American Red Cross
Advisory Council on
First Aid, Aquatics,
Safety and Preparedness

ACFASP Scientific Review

Compression Only CPR

Questions to be addressed:
Should continuous cardiac compressions (CCC) without expired air ventilation be recommended for the treatment of adult out-of-hospital cardiac arrest by lay responders?

Introduction/Overview:

Several observational studies document improved survival from out-of-hospital arrest with bystander CPR [*Thompson, Ann Intern Med 1979, Cummins RO, JAMA 198*5]. However, many individuals may be reluctant to provide mouth-to-mouth assisted ventilations, and thus not provide any CPR. Thus, the concept of compression only CPR or continuous chest compressions (CCC) as an alternative to standard CPR with mouth-to-mouth ventilations and chest compressions has been advocated by some in order to increase the frequency of bystander CPR. There have been many animal studies, observational studies in humans, and one prospective randomized trial in humans that have supported this concept. These studies have generally demonstrated equivalent or superior outcomes with CCC as compared to standard CPR. The current recommendation by the American Heart Association and the European Resuscitation Council is to encourage laypersons to perform compression-only CPR if they are unable or unwilling to perform rescue breaths, though the preferred method is standard CPR with compressions and ventilations.

Review Process and Literature Search Performed

Cochrane – no relevant reviews with search of “cardiopulmonary resuscitation”, “chest compressions” or “cardiocerebral resuscitation”.

Pubmed searched for studies that included patients that received chest compressions without ventilations at some point in the resuscitation. This included either bystander CPR or CPR performed without ventilations by emergency personnel. The continuous chest compression (CCC) group must have been separated from other groups of CPR in the analysis to be included. Outcomes had to be clearly defined with the primary and secondary outcomes of interest listed below. Animal studies were included as were simulation studies.

Pubmed search with following terms:
SEARCH TERM: **cardiocerebral resuscitation**
cardiocerebral[All Fields] AND ("resuscitation"[MeSH Terms] OR "resuscitation"[All Fields]) –

27 results, 4 kept

SEARCH TERM: cardiopulmonary resuscitation AND chest compressions
("cardiopulmonary resuscitation"[MeSH Terms] OR ("cardiopulmonary"[All Fields] AND "resuscitation"[All Fields]) OR "cardiopulmonary resuscitation"[All Fields]) AND (("thorax"[MeSH Terms] OR "thorax"[All Fields] OR "chest"[All Fields]) AND compressions[All Fields])

651 results, 35 kept

SEARCH TERM: continuous chest compressions
continuous[All Fields] AND ("thorax"[MeSH Terms] OR "thorax"[All Fields] OR "chest"[All Fields]) AND compressions[All Fields]

91 results 13 kept

Review of bibliography of selected manuscripts

3 additional studies

Criteria for considering studies for this review

Primary outcomes – Neurologically intact survival at hospital discharge – Change this to primary outcome? Survival to hospital discharge
Secondary outcomes – Neurologically intact survival at hospital discharge, ROSC, survival to hospital admission, improved hemodynamics, improved gas exchange, adherence of compressions with guidelines
Adverse outcomes – Worsened survival, worse hemodynamics, worse gas exchange, worse adherence of compressions with guidelines

Scientific Foundation:

There is one prospective randomized trial where 911 telephone dispatchers were randomized to give instructions for compressions alone (n=241) or compressions plus ventilations (n=279) for apparent cardiac arrest. The primary outcome was survival to hospital discharge, which was similar in the compression only group (14.6%) and the compression plus ventilations group (10.4%) (p=0.18). The study was designed to detect a 3.5% absolute improvement in survival, which was demonstrated; however, it failed to reach statistical significance in the final analysis. [*Hallstrom, NEJM 2000, LOE 1b*].

