WORKSHEET for Evidence-Based Review of Science for Veterinary CPCR

1. Basic Demographics

Worksheet author(s)

Kate Hopper	**Date Submitted for review:**
[redacted]	[redacted]

2. Clinical question:

In veterinary CPR providers (P), does performing CPR for an extended period of time (e.g. 5 minutes) (I), compared to a short time (e.g. 1 minute) (C), impair quality of CPR (eg. chest compression depth, leaning, compression rate) (O)?

3. Conflict of interest specific to this question:

None

4. Search strategy (including electronic databases searched):

4a. Databases

Pubmed (NLM) (no date restriction) (performed on July 3, 2011)
1. chest compressions
2. timing
3. fatigue
4. quality
5. leaning
6. Guidelines

1 and 2: 1 relevant hits out of 22 total hits
1 and 3: 4 relevant hits out of 39 total hits
1 and 4: 0 relevant hits out of 192 total hits
1 and 5: 0 relevant hits out of 8 total hits
1 and 6: 1 relevant hits out of 248 total hits

Cab Abstracts (1910 to Feb 2011) (performed on June 10, 2011)
(1) Chest compression
(2) Fatigue
(3) Timing
(1) No relevant hits
(2) No relevant hits
(1) and (3) no relevant hits
(2) and (3) no relevant hits

Google Scholar

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Chest compressions AND fatigue – 2 additional relevant hits

4b. Other sources

In addition the references of the review articles Berg 2010 and Chi 2010 were searched and this revealed two more relevant articles.

4c. State inclusion and exclusion criteria for choosing studies and list number of studies excluded per criterion

Inclusion criteria

Evaluation of quality of chest compressions over time

Exclusion criteria

Abstracts only, English language articles only.

4d. Number of articles/sources meeting criteria for further review: 9

One human clinical study (Sugerman 2009) and eight experimental manikin studies were identified. (Chi 2010; Bjorshol 2008; Riera 2007; Heidenreich 2006; Aufderheide 2005; Ashton 2002; Ochoa 1998; Hightower 1995)

5. Summary of evidence

Evidence Supporting Clinical Question

Good						
Fair						***Sugerman 2009***; *E = compression rate and depth* ***Chi 2010***; *E=compression force & rate* ***Heidenreich 2006;*** *E=compression rate & depth and rescuer fatigue* ***Ashton 2002***; *E=compression rate & depth* ***Ochoa 1998***; *E=compression rate & depth* ***Hightower 1995***; *E=compression rate & depth*
Poor						***Aufderheide 2005***; *E=airway pressure, chest wall compression & decompression*
	1	**2**	**3**	**4**	**5**	**6**
Level of evidence						

(P)						

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Non-target species studies

Evidence Neutral to Clinical question

Good						
Fair						
Poor						***Riera 2007****; E=compression rate & rescuer responses*
	1	**2**	**3**	**4**	**5**	**6**
Level of evidence (P)						

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Non-target species studies

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Evidence Opposing Clinical Question

Good						
Fair						
Poor						***Bjorshol 2008****; E = compression rate and depth*
	1	**2**	**3**	**4**	**5**	**6**
Level of evidence (P)						

A = Return of spontaneous circulation
B = Survival of event
C = Survival to hospital discharge
D = Intact neurological survival
E = Other endpoint
Italics = Non-target species studies

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

Effective chest compressions need to be performed at an adequate rate and appropriate chest wall compression and decompression must occur. Performing chest compressions is strenuous exercise and leads to rescuer fatigue and suggests the rescuer doing chest compressions should be alternated on a regular basis, if possible. There are several studies in the literature, primarily manikin based studies, demonstrating that loss of chest compression quality occurs within the first 1 to 2 minutes of chest compressions and that 5 minutes of chest compressions by a single rescuer is too long. No animal studies addressing this issue were found.

