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

Worksheet author(s)

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Clinical question.

BLS020B: In adult and pediatric patients in cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of feedback regarding the mechanics of CPR quality (e.g. rate and depth of compressions and/or ventilations) (I) compared with no feedback (C), improve any outcomes (eg. 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 of CPR prompt worksheets

Conflict of interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? No

Search strategy (including electronic databases searched).

PubMed from 1966 (to 31st Jan 2010):
"feedback" AND ("Heart Arrest"[Mesh] Or "Resuscitation"[Mesh] OR "Cardiopulmonary Resuscitation"[Mesh]) AND ((clinical[Title/Abstract] AND trial[Title/Abstract]) OR clinical trials[MeSH Terms] OR clinical trial[Publication Type] OR random*[Title/Abstract] OR random allocation[MeSH Terms] OR therapeutic use[MeSH Subheading]): 82 hits

"prompt*"[All Fields] AND ("Heart Arrest"[Mesh] Or "Resuscitation"[Mesh] OR "Cardiopulmonary Resuscitation"[Mesh]) AND ((clinical[Title/Abstract] AND trial[Title/Abstract]) OR clinical trials[MeSH Terms] OR clinical trial[Publication Type] OR random*[Title/Abstract] OR random allocation[MeSH Terms] OR therapeutic use[MeSH Subheading]): 187 hits

Embase (from 1990):
prompt$.tw. and detailed embase search (17 March 09): 32 hits, 31 excluded (one new one: Kern 1992, 145).
feedback.tw. and detailed embase search (17 March 09): 11 hits, 5 excluded (one new: Fletcher 2008, 127).

1. Heart Arrest/
2. Sudden Death/
3. cardiac arrest.tw.
4. heart arrest.tw.
5. cardiopulmonary arrest.tw.
6. sudden cardiac death$.tw.
7. sudden death$.tw.
8. or/1-7
9. Resuscitation/
10. Heart Massage/
11. cpr.tw.
12. cardiopulmonary resuscitation.tw.
13. chest compression$.tw.
14. resuscitat$.tw.
15. or/9-14
16. 8 and 15
17. clinical trial/
18. random$.tw.
19. randomized controlled trial/
20. trial$.tw.
21. follow-up.tw.
22. double blind procedure/
23. placebo$.tw.
24. placebo/
25. factorial$.ti,ab.
26. (crossover$ or cross-over$).ti,ab.
27. (double$ adj blind$).ti,ab.
28. (singl$ adj blind$).ti,ab.
29. assign$.ti,ab.
30. allocat$.ti,ab.
31. volunteer$.ti,ab.
32. Crossover Procedure/
33. Single Blind Procedure/
34. or/17-33
35. (exp animal experiment/ or nonhuman/) not exp human/
36. 34 not 35
37. 16 and 36

Additional studies identified from known lists of references.
• State inclusion and exclusion criteria **I**ncluded: all studies in human cardiac arrests where feedback regarding the mechanics of CPR quality (e.g. rate and depth of compressions and/or ventilations) was utilised. Studies using prompt devices (eg. metronomes) were also included. Excluded: Abstract only studies, case reports, review articles, non-peer reviewed studies, and ones that did not directly answer question (eg. 11 manikin only studies (Wik, 2001 167; Wik, 2002 273; Handley, 2003 57; Noordergraaf, 2006 241; Spooner, 2007 417; Sutton, 2007 161; Betz, 2008 278; Dine, 2008 2817; Isbye, 2008 73; Oh, 2008 273; Roessler, 2009 104), animal studies (MILANDER 1995???), physiological feedback [eg. ETCO2], feedback after resuscitation, observed but no feedback (1 = Abella, 2005 428). Also excluded VF waveform analysis (eg. Li 2008, as covered in separate worksheet). Specific articles that illustrated concerns were also included (including manikin studies).
• Number of articles/sources meeting criteria for further review: 16 2 LOE 2 (Berg, 1994, 35; Kern 1992, 145), 5 LOE 3 (Abella, 2007 54; Chiang, 2005 297; Fletcher 2008, 127; Kramer-Johansen, 2006, 283; Olasveengen, 2007, 427-33), 5 LOE 4 (Edelson, 2008, 1063; Gruben, 1990, 204-10; Pierpont, 1985, 513-20; Pytte, 2007, 770-2; Risdal, 2007, 2237-45), and 4 LOE 5 (Cho 2009, 600; Odegaard, 2007, 127-34; Perkins 2009, 79; Yeung, 2009, 743).