There are eight observational studies that have also supported the concept of compression only CPR. A retrospective study of all non-traumatic cardiac arrests on Olso, Norway between 2003 and 2006 found that patients receiving compression only CPR (n=145) had similar survival to hospital discharge in patients receiving standard CPR (n=281) Survival in compression only 10% and standard CPR 13%. No difference in subgroup with witnessed VT/VF arrest [*Olasveengen, Acta Anaesthesiol Scan 2008, LOE 3a*]. It is important to note that failing to find a difference in outcome does not necessarily imply that there is no statistical difference in outcome. The study does not include any power calculation on the number of events that would be necessary to reliably conclude that the differences in treatment are no different. For example, quick power calculation assuming a 15% survival with standard CPR and wanting to determine if CCC was associated with a worse (10%) survival with a power of 0.8 and a p-value of 0.05 would require 726 subjects in each group (1452 total). This study was an observational study, not a trial, but the principle is the same. This limitation applies to essentially all of the observational studies described below that find no difference in outcomes.

A prospective observational study in Singapore from 2001 to 2004 found that compression only CPR (n=154) had similar results to standard CPR (n=287) in ROSC (17.5% vs 16.7%), survival to hospital admission (7.8% vs 10.5%), and survival to hospital discharge (2.6% vs 2.8%) (p=1.0). Among patients with VT/VF, compression only CPR had higher initial ROSC, but no difference in survival to hospital discharge. Patients who received standard CPR (OR 5.4, 95% CI 2.1-14.0) or CC-CPR (OR 5.0, 95% CI 1.5-16.4) were more likely to survive to discharge than those who had no bystander CPR. [*Ong, Resuscitation 2008, LOE 3a*].

The SOS-KANTO study, a prospective observational study in the KANTO region of Japan (2002 to 2003), described a survival with favorable neurological outcome (CPC 1 or 2 at 30 days post-arrest) benefit of compression only CPR (n=439) compared to standard CPR (n=718) among patients with apnea, shockable rhythm, and resuscitation started within 10 minutes of the arrest. There was no benefit of ventilations in any of the subgroups. The frequency of favorable neurological outcome at 30 days did not differ between the cardiac-only resuscitation (6%) group and the conventional CPR (4%) group for the whole cohort on univariate analysis (p=0.15). However, the adjusted odds ratio for a favorable neurological outcome after cardiac-only resuscitation was 2.2 (95% CI 1.2–4.2) in patients who received any resuscitation from bystanders [*SOS-Kanto Study Group, Lancet 2007, LOE 3a*]. The same region reported 1-year survival with favorable neurological outcomes for arrests 1998 to 2003. In this cohort, compression only CPR (n=544) had similar 1-year survival with favorable neurological outcomes (3.5%) compared to CPR with ventilations (n=783) with survival of 3.6% and improved compared to no CPR (n=4902) with a survival of 2.1%. For arrests > 15 minutes, CPR with ventilations had improved survival (2.2%) over compression only CPR (0%) and no CPR (0.3%) [*Iwami, Circulation 2007, LOE 3a*].

A prospective observational study in Amsterdam from 1995 to 1997 found in the 41 patients with compression only CPR by bystanders the survival to hospital discharge was similar to those receiving compressions (15%) and ventilations (14%). Again, any CPR was found to be better than no CPR (6%) survival to hospital discharge [*Waalewijn, Resuscitation 2001, LOE 3b*]. Another large prospective observational study in Sweden between 1983 and 1995 found that of 9877 arrests, 3% (n=228) were given compression only CPR by bystanders. This study lumped compression only CPR with ventilation only CPR (n=620) for analysis and found that complete CPR (compressions and ventilations) was superior. However, compression only CPR was not evaluated as a separate group. [*Holmberg, Eur Heart J 2001, LOE 3a*]. There are two prospective observational studies from Belgium, one from 1983 to 1987 and one from 1983 to 1989. The earlier study found that CPR with or without ventilations (n=998) was superior to no CPR (n=2005). Compression only CPR (n=258)had overall survival at 14 days post arrest of 9% and 15% if the quality of compressions was high. However, compression only CPR did not have a survival benefit if the quality of CPR was poor [*Bossaert, Resuscitation 1989, LOE 3a*]. The latter study found that compression only CPR (n=263) had similar 14 day survival (10%) compared to standard CPR (16%), which was superior to no CPR (7%) [*Van Hoeyweghen, Resuscitation 1993, LOE 3a*].