One human clinical study and six manikin studies reported a decline in the quality of chest compressions over time. The clinical study found that the depth of chest compressions declined after 90 seconds of CPR despite provision of automated audiovisual CPR feedback (Sugarmen 2009a). This finding was similar to the manikin studies. There is no consensus as to how quickly fatigue occurs and it may vary between individual rescuers, the position the rescuer is in when performing chest compressions and the compression:ventilation (C:V) ratio used. There is evidence that fatigue and loss of chest compression quality can occur as early as one minute after starting chest compressions. A manikin study in which the number of correct chest compressions (defined by hand position and compression depth) performed declined every minute for the 5 minute study period from 93% in the first minute to 67%, 39%, 31% and 18% for each following minute, respectively. Further, the rescuers in this study failed to identify when they were fatigued (Hightower 1995). In another manikin study the quality of chest compressions significantly declined after the first minute of cpr although rescuers on average did not identify fatigue until they had performed 2 minutes of cpr (Ochoa 1998). Three more manikin studies were found that all suggested chest compressions for 3 minutes or longer was associated with loss of compression quality. (Ashton 2002; Heidenreich 2006; Chi 2010).

Adequate chest wall decompression is also essential for effective CPR and rescuer fatigue may contribute to incomplete chest wall decompression. One manikin study demonstrated that incomplete chest wall decompression is a common problem in CPR and made an anecdotal observation that rescuer fatigue contributed to the occurrence of inadequate decompression. (Aufderheide 2005)

In contrast to all the other studies identified, Bjorshol et al. found that the quality of chest compressions could be maintained for a 10 minute period of single rescuer CPR on manikins at varying C:V ratios (Bjorshol 2008). Chest compression depth did deteriorate after the first 2 minutes in this study but remained above an acceptable level for the entire study.

There is sufficient evidence to suggest that performance of chest compressions for 5 minutes or longer is likely to be associated with rescuer fatigue and a decline in quality of chest compressions. Although the ideal time to alternate rescuers is unknown, the current human medical guideline of every 2 minutes would appear to be reasonable. As there are no animal studies evaluating this issue the relevance of this information to CPR in dogs and cats is unclear.

7. Conclusion

DISCLAIMER: Potential possible wording for a Consensus on Science Statement. Final wording will differ due to other input and discussion.
CONSENSUS ON SCIENCE: One human clinical study (Sugerman 2009, LOE6) and five experimental manikin studies (Chi 2010, LOE6)(Heidenreich 2006, LOE6)(Aufderheide 2005, LOE6)(Ashton 2002, LOE6)(Hightower 1995, LOE6) demonstrated a loss in quality of chest compressions within the first 1 to 3 minutes. One human manikin study (Riera 2007, LOE6) found that 2 minutes of cpr was well sustained by rescuers while another human manikin study (Bjorshol 2008, LOE6) reported that chest compressions could be

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maintained for 10 minutes by a single rescuer without the quality of cpr deteriorating below an acceptable level. No animal studies were found related to this issue. The results of these studies would suggest that performing CPR for 5 minutes or longer is likely to be associated with fatigue and loss of quality of chest compressions.

8. Acknowledgement

9. Citation list

Part 5: adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.

Berg RA, Hemphill R, Abella BS, Aufderheide TP, Cave DM, Hazinski MF, Lerner EB, Rea TD, Sayre MR, Swor RA.
Circulation. 2010;122(18 Suppl 3):S685-705.

Abstract
The critical lifesaving steps of BLS are ● Immediate Recognition and Activation of the emergency response system ● Early CPR and ● Rapid Defibrillation for VF. When an adult suddenly collapses, whoever is nearby should activate the emergency system and begin chest compressions (regardless of training). Trained lay rescuers who are able and healthcare providers should provide compressions and ventilations. Contrary to the belief of too many in this situation, CPR is not harmful. Inaction is harmful and CPR can be lifesaving. However, the quality of CPR is critical. Chest compressions should be delivered by pushing hard and fast in the center of the chest (ie, chest compressions should be of adequate rate and depth). Rescuers should allow complete chest recoil after each compression and minimize interruptions in chest compressions. They should also avoid excessive ventilation. If and when available, an AED should be applied and used without delaying chest compressions. With prompt and effective provision of these actions, lives are saved every day.
Key points: Current recommendation is that when 2 or more rescuers are available it is reasonable to switch chest compressions approximately every 2 minutes.

Effects of compression-to-ventilation ratio on compression force and rescuer fatigue during cardiopulmonary resuscitation.

