when the duty cycle is maintained at 50% and rate progressively increased up to 150 /min ***(LOE 6)*****.**

- A metronome or other timing device is associated with improvement of ETCO2 in humans during cardiac arrest ***(LOE 5)***.

- High rate (120 /min) CPR matched with *high-impulse compressions* (duty cycle less than 50%) increases coronary perfusion in humans ***(LOE 5).***

- Speed of chest compression in adults remains dependent upon the C:V ratio and the limitations provided by the time necessary to provide mouth-to-mouth or bag-mask ventilation and onset of rescuer fatigue ***(LOE 5 and 6).***

Current C2010 Review

One study of in-hospital cardiac arrest patients (Abella BS. 428) (***LOE 4***, case series) showed that chest compression rates >80/min were associated with ROSC and patients who had ROSC received a higher mean chest compression rate (90±17) compared with those without ROSC (79±18). Another study of out-of-hospital cardiac arrest **(LOE 3)** (Kellum 2006, 335) showed an association of improved neurologically intact survival when continuous chest compressions at a rate of 100/min without pauses along with other interventions was used. An observational study **(LOE 4)** (Christenson 2009, 1241) of 506 patients showed improved survival to hospital discharge when at least 60 chest compressions per minute were delivered (median rate 99-115 CC/min). The group with the highest survival rate received compressions 61% - 80% of the time chest compression fraction) and had a median compression rate of 111 (IQR 100 – 123). This translates into actually delivering 68 – 89 chest compressions/min. This study suggests that a chest compression rate as high as 120/min is acceptable since it is associated with improved survival by delivering more chest compressions/min.

Five human studies (***LOE 4***) and twelve manikin studies (***LOE 5***) support the feasibility of using a chest compression rate of 100/min. Human and manikin studies show that the recommended chest compression rate is frequently used. A number of human studies show that healthcare providers often use chest compression rates greater than 100/min (Christenson 2009, 1241; Fletcher 2008, 127; Wik 2005, 299) However, interruptions in chest compression are common and result in a much lower number of chest compressions actually delivered. One study showed that professional rescuers used a median chest compression rate of about 128/min and with use of metronome guidance decreased to 106/min, which was associated with improved survival-to-hospital discharge (Fletcher 2008, 127). A number of other improvements in CPR quality also occurred, such as increased hands-on time, and decreased chest compression-to-shock interval. Thus, the improved survival rate can't be attributed to the change in chest compression rate alone.

Acknowledgements: Ms. Lorrie Burkhalter provided extraordinary assistance in gathering the literature used for this review.

Summary Outcomes

Use a chest compression rate of 100/min and/or deliver at least 70 – 90 compressions/min

Patient group	Numbers	ROSC	Long term survivors
Adult in-hosp CA (Abella)	97	61/97 (63%)	NA
Adult OOH CA (Kellum)	135	37/135 (27%)	30/135 (22%)
Adult OOH CA (Christenson)	506	309/506 (61%)	117/506 (23%)
Total adult	738	407/738 (55%)	147/641 (23%)

Knowledge Gaps

A controlled clinical trial comparing chest compression rates would add to our knowledge of which rate is best.

What is the relationship between chest compression rate and depth? Does a faster rate result in less compression depth? Is it associated with increased rescuer fatigue?

Citation List

(Abella, Sandbo et al. 2005)

Abella, B. S., N. Sandbo, et al. (2005). "Chest compression rates during cardiopulmonary resuscitation are suboptimal: a prospective study during in-hospital cardiac arrest." Circulation **111**(4): 428-434.

(LOE 4, Good) This study supports the concept that the number of chest compressions delivered per minute is of great importance for survival.

Beckers, S. K., M. H. Skorning, et al. (2007). "CPREzy improves performance of external chest compressions in simulated cardiac arrest." Resuscitation **72**(1): 100-7.

(LOE 5, Good). Chest compression rate can be improved with a feedback device.

Brown, T. B., J. A. Dias, et al. (2006). "Relationship between knowledge of cardiopulmonary resuscitation guidelines and performance." Resuscitation **69**(2): 253-61.

(LOE 5, Good). Cognitive knowledge of CPR guidelines affects quality of CPR.

Christenson, J., D. Andrusiek, et al. (2009). "Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation." Circulation **120**(13): 1241-7.

(LOE 4, Good) This study supports the concept that the number of chest compressions delivered per minute is of great importance for survival. It also suggests that a chest compression rate as high as 120/min is acceptable.

Dawkins, S., C. D. Deakin, et al. (2008). "A prospective infant manikin-based observational study of telephone-cardiopulmonary resuscitation." Resuscitation **76**(1): 63-8.

(LOE 5, Good) Instructions for CPR over the telephone were associated with poor CPR quality.

de Vries, W. and A. J. Handley (2007). "A web-based micro-simulation program for self-learning BLS skills and the use of an AED. Can laypeople train themselves without a manikin?" Resuscitation **75**(3): 491-8.

(LOE 5, Good). While computer-based CPR instruction was associated with poor CPR quality, correct application of an AED was good. This study supports the notion that CPR is primarily a psychmotor skill, while AED application is primarily a cognitive skill, which can be taught by a computer program.