There are three case control studies before and after implementation of a protocol for pre-hospital responders to perform CCC without ventilations on arrival to the patient. These studies did not evaluate lay bystander performance of CCC but rather and CCC as a component of the resuscitation protocol by professionals. In Wisconsin a protocol for resuscitation was instituted in 2004 that has EMS personnel perform 200 compressions followed by rhythm analysis +/- shock. CCC resumed immediately after analysis/shock. Airway management delayed until 2nd rescuer. Airway management consisted of oral-pharyngeal airway and O_2 by non-rebreather mask. If the arrest was witnessed, and down time was less than 12 minutes, rescue breaths and
assisted ventilations were not performed until after the return of spontaneous circulation or until after 3 cycles of chest compressions followed by rhythm analysis +/- a shock were completed. The first study evaluated the post-protocol period of 2004 to 2005 (33 arrests with shockable rhythm) compared to the

pre-protocol period of 2001-2003 (92 arrests with shockable rhythm) where EMS followed the 2000 AHA guidelines. In patients with a ***witnessed arrest and shockable rhythm***, survival (20% vs 57%) and neurologically intact survival (CPC category 1) (15% vs 48%) improved in CCC group [*Kellum, Am J Med 2006, LOE 2a*]. The same group evaluated the period 2004 to 2007 and found again that in patients with a ***witnessed arrest and shockable rhythm*** (n=89), survival favored the CCC group (39% vs 15% neurologically intact survival) [*Kellum, Ann Emerg Med 2008, LOE 2a*]. It is important to note that these studies do not evaluate CPR by bystanders or lay persons and do not include all cases of cardiac arrest.

A similar protocol was used Arizona. The study evaluated cardiac arrests in two metropolitan cities. Additional analyses were performed on compliance with the protocol which included an additional 60 fire departments Prehosptial personnel delivered 200 uninterrupted compressions followed by rhythm analysis +/- shock, followed by 200 chest compression then pulse check, rhythm analysis. Intubation delayed until 3 cycles of compressions. Oral-pharyngeal airway placed and high-flow O_2 delivered. Overall survival to hospital discharge greater post-protocol (36/668, 5.4% vs 4/218, 1.8%) and for witnessed VF (23/131, 17.6% vs 2/43, 4.7%). In the compliance analysis, 1799/2460 (73%) were not compliant with protocol, though 50/62 (81%) fire departments not trained in the protocol. Survival was also higher when EMS personnel were compliant with the protocol [*Bobrow, JAMA 2008, LOE 2a*].

There were 17 animal studies identified that evaluated outcomes with compression only CPR. Most of these studies are from one group. The majority of these studies are in a swine model of VF arrest. VF was untreated for varying duration; the animals were then randomized to CPR consisting of CCC or compressions with ventilations for varying duration, followed by ACLS. Similar 24 hour survival [*Berg, Circulation 1997, LOE 4*] and neurologically normal survival found [*Berg, Circulation 1993, LOE 4*] [*Berg, Ann Emerg Med 1995, LOE 4*] [*Berg, Circulation 2001, LOE 4*] in the CCC groups. One study found that CCC for 4 minutes followed by compression to ventilation ratio of 100:2 had higher neurologically intact survival compared to CCC alone *[Sanders, Ann Emerg Med 2002, LOE 4*]. Another study with the same swine model of VF arrest designed to simulate a single rescuer by stopping compressions for 16 sec for ventilations in the standard CPR group found improved neurologically intact survival in animals given 12 minutes of CCC [*Kern, Circulation 2002, LOE 4*]. Improved neurologically intact survival was also found comparing CCC to a compression to ventilation rate of 30:2 [*Ewy, Circulation 2007, LOE 4*]. CCC also evaluated in the presence of an occluded endotracheal tube. The neurologically intact survival was still similar to standard CPR [*Ewy, Resuscitation 2010, LOE 4*] [*Kern, Resuscitation 1998, LOE 4*]. The model was altered to include occlusion of the left anterior descending coronary artery followed by VF. This study found similar survival among animals receiving CCC and compressions with ventilations. Both groups fared better than animals receiving no CPR for 10 minutes [*Berg, Circulation 1997, LOE 4*]. A different model using dogs evaluated the gas exchange that occurs during 20 minutes of CCC and giving O2 through the pharyngeal lumen of a pharyngeal-tracheal lumened airway. PCO2 and PO2 values similar to pre-arrest values and 73% of animals resuscitated successfully [*Kern, Chest 1992, LOE 4*]. A piglet model of asphyxial cardiac arrest from the same lab found that when CPR was started when the aortic pressure was < 2 mmHg, 24 hour survival and neurologically normal survival higher in compression + ventilation group than the CCC group [*Berg, Crit Care Med 1999, LOE 4*]. However, when CPR was started with higher aortic pressures (<50) 24 survival was similar in CCC, compression and ventilation, and ventilation only. All three groups were better than no resuscitation groups [*Berg, Circulation 2000, LOE 4*].