Chi CH, Tsou JY, Su FC.
Am J Emerg Med. 2010;28(9):1016-23

INTRODUCTION:
Although increasing consecutive compressions during cardiopulmonary resuscitation (CPR) is beneficial to patients, it possibly affects the workload and, ultimately, the quality of CPR. This study examines the effects of compression-to-ventilation ratio on external chest compression performance of rescuers.
METHODS:
Subjects were 17 health care providers. Each participant performed CPR with 3 compression-to-ventilation ratios: 15:2, 30:2, and 50:5. The duration of CPR was 5 minutes in each group, with a rest period of 50 minutes in between. The manikin was equipped with a 6-axis force load cell to measure the force applied. An 8-camera digital motion analysis system was used to collect the 3-dimensional trajectory information. Data were compared using the crossover design. Ratings of perceived exertion and body area discomfort were measured.
RESULTS:
The mean compression forces (in Newtons) delivered at 1 minute 20 seconds to 1 minute 40 seconds and at 4 minutes 20 seconds to 4 minutes 40 seconds were 494.65 ± 53.58 and 478.64 ± 50.29, respectively ($P = .047$), for compression-to-ventilation ratios of 15:2; 473.57 ± 49.69 and 435.59 ± 56.79, respectively ($P < .001$), for ratios of 30:2; and 468.44 ± 38.05 and 442.18 ± 43.40, respectively ($P = .012$), for ratio of 50:5. Diminished compression force in the ratio 50:5 was observed at 1 minute 20 seconds, and in the 30:2 ratio, it was observed at 4 minutes 20 seconds. The mean joint angles in each group did not differ significantly between 1 minute 20

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seconds and 4 minutes 20 seconds. The Ratings of Perceived Exertion Scale was 3.38 ± 1.64 in 15:2, 4.06 ± 1.43 in 30:2, and 4.35 ± 1.54 in 50:5 (P = .045). Waist discomfort was noted in 50:5 after 4 minutes 20 seconds of external chest compression.
CONCLUSIONS:
Rescuer fatigue must be considered when raising the consecutive compression during CPR. Switching the compressor every 2 minutes should be followed where possible.
Key Points: LOE 6, supportive, fair: Most rescuers can do 5 min of CPR but compression force was decreased at 4min and 20sec time point. Supports changing the compressor every 2 minutes.

Rescuer fatigue during actual in-hospital cardiopulmonary resuscitation with audiovisual feedback: a prospective multicenter study.

Sugerman NT, Edelson DP, Leary M, Weidman EK, Herzberg DL, Vanden Hoek TL, Becker LB, Abella BS.
Resuscitation. 2009;80(9):981-4.

BACKGROUND:
Rescuer fatigue during cardiopulmonary resuscitation (CPR) is a likely contributor to variable CPR quality during clinical resuscitation efforts, yet investigations into fatigue and CPR quality degradation have only been performed in simulated environments, with widely conflicting results.
OBJECTIVE:
We sought to characterize CPR quality decay during actual in-hospital cardiac arrest, with regard to both chest compression (CC) rate and depth during the delivery of CCs by individual rescuers over time.
METHODS:
Using CPR recording technology to objectively quantify CCs and provide audiovisual feedback, we prospectively collected CPR performance data from arrest events in two hospitals. We identified continuous CPR "blocks" from individual rescuers, assessing CC rate and depth over time.
RESULTS:
135 blocks of continuous CPR were identified from 42 cardiac arrests at the two institutions. Median duration of continuous CPR blocks was 112s (IQR 101-122). CC rate did not change significantly over single rescuer performance, with an initial mean rate of 105+/-11/min, and a mean rate after 3 min of 106+/-9/min (p=NS). However, CC depth decayed significantly between 90s and 2 min, falling from a mean of 48.3+/-9.6mm to 46.0+/-9.0mm (p=0.0006) and to 43.7+/-7.4mm by 3 min (p=0.002).
CONCLUSIONS:
During actual in-hospital CPR with audiovisual feedback, CC depth decay became evident after 90s of CPR, but CC rate did not change. These data provide clinical evidence for rescuer fatigue during actual resuscitations and support current guideline recommendations to rotate rescuers during CC delivery.
Key Points: LOE 6, supportive, fair: The quality of chest compressions declines after 3 minutes of continuous CPR despite the provision of automated CPR audiovisual feedback.

Rescuer fatigue: standard versus continuous chest-compression cardiopulmonary resuscitation.

Heidenreich JW, Berg RA, Higdon TA, Ewy GA, Kern KB, Sanders AB.
Acad Emerg Med. 2006;13(10):1020-6.