Deakin, C. D., J. F. O'Neill, et al. (2007). "Does compression-only cardiopulmonary resuscitation generate adequate passive ventilation during cardiac arrest?" Resuscitation **75**(1): 53-9.

(LOE 5, Fair). While this study does not speak to the question of chest compression rate, it adds to our knowledge of chest com,pression only CPR. It shows that the concept of "passive ventilation" may be misleading.

Deschilder, K., R. De Vos, et al. (2007). "The effect on quality of chest compressions and exhaustion of a compression--ventilation ratio of 30:2 versus 15:2 during cardiopulmonary resuscitation--a randomised trial." Resuscitation **74**(1): 113-8.

(LOE 5, Good). This study showed that a chest compression ventilation ratio of 30:2 resulted in significantly more chest compressions per minute when compared with a ratio of 15:2. This is important to know since this was the primary goal for changing this guideline 5 years ago.

Dias, J. A., T. B. Brown, et al. (2007). "Simplified dispatch-assisted CPR instructions outperform standard protocol." Resuscitation **72**(1): 108-14.

(LOE 5, Good). Specific dispatch instructions can affect quality of CPR.

Fletcher, D., R. Galloway, et al. (2008). "Basics in advanced life support: a role for download audit and metronomes." Resuscitation **78**(2): 127-34.

(LOE 4, Fair). this is an important study showing that quality of CPR can be improved and is associated with increased survival to hospital discharge.

Heidenreich, J. W., R. A. Berg, et al. (2006). "Rescuer fatigue: standard versus continuous chest-compression cardiopulmonary resuscitation." Acad Emerg Med **13**(10): 1020-6.

(LOE 5, Good) A study comparing continuous chest compression CPR with 30:2 CPR showed more adequate chest compressions with CCC for the first 2 min, but no difference beyond 2 min probably because of increased rescuer fatigue.

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

(LOE 3, Fair) An important study showing that continuous chest compressions at 100/min was associated with improved neurologically intact survival. The study methods were fair since there were a number of other important changes in the CPR protocol used in addition to CCC, this was a before and after study design, the actual performance of CPR was not measured and, therefore, protocol adherance must be assumed. In addition, there probably was a substantial Hawthorne Effect since the subjects knew they were being studied in the after phase but not in the before phase.

Kramer-Johansen, J., L. Wik, et al. (2006). "Advanced cardiac life support before and after tracheal intubation--direct measurements of quality." Resuscitation **68**(1): 61-9.

(LOE 4, Good). Chest compression fraction was low in this study and was better after intubation because pauses for ventilation were eliminated after intubation. This study highlights the importance of measuring CPR performance.

Losert, H., F. Sterz, et al. (2006). "Quality of cardiopulmonary resuscitation among highly trained staff in an emergency department setting." Arch Intern Med **166**(21): 2375-80.

(LOE 4, Good). This observational study measured CPR performance. It showed that healthcare professionals use a chest compression rate of 112 - 116, resulting in 96 chest compressions/min.

Lynch, B., E. L. Einspruch, et al. (2005). "Effectiveness of a 30-min CPR self-instruction program for lay responders: a controlled randomized study." Resuscitation **67**(1): 31-43.

(LOE 5, Good). Video-based self-instruction is a reasonable alternative CPR training method.

Perkins, G. D., B. T. Stephenson, et al. (2004). "A comparison between over-the-head and standard cardiopulmonary resuscitation." Resuscitation **61**(2): 155-161.

(LOE 5, Good). A study showing an alternative chest compression technique is effective.

Roppolo, L. P., P. E. Pepe, et al. (2007). "Prospective, randomized trial of the effectiveness and retention of 30-min layperson training for cardiopulmonary resuscitation and automated external defibrillators: The American Airlines Study." Resuscitation **74**(2): 276-85.

(LOE 5, Good) Video-based self-instruction was as effective as a standard 3-4 hour course. Retention of skills after 6 months were good and not significantly different for either course. The AED training in the self-instruction course consisted of a 5 minute demonstration without any hands-on training and was as effective as the standard hands-on training, even after 6 months. This again supports the notion that AED use is mostly a cognitive skill.

Trowbridge, C., J. N. Parekh, et al. (2009). "A randomized cross-over study of the quality of cardiopulmonary resuscitation among females performing 30:2 and hands-only cardiopulmonary resuscitation." BMC Nurs **8**: 6.

(LOE 5, Good). This study showed increased fatigue and worse CPR quality with Hands-only CPR compared with 30:2 CPR.

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

(LOE 4, Good). An important study showing that professionals use a mean chest compression rate of 121/min, with only 64 compression/min being delivered because of substantial hands-off time. This study highlights the importance of measuring CPR performance.

Williamson, L. J., P. D. Larsen, et al. (2005). "Effect of automatic external defibrillator audio prompts on cardiopulmonary resuscitation performance." Emerg Med J **22**(2): 140-3.

(LOE 5, Fair). Audio prompts can improve quality of CPR.