Additional animal studies include a swine model of VF arrest where CCC compared to a compression to ventilation ratio of 30:2. More pigs in 30:2 group had ROSC at 2 min, but no difference on overall ROSC. Hemodynamic data similar between groups, but oxygenation higher in 30:2 group [*Dorph, Resuscitation*

2004, LOE 4]. Immediate results in a swine model of 10 minutes untreated VF followed by CCC (100/min) versus CPR with CC:V (30:2). CCC group improved VF termination (0.5 vs 0.8), ROSC (0.3 vs .059) and 20-min survival (0.19 vs 0.4) [*Mader, Resuscitation 2010, LOE 4*]. A different result was reached from another lab, also in a swine model of VF arrest with 8 minutes of untreated VF followed by 8 minutes of CCC or 10 ventilations / minute. At 24 hours, neurologically intact survival favored ventilation group over CCC (71% vs 44%). [*Yannopoulos, Crit Care Med 2010, LOE 4*]. Another pediatric swine model of asphyxial arrest found pH higher, PCO2 lower in ventilated animals compared to CCC [*Iglesias, Intensive Care Med 2010, LOE 4*].

Additionally there are several simulation studies on compression only CPR including one computer simulation study of four different conditions (CCC, compression to ventilation ratio of 5:1, 15:2, and 50:5). Cardiac output greatest in CCC group. PO_2 lowest and PCO_2 highest in CCC group. O_2 delivery highest in CCC at 2 min but lowest in CCC at 6 min. 15:2 and 50:5 provide roughly equal O_2 deliver, which is maintained throughout the 6 min [*Turner, Resuscitation 2002, LOE 4*]. The other simulation studies involved volunteers performing CPR on manikins. These included a study of elderly subjects randomized to continuous chest compressions or compression to ventilation of 15:2. All could perform CPR for 10 minutes at 5-7 months after class. CCC had fewer pauses and increased number of compressions [*Neset, Resuscitation 2010, LOE 4*]. A similar study evaluated CCC versus compression to ventilation ratio of 15:2 and 30:2 for 5 minutes of CPR. The depth of compressions significantly decreased over time in the CCC group (mean < 30mm at 5min). The number of compression given was significantly greater in CCC group. ***Half of the ventilation attempts were unsuccessful. Half of the time in the 15:2 and 38% of the time in 30:2 were used for ventilations*** [*Odegaard, Resuscitaiton 2006, LOE 4*]. A study from Japan evaluated CPR skills 1 month after training with standard CPR vs CCC. Subjects in the CCC group had greater number of total chest compressions, appropriate compressions, and less time without compressions [*Nishiyama, Resuscitation 2008, LOE 4*]. Two studies of medical students found that CCC provided more adequate compressions for the first two minutes in 9 minutes of CPR [*Heidenreich, Acad Emerg Med 2006, LOE 4*] and that when students were given courses on either CCC or standard CPR, the CCC group provided more adequate compressions after 18 months [*Heidenreich, Resuscitation 2004, LOE 4*]. In a cross-over study of paramedics, performing CCC resulted in a greater number of compressions per minute [*Higdon, Resuscitation 2006*]. A randomized trial of dispatcher assisted CPR to volunteers performing with CCC or standard CPR of manikins found that those performing CCC completed 4 cycles of CPR earlier and had fewer pauses. ***Only 9% of the ventilations were of correct TV*** (between 800-1200cc) and only 21% (500-1200cc) in the standard CPR group and depth of compressions was poor in both groups [*Williams, Prehos Emerg Care 2006, LOE 4*]. Another randomized study of telephone instructions for CPR comparing standard CPR to CCC found that the CCC group performed more compressions in 10 minutes with a similar percentage of compressions at adequate depth. In the standard CPR group, few ventilations were of adequate tidal volume [*Willard, Resuscitation 2003, LOE 4*].