OBJECTIVES:
Continuous chest-compression cardiopulmonary resuscitation (CCC-CPR) has been advocated as an alternative to standard CPR (STD-CPR). Studies have shown that CCC-CPR delivers substantially more chest compressions per minute and is easier to remember and perform than STD-CPR. One concern regarding CCC-CPR is that the rescuer may fatigue and be unable to maintain adequate compression rate or depth throughout an average emergency medical services response time. The specific aim of this study was to compare the effects of fatigue on the performance of CCC-CPR and STD-CPR on a manikin model.
METHODS:
This was a prospective, randomized crossover study involving 53 medical students performing CCC-CPR and STD-CPR on a manikin model. Students were randomized to their initial CPR group and then performed the other type of CPR after a period of at least two days. Students were evaluated on their performance of 9 minutes of CPR for each method. The primary endpoint was the number of adequate chest compressions (at least 38 mm of compression depth) delivered per minute during each of the 9 minutes. The secondary endpoints were total compressions, compression rate, and the number of breaks taken for rest. The students'

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performance was evaluated on the basis of Skillreporter Resusci Anne (Laerdal, Wappingers Falls, NY) recordings. Primary and secondary endpoints were analyzed by using the generalized linear mixed model for counting data.

RESULTS:

In the first 2 minutes, participants delivered significantly more adequate compressions per minute with CCC-CPR than STD-CPR, (47 vs. 32, p = 0.004 in the 1st minute and 39 vs. 29, p = 0.04 in the 2nd minute). For minutes 3 through 9, the differences in number of adequate compressions between groups were not significant. Evaluating the 9 minutes of CPR as a whole, there were significantly more adequate compressions in CCC-CPR vs. STD-CPR (p = 0.0003). Although the number of adequate compressions per minute declined over time in both groups, the rate of decline was significantly greater in CCC-CPR compared with STD-CPR (p = 0.0003). The mean number of total compressions delivered in the first minute was significantly greater with CCC-CPR than STD-CPR (105 per minute vs. 58 per minute, $p < 0.001$) and did not change over 9 minutes in either group. There were no differences in compression rates or number of breaks between groups.

CONCLUSIONS:

CCC-CPR resulted in more adequate compressions per minute than STD-CPR for the first 2 minutes of CPR. However, the difference diminished after 3 minutes, presumably as a result of greater rescuer fatigue with CCC-CPR. Overall, CCC-CPR resulted in more total compressions per minute than STD-CPR during the entire 9 minutes of resuscitation.

Key Points: LOE 6, supportive, fair: When rescuers perform chest compressions on a manikin the continuous chest compression technique performed better in the first 2 minutes than standard CPR. Continuous CPR was associated with a greater rate of decline in chest compression rate (reflecting fatigue) compared to standard CPR.

Incomplete chest wall decompression: a clinical evaluation of CPR performance by EMS personnel and assessment of alternative manual chest compression-decompression techniques.

Aufderheide TP, Pirrallo RG, Yannopoulos D, Klein JP, von Briesen C, Sparks CW, Deja KA, Conrad CJ, Kitscha DJ, Provo TA, Lurie KG.

Resuscitation. 2005;64(3):353-62.

BACKGROUND:

Complete **chest wall** recoil improves hemodynamics during cardiopulmonary resuscitation (CPR) by generating relatively negative intrathoracic pressure and thus draws venous blood back to the heart, providing cardiac preload prior to the next **chest** compression phase.

OBJECTIVE:

Phase I was an observational case series to evaluate the quality of **chest wall** recoil during CPR performed by emergency medical services (EMS) personnel on patients with an out-of-hospital cardiac arrest. Phase II was designed to assess the quality of CPR delivered by EMS personnel using an electronic test manikin. The goal was to determine if a change in CPR technique or hand position would improve complete **chest wall** recoil, while maintaining adequate duty cycle, compression depth, and correct hand position placement. Standard manual CPR and three alternative manual CPR approaches were assessed.