Summary of evidence

Evidence Supporting Clinical Question

Good			**Abella, 2007 Monitor-defib E (V, C) Chiang, 2005 audio-prompt E (C) Kramer-Johansen, Monitor-defib 2006 E (C)**	**Edelson, 2008 Q-CPR E (V. C) Risdal, 2007 Thoracic impedance E(V)**	**Yeung, 2009 E**
Fair		**Kern, 1992 Audiotone E (H)**		**Gruben, 1990 Pressure-sensing arm E(C) Pierpont, 1985 Intra-arterial line E(C)**	
Poor		**Berg, 1994 Audiotone E (H)**	**Fletcher 2008, Metronome C, E (C)**	**Pytte, 2007 Thoracic impedance E(V)**	
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
(V) = ventilation parameters

C = Survival to hospital discharge
D = Intact neurological survival
(C) = compression parameters

E = Other endpoint
Italics = Animal studies
(H) = haemodynamics/ETCO2

Evidence Neutral to Clinical question

Good			**Kramer-Johansen, Monitor-defib 2006 E (V) Olasveengen, 2007 Monitor-defib E(V, C)**		
Fair					**Odegaard, 2007 Monitor-defib E(C)**
Poor		**Berg, 1994 Audiotone E (H)**			
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
(V) = ventilation parameters
C = Survival to hospital discharge
D = Intact neurological survival
(C) = compression parameters
E = Other endpoint
Italics = Animal studies
(H) = haemodynamics/ETCO2

Evidence Opposing Clinical Question

Good					
Fair					**Perkins, 2009 Q-CPR manikin E (C)**
Poor					**Cho 2009 E**
	1	**2**	**3**	**4**	**5**
Level of evidence					

A = Return of spontaneous circulation
B = Survival of event
(V) = ventilation parameters
C = Survival to hospital discharge
D = Intact neurological survival
(C) = compression parameters
E = Other endpoint
Italics = Animal studies
(H) = haemodynamics/ETCO2

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

Various devices have been suggested over the years to potentially improve the quality of CPR (compressions and ventilation). These range from intra-arterial pressure measurements to a variety of force and pressure transducers, and devices to measure transthoracic impedance. There are no published RCTs addressing the use of feedback regarding the mechanics of CPR quality in human cardiac arrests. A literature review (LOE 5) based on the ILCOR worksheet process was published in 2009 [Yeung, 2009, 743]. Review of references revealed no additional studies.

Intra-arterial line:
Pierpont (1985) reported a **case series** (fair LOE 4) in **in-hospital cardiac arrests**, where he was able to demonstrate **haemodynamic improvements** in compression technique after insertion of **intra-arterial** monitoring device. [Pierpont, 1985, 513-20]

Force and acceleration sensors:
Gruben (1990) reported a **series** of patients (fair, LOE 4) where a **position-sensing arm** was used which allowed measurement of force and acceleration at the sternum. This was a **supportive** case series for **haemodynamic effects** when feedback provided during in-hospital cardiac arrests.[Gruben, 1990, 204-10]

Abella (2007) reports in a before and after study (good LOE 3) using an investigational monitor/defibrillator with realtime CPR-sensing and feedback capabilities during **in-hospital cardiac arrests**. Historical controls were used (CPR without feedback). There was a trend toward improvement in the mean values of CPR variables in the feedback group, and **narrowing of distribution** of **rate of compressions** (104+/-18 to 100+/-13 min(-1); test of means, p=0.16; test of variance, p=0.003) and **ventilation rate** (20+/-10 to 18+/-8 min(-1); test of means, p=0.12; test of variance, p=0.04) was seen. [Abella, 2007, 54-61]