In summary, there is one prospective randomized trial of 911 dispatchers giving instructions on CPR for either compression only CPR or compressions with ventilations that found similar survival to hospital discharge. There are eight observational trials of bystander CPR that had compression only CPR as one of the groups. One study demonstrated that CPR with compressions and ventilations had superior outcomes compared to CPR without compressions or ventilations; however, compression only CPR was not evaluated. The other observational studies have found that compression only CPR was not worse than standard CPR with ventilations. One of these studies found no difference in outcome on univariate analysis; however, the multivariate analysis found that survival was improved with compression only CPR compared to standard CPR. There are three before-and-after studies of a protocol implementation by EMS systems that contained CCC as part of the initial resuscitation for cardiac arrests. Two of these studies only reported outcomes of arrests with an initial shockable rhythm. The other study included all cardiac arrests, but compliance with the protocol as limited. Survival was improved in the post-protocol implementation group. Several, but not all, of the animal studies have found equivalent or improved outcomes with CCC. Most of these models are of ventricular fibrillation. It is important that the limited studies on pediatric asphyxial models have revealed concern of CCC. A consistent finding is that any CPR is superior to no CPR. In simulation studies, CCC is easy to remember, subjects perform more compression with CCC, but fatigue is greater with CCC. Ventilations are performed poorly and take a significant amount of time during which compressions are not being performed.

Compression only CPR is acceptable for adult out-of-hospital cardiac arrests. The available evidence does not strongly support that compression only CPR provides a survival advantage over standard CPR performed by the lay responder. Given that the lay public may be more likely to perform compression only CPR without ventilations, that ventilations are generally of poor quality and cause significant delays, and that 911 dispatcher CPR instructions on compression only CPR takes less time, compression only CPR is the preferred technique for the lay responder. For the trained responder, compression only CPR should be performed if the responder is unable or unwilling to perform standard CPR.

<u>Recommendations and Strength:</u>

Standards: Perform chest compressions with or without ventilations on adult out-of-hospital cardiac arrests victims.

Guideline: None

Options: Compression only CPR may be considered for treatment of adult out-of-hospital cardiac arrest victims.

Summary of Key Articles/Literature Found and Level of Evidence:

	Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to this review)	Level of Evidence
1	Mader TJ, Kellogg AR, Walterscheid JK, Lodding CC, Sherman LD	A randomized comparison of cardiocerebral and cardiopulmonary resuscitation using a swine model of prolonged ventricular fibrillation. Mader TJ, Kellogg AR, Walterscheid JK, Lodding CC, Sherman LD. Resuscitation. 2010	Swine model of VF arrest. 53 swine randomized (block randomization)10 minutes untreated VF followed by CCC (100/min) versus CPR with CC:V (30:2) with CPR stopped for two 30sec intervals to simulate iv placement and intubation. Failed rescue shock resulted in ventilations in both groups. CCC group improved VF termination (0.5 vs 0.8), ROSC (0.3 vs .059) and 20-min survival (0.19 vs 0.4) – Study demonstrates improved immediate outcomes with CCC in animal model	4
2	Kellum MJ, Kennedy KW, Barney R, Keilhauer FA, Bellino M, Zuercher M, Ewy GA	Cardiocerebral resuscitation improves neurologically intact survival of patients with out-of-hospital cardiac arrest. Kellum MJ, Kennedy KW, Barney R, Keilhauer FA, Bellino M, Zuercher M, Ewy GA. Ann Emerg Med. 2008 Sep;52(3):244-52. Epub 2008 Mar 28.	Before and after case-control study of implementation of cardiocerebral protocol in Wisconsin. Main outcome neurologicall intact survival (CPC 1) Control group (2001-2003) received CPR per 2000 AHA Guidelines, Case group (2004-2007) 2 min CCC followed by rhythm analysis +/- shock. CCC resumed immediately after analysis/shock. Airway management delayed until 2nd rescuer. If initial rhythm shockable; invasive airway and ventilation delayed until ROSC or 3 cycles of CCC and anlysis/shock completed. If initial rhythm nonshockable, airway/ventilation after 1 cycle. Survival (20% vs 47%) and neurologic intact survival (15% vs 39%) favored CCC group. – Study demonstrates improved neurologically intact survival in "real world" setting. How much CCC varied in cases. Study is basically an extension of the authors' 2006 study with same control group and more years in the case group	2a
3	Kellum MJ, Kennedy KW, Ewy GA	Cardiocerebral resuscitation improves survival of patients with out-of-hospital cardiac arrest. Kellum MJ, Kennedy	Before and after case-control study of implementation of cardiocerebral protocol in Wisconsin. Main outcome neurologicall intact survival (CPC 1)	2a