METHODS AND RESULTS:

Phase I--The clinical observational study was performed by an independent observer noting incomplete **chest wall decompression** and correlating that observation with electronically measured airway pressures during CPR in adult patients with out-of-hospital cardiac arrest. Rescuers were observed to maintain some residual and continuous pressure on the **chest wall** during the **decompression** phase of CPR, preventing full **chest wall** recoil, at some time during resuscitative efforts in 6 (46%) of 13 consecutive adults (average +/- S.D. age 63 +/-5.8 years). Airway pressures were consistently positive during the **decompression** phase (>0 mmHg) during those observations. Phase II: This randomized prospective trial was performed on an electronic test manikin. Thirty EMS providers (14 EMT-Basics, 5 EMT-Intermediates, and 11 EMT-Paramedics), with an average age +/- S.D. of 32 +/- 8 years and 6.5 +/- 4.2 years of EMS experience, performed 3 min of CPR on a Laerdal Skill Reporter CPR manikin using the Standard Hand Position followed by 3 min of CPR (in random order) using three alternative CPR techniques: (1) Two-Finger Fulcrum Technique--lifting the heel of the hand slightly but completely off the **chest** during the **decompression** phase of CPR using the thumb and little finger as a fulcrum; (2) Five-Finger Fulcrum Technique--lifting the heel of the hand slightly but completely off the **chest** during the **decompression** phase of CPR using all five fingers as a fulcrum; and (3) Hands-Off Technique--lifting the heel and all fingers of the hand slightly but completely off the **chest** during the **decompression** phase of CPR. These EMS personnel did not know the purpose of the studies prior to or during this investigation. Adequate compression depth was poor for all hand positions tested and ranged only from 29.9 to 48.5% of all compressions. When compared with the Standard Hand Position, the Hands-Off Technique decreased mean compression duty cycle from 46.9 +/- 6.4% to 33.3 +/- 4.6%, ($P < 0.0001$) but achieved the highest rate of complete **chest wall** recoil (95.0% versus 16.3%, $P < 0.0001$) and was 129 times more likely to provide complete **chest wall** recoil (OR: 129.0; CI: 43.4-382.0). There were no significant differences in accuracy of hand placement, depth of compression, or reported increase in fatigue or discomfort with its use compared with the Standard Hand Position.

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CONCLUSIONS:
Incomplete **chest wall decompression** was observed at some time during resuscitative efforts in 6 (46%) of 13 consecutive adult out-of-hospital cardiac arrests. The Hands-Off Technique decreased compression duty cycle but was 129 times more likely to provide complete **chest wall** recoil (OR: 129.0; CI: 43.4-382.0) compared to the Standard Hand Position without differences in accuracy of hand placement, depth of compression, or reported increase in fatigue or discomfort with its use. All forms of manual CPR tested (including the Standard Hand Position) in professional EMS rescuers using a recording manikin produced an inadequate depth of compression more than half the time. These data support development and testing of more effective means to deliver manual as well as mechanical CPR.
Key Points: LOE 6, supportive, fair: This study demonstrated that incomplete chest wall decompression is a common problem in CPR. An anecdotal observation of this study was that rescuer fatigue contributed to inadequate decompression.

Effect of rescuer fatigue on performance of continuous external chest compressions over 3 min.

Ashton A, McCluskey A, Gwinnutt CL, Keenan AM.
Resuscitation. 2002;55(2):151-5.

Abstract
Guidelines for the performance of cardiopulmonary resuscitation (CPR) have been revised recently and now advocate that chest compressions are performed without interruption for 3 min in patients during asystole and pulseless electrical activity. The aim of the present study was to determine if rescuer fatigue occurs during 3 min of chest compressions and if so, the effects on the rate and quality of compressions. Forty subjects competent in basic life support (BLS) were studied. They performed continuous chest compressions on a Laerdal Skillmeter Resusci-Anne manikin for two consecutive periods of 3 min separated by 30 s. The total number of compressions attempted was well maintained at approximately 100 min(-1) throughout the period of study. However, the number of satisfactory chest compressions performed decreased progressively during resuscitation ($P < 0.001$) as follows: first min, 82 min(-1); second, 68 min(-1); third, 52 min(-1); fourth, 70 min(-1); fifth, 44 min(-1); sixth, 27 min(-1). We observed significant correlations between the number of satisfactory compressions performed and both height and weight of the rescuer. Female subjects achieved significantly fewer satisfactory compressions compared with males ($P = 0.03$). Seven subjects (five female, two male) were unable to complete the second 3-min period because of exhaustion. We conclude that rescuer fatigue adversely affects the quality of chest compressions when performed without interruption over a 3-min period and that this effect may be greater in females due to their smaller stature. Consideration should be given to rotating the rescuer performing chest compressions after 1 min intervals.
Key Points: LOE 6, supportive, fair: A manikin study where chest compressions were maintained for 3 minute intervals. Quality of chest compressions declined during this period and suggests rescuers should be alternated more frequently than every 3 minutes.