Kramer-Johansen (2006) reports a before after **OOHCA** study (good LOE 3 but describe as "prospective non-randomised"), involving the use of a prototype defibrillator to provide feedback regarding. There were no changes in the mean number of ventilations per minute; 11 +/- 5 min(-1) versus 11 +/- 4 min(-1) (difference 0 (-1, 1), P = 0.8) or the fraction of time without chest compressions; 0.48 +/- 0.18 versus 0.45 +/- 0.17 (difference -0.03 (-0.08, 0.01), P = 0.08). Average **compression depth** increased from (mean +/- S.D.) 34 +/- 9 to 38 +/- 6 mm (mean difference (95% CI) 4 (2, 6), P < 0.001), and median percentage of compressions with adequate depth (38-51 mm) increased from 24% to 53% (P < 0.001, Mann-Whitney U-test) with feedback. Mean **compression rate decreased** from 121 +/- 18 to 109 +/- 12 min(-1) (difference -12 (-16, -9), P = 0.001). With intention to treat analysis 7/241 control patients were discharged alive (2.9%) versus 5/117 with feedback (4.3%) (OR 1.5 (95% CI; 0.8, 3), P = 0.2). In a logistic regression analysis of all cases, witnessed arrest (OR 4.2 (95% CI; 1.6, 11), P = 0.004) and average compression depth (per mm increase) (OR 1.05 (95% CI; 1.01, 1.09), P = 0.02) were associated with rate of hospital admission. [Kramer-Johansen, 2006, 283-92]

Olasveengen (2007) reports (in a neutral before after study (good LOE 3)) a study of realtime automated and visual feedback in **adult OOHCA** (85) compared with previous CPR (39). Performance characteristics were **not improved with feedback**: no flow, compressions, or ventilation. No significant improvement was seen in quality of CPR after CPR-PE. No chest compressions were given 40% of the time before versus 41% after CPR-PE. The median (95% confidence interval) percentage of chest compressions within the recommended depth range (38-51 mm) was 35% (27-57) before versus 51% (42-60) after CPR-PE, a potentially clinically significant difference, but because of small numbers the result was not statistically significant (p = 0.12). [Olasveengen, 2007, 427-33]

Edelson (2008) is a good LOE 4 study. A series of 224 patients resuscitated using Q-CPR (CPR-sensing and feedback-enabled defibrillator). Use was associated with recorded outcomes for various parameters including ventilation rate, compression rate and depth, and interruptions to CPR. [Actual specific purpose of study was to compare controls with debriefing intervention using quality of CPR data: mean (SD) ventilation rate decreased (13 [7]/min vs 18 [8]/min; P < .001) and compression depth increased (50 [10] vs 44 [10] mm; P = .001)].

Odegaard (2007) reports the results from evaluation forms (accompanying a **manikin study;** poor LOE 5**)** where rescuers express **concerns about depth of compression** and damage to patient and stating this may decrease likelihood of health care providers responding to feedback regarding compressions, and limit the potential benefits of the feedback techniques. [Odegaard, 2007, 127-34]

Perkins (2009) reports the results of a manikin study which comparisons of depth of chest compression (via manikin sensors), and those measured by the accelerometer (Q-CPR), on various surfaces. Feedback provided by the accelerometer device led to significant under compression of the chest when CPR was performed on a bed with a foam 26.2 (2.2) mm or inflatable mattress 32.2 (1.16) mm. This undercompression represented approximately 35–40% of total compression depth.

Cho [Cho 2009, 600] reported 2 cases where significant skin and soft tissue damage was related to use of feedback-sensor for Phillips/Laedal device. Both patients died.