		KW, Ewy GA. Am J Med. 2006 Apr;119(4):335-40.	Control group (2001-2003) received CPR per 2000 AHA Guidelines, Case group (2004-2005) 200 CCC followed by rhythm analysis +/- shock. CCC resumed immediately after analysis/shock. Airway management delayed until 2nd rescuer. Airway management consisted of OP airway and O_2 by nonrebreather mask. In patients with a shockable rhythm, survival (20% vs 57%) and neurologically intact survival (15% vs 48%) improved in CCC group. - Study demonstrates improved neurologically intact survival in "real world" setting.	
4	Neset A, Birkenes TS, Myklebust H, Mykletun RJ, Odegaard S, Kramer-Johansen J	A randomized trial of the capability of elderly lay persons to perform chest compression only CPR versus standard 30:2 CPR. Neset A, Birkenes TS, Myklebust H, Mykletun RJ, Odegaard S, Kramer-Johansen J. Resuscitation. 2010 Apr 23.	Simulation study – 64 elderly subjects randomized to CCC or 30:2 ratio, and feedback (FB) or no FB. All could perform CPR for 10 minutes at 5-7 months after class. CCC had fewer pauses and increased number of compressions. – Study demonstrates feasibility and efficacy of CCC in simulated model among elderly subjects	4
5	Ewy GA, Hilwig RW, Zuercher M, Sattur S, Sanders AB, Otto CW, Schuyler T, Kern KB	Continuous chest compression resuscitation in arrested swine with upper airway inspiratory obstruction. Ewy GA, Hilwig RW, Zuercher M, Sattur S, Sanders AB, Otto CW, Schuyler T, Kern KB. Resuscitation. 2010 May;81(5):585-90.	Randomized trial in swine model of upper airway obstruction. Swine had 2 min untreated VF followed by CCC or 30:2. The CCC group had either unobstructed ET tube or ET tube that did not allow inflow. No difference in 24 good neurological survival. At 11 minutes a shock delivered. Number of shocks, and epinephrine doses for ROSC greater in the 30:2 group. - Study demonstrates efficacy of CCC in airway inspiratory obstruction VF animal model	4
6	Yannopoulos D, Matsuura T, McKnite S, Goodman N, Idris A, Tang W, Aufderheide TP, Lurie KG	No assisted ventilation cardiopulmonary resuscitation and 24-hour neurological outcomes in a porcine model of cardiac arrest. Yannopoulos D, Matsuura T, McKnite S, Goodman N, Idris A, Tang W, Aufderheide TP, Lurie KG. Crit Care Med. 2010 Jan;38(1):254-60.	Randomized trial in swine model of VF. 16 pigs randomized to 8 min of untreated VF, followed by 8 minutes of CCC or 10 ventilations / minute. At 24 hours, neurologically intact survival favored ventilation group over CCC (71% vs 44%). PO_2, SVO2 higher and CO_2 lower in ventilation group. – Study demonstrates that prolonged periods of no ventilation may be detrimental	4
7	Trowbridge C, Parekh JN, Ricard MD, Potts J,	A randomized cross-over study of the quality of cardiopulmonary resuscitation	Simulation cross-over study comparing 10 minutes of CCC vs 30:2 in 20 healthy females (22 – 60 years-old).	4