The effect of rescuer fatigue on the quality of chest compressions.

Ochoa FJ, Ramalle-Gómara E, Lisa V, Saralegui I.
Resuscitation. 1998;37(3):149-52.

OBJECTIVE:
The aim of this study was to evaluate the influence of rescuer fatigue on the quality of chest compressions and the influence of the rescuer's gender, age, weight, height or professional status on the reduction of quality of chest compressions caused by fatigue.
MATERIAL AND METHODS:
The study was carried out with the Laerdal Skillmeter Resusci Anne manikin. The participants were doctors and nurses who work in the Intensive Care and Emergency departments, with an age ranging from 25 to 45 years and trained in cardiopulmonary resuscitation (CPR). Statistical analysis of results includes analysis variance and three models of multiple linear regression.
RESULTS:
Thirty-eight people took part in the experiment; 20 (52.6%) were females; 15 (39.5%) staff physicians, 15 (39.5%) nurses and eight residents. Mean age was 34.1 years ($SD = 4.1$). We found a significant reduction in correct compression performance over the course of time: in the first minute 79.7%, in the second 24.9%, in the third 18%, in the fourth 17.7% and in the last minute 18.5%. There were no differences related to the rescuer's gender or profession. The median interval until rescuers appreciated the effect of the fatigue on chest compressions quality was 186 s ($SD = 84.1$); that appreciation was not influenced by gender, age, weight, height or profession. There were no differences in the percentage of correct compressions related to gender ($P = 0.07$), insufficient sternal depression ($P = 0.23$) or total number of compressions in the first minute.
DISCUSSION:
A decrease of compressions quality after the first minute of CPR is produced. This effect does not depend on gender, age, weight, height or rescuer's profession and it is not adequately perceived by the person who performs the chest compressions.

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Key Points: LOE 6, supportive, fair: In a manikin study the quality of chest compressions significantly declined after the first minute of cpr although rescuers on average did not identify fatigue until they had performed 2 minutes of cpr.

Decay in quality of closed-chest compressions over time.

Hightower D, Thomas SH, Stone CK, Dunn K, March JA.
Ann Emerg Med. 1995;26(3):300-3.

STUDY OBJECTIVE:
To characterize fatigue-induced deterioration in the adequacy of closed-chest compressions performed over a period of 5 minutes and to determine whether CPR providers can recognize the effects of fatigue on compression adequacy.
DESIGN:
Prospective evaluation of study subjects performing closed-chest compressions on an electronic mannequin that assesses compression placement and depth.
SETTING:
Major resuscitation room in rural university hospital emergency department.
PARTICIPANTS:
Eleven experienced nursing assistants who regularly provide CPR in the ED.
RESULTS:
Each study participant performed 5 minutes of closed-chest compressions. Compression adequacy (for placement and depth) was assessed with the mannequin and reported on an attached monitor out of view of the study subjects. Subjects were asked to verbally indicate the point during their 5-minute compression period at which they felt too fatigued to provide effective compressions (arbitrarily defined as a minimum of 90% of all compressions being judged correct by the mannequin). We used one-way repeated-measures ANOVA and regression analysis to determine whether compression adequacy diminished over time. ANOVA was also used to determine whether the total compressions performed per minute diminished over time. The percentage of correct chest compressions decreased significantly after 1 minute of compressions (P = .0001). We found 92.9% of compressions performed during minute 1 to be correct. The percentages for minutes 2 through 5 were as follows: 67.1%, 39.2%, 31.2%, and 18.0%. Regression analysis revealed a decrement in compression adequacy of 18.6% per minute after the first minute of compressions. The number of total compressions attempted per minute did not decrease (P = .98). Study subjects did not accurately identify the point during their 5-minute sessions at which their fatigue caused compressions to become impaired. Whereas mean compression adequacy declined below 90% after only 1 minute, the time of indicated fatigue was 253 +/- 40 seconds (mean +/- SD).
CONCLUSION:
Although compression rate was maintained over time, chest compression quality declined significantly over the study period. Because CPR providers could not recognize their inability to provide proper compressions, cardiac arrest team leaders should carefully monitor compression adequacy during CPR to assure maximally effective care for patients receiving CPR.
Key points: LOE 6, supportive, fair: A manikin study in which the number of correct chest compressions performed declined every minute for the 5 minute study period. Rescuers were unable to identify when they were fatigued and the quality of chest compressions had decreased.