Transthoracic impedance:
Abella (2007) reports in a before and after study (good LOE 3) that the use of an investigational monitor/defibrillator with realtime CPR-sensing and feedback capabilities during **in-hospital cardiac arrests** resulted in a **narrowing of distribution** of **ventilation rate** (20+/-10 to 18+/-8 min(-1); test of means, p=0.12; test of variance, p=0.04). [Abella, 2007, 54-61]

Risdal (2007) reports a series of patients in cardiac arrest (good LOE 4 study), in which **thoracic impedance was used for detection of ventilation**.[Risdal, 2007, 2237-45]

Pytte (2007) reports two cases (poor LOE 4) of OOHCA where **trans-thoracic impedance detected misplaced ETTs by detecting inadequate ventilation**. [Pytte, 2007, 770-2]

Audio-prompts:
Kern (1992) is a fair quality LOE 2 study (using concurrent controls in a cross-over fashion). In-hospital adult cardiac arrests, an audio-tone was used to guide compressions at 80/min or 120/min. Control group = before audiotone guidance, then guide to 80, then guide to 120/min. The **mean end-tidal carbon dioxide** level during compressions of 120 per minute was 15.0+/-1.8 mm Hg, slightly but **significantly higher** than the mean level of 13.0+/-1.8 mm Hg at a compression rate of 80 per minute.
Berg (1994) is a small LOE 2 study (using concurrent controls in a cross-over fashion). In-hospital cardiac arrests in children. . Control group = before audiotone guidance, then guide to 100, then guide to 140/min. Increase in ETCO2 with 100/min not significant (but borderline for 140/min compared with baseline).
Chiang (2005) is a good quality LOE 3 (before after study) in ED. Good. 30 resuscitation attempts were recorded during study period: 17 patients were in the observation group (Sept 1 2003 to 30 Nov 2003) and 13 patients in the intervention group (1 Dec 2003 to 31 Mar 2004). Intervention group = audiotape recorded from a metronome at 100 bleeps/min, and the other was a siren that sounded once every 20 s. Compared to the observation group, the intervention group showed a significant improvement in the hands-off period per minute during CPR (12.7 +/- 5.3 s versus 16.9+/-7.9 s, P < 0.05), the total hands-off time during CPR (164 +/-

94 s versus 273 +/- 153 s, P < 0.05), the proportion of intubation attempts taking under 20 s (56.3% versus 10%, P < 0.05).
Fletcher (2008) is a poor quality LOE 3 study (using retrospective controls). A new protocol for CPR commenced in one ambulance service with continuous compressions for first 2 minutes CPR, and musicians' metronomes were introduced progressively over several months from January 2005. Patients observed between May 2004 to December 2006. Improvement in unexplained "hands-off" time, survival to hospital discharge (2003: 2 of 202 admitted to hospital [which includes CPR on route], 2004: 7/196 [but no CPR en route], and 17/139 in 2005). Claim if adjust denominator for 20% increase per year, significant increase in survival persists (chi-square=8.02,d.f.=2,p=0.02). Also improvement in mid-range compression rate which fell significantly from 2004 to 2005 (p=0.003) and from 2005 to 2006 (p<0.001). Control group is recently implemented chest compression only for first 2 minutes policy.

Acknowledgements: Nil

Citation List

Abella BS, Edelson DP, Kim S, Retzer E, Myklebust H, Barry AM, et al. CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system. Resuscitation. 2007 Apr;73(1):54-61.

LOE 3, good. Supportive. Investigational monitor/defibrillator with CPR-sensing and feedback capabilities was used during in-hospital cardiac arrests. Historical controls (without feedback). Narrowing of distribution of rate of compressions (104+/-18 to 100+/-13 min(-1); test of means, p=0.16; test of variance, p=0.003) and ventilation rate (20+/-10 to 18+/-8 min(-1); test of means, p=0.12; test of variance, p=0.04).

Berg RA, Sanders AB, Milander M et al. (1994) Efficacy of audio-prompted rate guidance in improving resuscitator performance of cardiopulmonary resuscitation on children. Acad Emerg Med 1:35-40

LOE 2 – neutral; quality poor

Chiang WC, Chen WJ, Chen SY, Ko PC, Lin CH, Tsai MS, et al. Better adherence to the guidelines during cardiopulmonary resuscitation through the provision of audio-prompts. Resuscitation. 2005;64(3):297-301.