	Patrickson WC, Cason CL	among females performing 30:2 and hands-only cardiopulmonary resuscitation. Trowbridge C, Parekh JN, Ricard MD, Potts J, Patrickson WC, Cason CL. BMC Nurs. 2009 Jul 7;8:6.	Compression rate lower in CCC group (91 vs 98 comp/minute), Depth of compression lower in CCC group, A greater decline in chest compression force noted with CCC group (fatigue greater),	
8	Olasveengen TM, Wik L, Steen PA	Standard basic life support vs. continuous chest compressions only in out-of-hospital cardiac arrest. Olasveengen TM, Wik L, Steen PA. Acta Anaesthesiol Scand. 2008 Aug;52(7):914-9.	Retrospective observational study of all non-traumatic cardiac arrests in Oslo, Norway (2003-2006). Standard CPR (S-CPR) (281 patients) compared to CCC (145 patients). No difference in survival with favorable outcome, or in sub-groups of patients with witnessed VT/VF arrest.	3a
9	Ewy GA, Zuercher M, Hilwig RW, Sanders AB, Berg RA, Otto CW, Hayes MM, Kern KB	Improved neurological outcome with continuous chest compressions compared with 30:2 compressions-to-ventilations cardiopulmonary resuscitation in a realistic swine model of out-of-hospital cardiac arrest. Ewy GA, Zuercher M, Hilwig RW, Sanders AB, Berg RA, Otto CW, Hayes MM, Kern KB. Circulation. 2007 Nov 27;116(22):2525-30.	Randomized trial in swine model of VF arrest. 64 swine in four groups of untreated VF with varying duration (3, 4, 5, or 6 min). Within each group randomized to CCC or 30:2. CPR given until 12 min post-arrest then shock delivered. Care then per ACLS guidelines. Neurologically intact survival at 24 hours greater in CCC group (70% vs 42%). Longer duration of VF, fewer neurologically intact survivors. Decreased epinephrine in CCC group. – Study demonstrates improved neurologically intact survival at 24 hours with CCC in animal model	4
10	Odegaard S, Saether E, Steen PA, Wik L	Quality of lay person CPR performance with compression: ventilation ratios 15:2, 30:2 or continuous chest compressions without ventilations on manikins. Odegaard S, Saether E, Steen PA, Wik L. Resuscitation. 2006 Dec;71(3):335-40.	Simulation study. 68 volunteers (age 15 – 87 yrs) randomized to CCC, 15:2, 30:2 for 5 min. No pre-trial training. Depth of compressions significantly decreased over time in the CCC group (mean < 30mm at 5min). Number of compression given significantly greater in CCC group. Half of the ventilation attempts unsuccessful. Half of the time in the 15:2 and 38% of the time in 30:2 used for ventilations. – Study demonstrates that volunteers (representatives of bystander CPR) able to perform CCC, though quality of compression decreases over time. An excessive amount of time is given for ventilations, and many ventilations are not successful.	4
11	Dorph E, Wik L,	Dispatcher-assisted	Simulation study of dispatcher	4

	Steen PA	cardiopulmonary resuscitation. An evaluation of efficacy amongst elderly. Dorph E, Wik L, Steen PA. Resuscitation. 2003 Mar;56(3):265-73.	instructions for elderly subjects. 20 Subjects randomized for instructions on CCC or 15:2. CCC had twice as many compressions. Depth of compressions poor in both groups (77-100% too shallow). No subject performed 50% of rescue breaths >700 cc. 86% < 400 cc. – Study demonstrates that elderly subjects perform poor quality CPR with dispatcher instructions. More compressions given with CCC. Rescue breath quality poor.	
12	Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA	Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Circulation. 2002 Feb 5;105(5):645-9.	Swine model of VF arrest. 30 swine randomized to CCC or 15:2 for 12 min after 3 min of untreated VF. After 12 min of CPR, ACLS protocol. No compressions for 16 sec around ventilations. Neurologically intact survival at 24 hours greater in CCC group (80%) vs (13%). – Study demonstrates improved neurologically intact survival with 12 min CCC vs 15:2 in VF swine model.	4
13	Turner I, Turner S, Armstrong V	Does the compression to ventilation ratio affect the quality of CPR: a simulation study. Turner I, Turner S, Armstrong V. Resuscitation. 2002 Jan;52(1):55-62.	Computer simulation of CPR of 6 min duration. Four different conditions simulated (CCC, 5:1, 15:2, and 50:5). Cardiac output greatest in CCC group. PO_2 lowest and PCO_2 highest in CCC group. O_2 delivery highest in CCC at 2 min but lowest in CCC at 6 min. 15:2 and 50:5 provide roughly equal O_2 deliver, which is maintained throughout the 6 min. – Study demonstrates CCC provides good O2 delivery early in resuscitation, but poor O2 delivery by 6 min. 15:2 or 50:5 ratio may have better O2 delivery overall in computer simulation model.	4
14	Kern KB, Nelson JR, Norman SA, Milander MM, Hilwig RW	Oxygenation and ventilation during cardiopulmonary resuscitation utilizing continuous oxygen delivery via a modified pharyngeal-tracheal lumened airway. Kern KB, Nelson JR, Norman SA, Milander MM, Hilwig RW. Chest. 1992 Feb;101(2):522-9.	Animal study. 21 dogs anesthetized and paralyzed. Continuous O_2 delivered to pharyngeal lumen of pharyngeal-tracheal lumened airway. Chest compressions performed during 20 min of VF. Ph less, but PCO_2 and PO_2 values similar to pre-arrest values. 73% of animals successfully resuscitated. – Study demonstrates in animal model that some oxygenation and ventilation can occur with chest compressions and O_2 delivered into the pharynx.	4