The physiological effect on rescuers of doing 2min of uninterrupted chest compressions.

Riera SQ, González BS, Alvarez JT, Fernández Mdel M, Saura JM.
Resuscitation. 2007;74(1):108-12

OBJECTIVES:
To analyse how rescuers tolerate the effort derived of giving **uninterrupted chest compressions** during 2min.
MATERIALS AND METHODS:
Twenty-three healthy volunteers, nurses and doctors of the Intensive Care Unit (ICU), members of the hospital cardiac arrest team, were enrolled in the study. Using a training manikin, participants were asked to perform **chest compressions** during 2min at a rate of 100min(-1). The oxygen saturation and cardiac rate of the subjects were monitored using pulse oximetry before and after one and 2min performing **chest compressions**. The percentage of the maximal heart rate of the rescuer over the theoretical maximum allowed in a conventional stress test was calculated, taking into account age and body mass index (BMI) of the subjects. Fatigue was measured using a visual analogical scale (VAS).
RESULTS:

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The means (+/-S.D.) of **chest compressions** in the first and second minutes were 103+/-12, and 104+/-11, respectively. The mean percent of the maximum heart rate observed was 61+/-8%. None of the subjects had difficulties to complete the test. All subjects recovered their basal values in less than 2min, and the mean value recorded in the VAS was 3+/-2.

CONCLUSIONS:

The practice of **uninterrupted chest compressions** during 2min by the same rescuer is well tolerated by health professionals trained in cardiopulmonary resuscitation (CPR).

Key Points: LOE 6, neutral, poor: Performance of 2 minutes of cpr was well tolerated by health professionals working on a human manikin – similar results were achieved by all rescuers despite gender, age, smoking status, etc.

Quality of chest compressions during 10min of single-rescuer basic life support with different compression: ventilation ratios in a manikin model.

Bjørshol CA, Søreide E, Torsteinbø TH, Lexow K, Nilsen OB, Sunde K.
Resuscitation. 2008;77(1):95-100

INTRODUCTION:

Good quality basic life support (BLS) improves outcome during cardiac arrest. As **fatigue** may reduce BLS performance over time we wanted to examine the quality of chest compressions in a single-rescuer scenario during prolonged BLS with different compression:ventilation ratios (C:V ratios).

MATERIAL AND METHODS:

Professional paramedics were asked to perform single-rescuer BLS with C:V ratios of 15:2, 30:2 and 50:2 for 10 min each in random order. A Laerdal Medical Resusci Anne Simulator with PC Skillreporting System was used for BLS quality analysis. Total number of chest compressions, compression depth and compression rate were measured and the differences between the C:V ratios were analysed with repeated measures ANOVA. For analysis of **fatigue**, chest compression variables for each 2-min period were analysed and compared with the first 2-min period using repeated measures ANOVA.

RESULTS:

Altogether 50 paramedics completed the study. The mean number of chest compressions increased significantly from 604 to 770 and 862 with C:V ratios of 15:2, 30:2 and 50:2, respectively. Chest compression rate was significantly higher with C:V ratio of 15:2 compared to 30:2 and 50:2 but was above 100 per minute for all three ratios. However, the mean chest compression depth did not change significantly between the different C:V ratios. The number of chest compressions did not change significantly with time for any of the three C:V ratios. Compression depth did decline after the first 2-min period for 30:2 and 50:2 as did compression rate for all three ratios. However all were above the guideline limits for the entire test period.

CONCLUSION:

Increasing the C:V ratio increases the number of chest compressions during 10 min of BLS. Compression depth and compression rate were within guideline recommendations for all three ratios. We found no decline in chest compression quality below guideline recommendations during 10 min of BLS with any of the three different C:V ratios.

Key Points: LOE 6, opposing, poor: A manikin study that reported no deterioration in quality of chest compressions over a 10 minute period of single rescuer CPR. Several different compression:ventilation ratios were evaluated.

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