LOE 3. Before after study. Good. Supportive for "other" endpoint (compressions).
30 resuscitation attempts were recorded during study period: 17 patients were in the observation group (Sept 1 2003 to 30 Nov 2003) and 13 patients in the intervention group (1 Dec 2003 to 31 Mar 2004). Intervention group = audiotape recorded from a metronome at 100 bleeps/min, and the other was a siren that sounded once every 20 s. Compared to the observation group, the intervention group showed a significant improvement in the hands-off period per minute during CPR (12.7 +/- 5.3 s versus 16.9+/-7.9 s, P < 0.05), the total hands-off time during CPR (164 +/- 94 s versus 273 +/- 153 s, P < 0.05), the proportion of intubation attempts taking under 20 s (56.3% versus 10%, P < 0.05).

Cho GC. Skin and soft tissue damage caused by use of feedback-sensor during chest compressions. Resuscitation. 2009;80(5):600; discussion 1.

LOE 5, Poor (case series of 2), Opposing
Case series of 2 cases where significant skin and soft tissue damage related to use of feedback-sensor for Phillips/Laedal device. Both patients died.

Edelson DP, Litzinger B, Arora V, Walsh D, Kim S, Lauderdale DS, et al. Improving in-hospital cardiac arrest process and outcomes with performance debriefing. Arch Intern Med. 2008;168(10):1063-9.

LOE 4. Good. Supportive for "other" endpoint (compression and ventilation).

Series of 224 patients resuscitated using Q-CPR (CPR-sensing and feedback-enabled defibrillator). Use was associated with recorded outcomes for various parameters including ventilation rate, compression rate and depth, and interruptions to CPR. (Mean (SD) ventilation rate decreased (13 [7]/min vs 18 [8]/min; P < .001) and compression depth increased (50 [10] vs 44 [10] mm; P = .001) with debriefing intervention using quality of CPR data).

Fletcher D, Galloway R, Chamberlain D, Pateman J, Bryant G, Newcombe RG. Basics in advanced life support: A role for download audit and metronomes. Resuscitation. 2008;78(2):127-34.

LOE 3. Retrospective controls. Poor (controls, confounders). Supportive survival to discharge, and "other" endpoint (compressions). New protocol for CPR commenced in one ambulance service with continuous compressions for first 2 minutes CPR, and introduction of musicians' metronomes progressively over several months from January 2005. Observed May 2004 to December 2006. Improvement in unexplained "hands-off" time, survival to hospital discharge (2003: 2 of 202 admitted to hospital [which includes CPR on route], 2004: 7/196 [but no CPR en route], and 17/139 in 2005). Claim if adjust denominator for 20% increase per year, significant increase in survival persists (chi-square=8.02,d.f.=2,p=0.02). Also improvement in mid-range compression rate which fell significantly from 2004 to 2005 (p=0.003) and from 2005 to 2006 (p<0.001). Control group is recently implemented chest compression only for first 2 minutes policy.

Gruben KG, Romlein J, Halperin HR, Tsitlik JE. System for mechanical measurements during cardiopulmonary resuscitation in humans. IEEE Trans Biomed Eng. 1990 Feb;37(2):204-10.

LOE 4, Fair. Supportive case series for haemodynamic effects when feedback provided during in-hospital cardiac arrests, via position-sensing arm, which allowed measurement of force and acceleration at the sternum.

Kern KB, Sanders AB, Raife J, Milander MM, Otto CW, Ewy GA. A study of chest compression rates during cardiopulmonary resuscitation in humans: The importance of rate-directed chest compressions. Archives of Internal Medicine. 1992;152(1):145-9.

LOE 2. Concurrent controls (cross-over). Fair. Supportive for other (haemodynamics).
In-hospital adult cardiac arrests, using audio-tone to guide compressions at 80/min or 120/min. Control group = before audiotone guidance, then guide to 80, then guide to 120/min. The mean end-tidal carbon dioxide level during compressions of 120 per minute was 15.0+/-1.8 mm Hg, slightly but significantly higher than the mean level of 13.0+/-1.8 mm Hg at a compression rate of 80 per minute.

Kramer-Johansen J, Myklebust H, Wik L, Fellows B, Svensson L, Sorebo H, et al. Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: a prospective interventional study. Resuscitation. 2006 Dec;71(3):283-92.

LOE 3 (before after, but describe as "prospective non-randomised"), supportive "other" endpoint (compressions). Consecutive OOHCA. Prototype defibrillator. Intention to treat analysis. Average compression depth increased from (mean +/- S.D.) 34 +/- 9 to 38 +/- 6 mm (mean difference (95% CI) 4 (2, 6), P < 0.001), and median percentage of compressions with adequate depth (38-51 mm) increased from 24% to 53% (P < 0.001, Mann-Whitney U-test) with feedback. Mean compression rate decreased from 121 +/- 18 to 109 +/- 12 min(-1) (difference -12 (-16, -9), P = 0.001). Increased depth of compression associated with increased survival.

Odegaard S, Kramer-Johansen J, Bromley A, Myklebust H, Nysaether J, Wik L, et al. Chest compressions by ambulance personnel on chests with variable stiffness: abilities and attitudes. Resuscitation. 2007 Jul;74(1):127-34.

LOE 5, Fair. Neutral. Evaluation forms and manikin study, reinforcing concerns about depth of compression and damage to patient and stating this may decrease likihood of haeth care providers responding to feedback.

Olasveengen TM, Tomlinson AE, Wik L, Sunde K, Steen PA, Myklebust H, et al. A failed attempt to improve quality of out-of-hospital CPR through performance evaluation. Prehosp Emerg Care. 2007 Oct-Dec;11(4):427-33.

Neutral before after study (good LOE 3). Olasveengen (2007) reports a before after study of realtime automated and visual feedback in adult OOHCA (85) compared with previous CPR (39). Similar performance characteristics: no flow, compressions, ventilation. No significant improvement was seen in quality of CPR after CPR-PE. No chest compressions were given 40% of the time before versus 41% after CPR-PE. The median (95% confidence interval) percentage of chest compressions within the recommended depth range (38-51 mm) was 35% (27-57) before versus 51% (42-60) after CPR-PE (p = 0.12).

Perkins GD, Kocierz L, Smith SC, McCulloch RA, Davies RP. Compression feedback devices over estimate chest compression depth when performed on a bed. Resuscitation. 2009;80(1):79-82.

LOE 5 Fair Opposing: Paper reports the results of a manikin study which comparisons of depth of chest compression (via manikin sensors), and those measured by the accelerometer (Q-CPR), on various surfaces. Feedback provided by the accelerometer device led to significant under compression of the chest when CPR was performed on a bed with a foam 26.2 (2.2) mm or inflatable mattress 32.2 (1.16) mm. This undercompression represented approximately 35–40% of total compression depth.

Pierpont GL, Kruse JA, Nelson DH. Intra-arterial monitoring during cardiopulmonary resuscitation. Cathet Cardiovasc Diagn. 1985;11(5):513-20.

LOE 4. Supportive of haemodynamic improvements in compression technique (in in-hospital cardiac arrests) after insertion of intra-arterial monitoring device.

Pytte M, Olasveengen TM, Steen PA, Sunde K. Misplaced and dislodged endotracheal tubes may be detected by the defibrillator during cardiopulmonary resuscitation. Acta Anaesthesiol Scand. 2007 Jul;51(6):770-2.

Supportive LOE 4 (poor). Case reports of 2 cases of OOHCA where trans thoracic impedance detected misplaced ETTs by detecting inadequate ventilation.

Risdal M, Aase SO, Stavland M, Eftestol T. Impedance-based ventilation detection during cardiopulmonary resuscitation. IEEE Trans Biomed Eng. 2007 Dec;54(12):2237-45.

LOE 4. Good. Supportive for accurate detection of ventilation using thoracic impedance.

Yeung J, Meeks R, Edelson D, Gao F, Soar J, Perkins GD. The use of CPR feedback/prompt devices during training and CPR performance: A systematic review. resuscitation. 2009;80(7):743-51.

LOE 5, Good, Supportive
Literature review based on ILCOR worksheet process.