15	Iglesias JM, López-Herce J, Urbano J, Solana MJ, Mencía S, Del Castillo J	Chest compressions versus ventilation plus chest compressions in a pediatric asphyxial cardiac arrest animal model. Iglesias JM, López-Herce J, Urbano J, Solana MJ, Mencía S, Del Castillo J. Intensive Care Med. 2010 Apr;36(4):712-6.	Infant swine model of asphyxial cardiac arrest. Infant pigs (12) paralyzed and disconnected from ventilator for at least 10 min and resuscitation started when no spontaneous circulation. Swine randomized to group 1: 3 min chest compression + 20 vent / min (10cc/kg TV), 3 min CCC, 3 min CC + ventilations. Group 2: 3 min CCC, 3min CC + vent, 3 min CCC. pH higher, PCO2 lower in vent group. There were no significant differences in the MAP, CVP; mPAP; peripheral, renal, and cerebral saturations; or lactate. – Animal study of pediatric model of asyphyxial arrest demonstrates acceptable hemodynamics with CCC but assisted ventilation better. Survival not assessed.	4
16	Nishiyama C, Iwami T, Kawamura T, Ando M, Kajino K, Yonemoto N, Fukuda R, Yuasa H, Yokoyama H, Nonogi H	Effectiveness of simplified chest compression-only CPR training program with or without preparatory self-learning video: a randomized controlled trial. Nishiyama C, Iwami T, Kawamura T, Ando M, Kajino K, Yonemoto N, Fukuda R, Yuasa H, Yokoyama H, Nonogi H. Resuscitation. 2009 ct;80(10):1164-8.	Randomized trial of 182 volunteers of 1hr training of CCC vs video + 1hr training. Total chest compressions, appropriate chest compressions, time to chest compressions, and time without compressions similar in both groups. Video improved performance before class in terms of attempting compressions, and total compressions, appropriate compressions were no different. – Study demonstrates CCC can be taught with acceptable results from lay public with immediate recall in simulated model.	4
17	Nishiyama C, Iwami T, Kawamura T, Ando M, Yonemoto N, Hiraide A, Nonogi H	Effectiveness of simplified chest compression-only CPR training for the general public: a randomized controlled trial. Nishiyama C, Iwami T, Kawamura T, Ando M, Yonemoto N, Hiraide A, Nonogi H. Resuscitation. 2008 Oct;79(1):90-6.	Randomized trial of volunteers (223) to CPR training with CCC or standard CPR. Skills evaluated at 1 month. Subjects in the CCC group had greater number of total chest compressions, appropriate compressions, and less time without compressions. – Study demonstrates retention of CCC skills at one month post-training among volunteers in a simulated model.	4
18	Ong ME, Ng FS, Anushia P, Tham LP, Leong BS, Ong VY, Tiah L, Lim SH, Anantharaman V	Comparison of chest compression only and standard cardiopulmonary resuscitation for out-of-hospital cardiac arrest in Singapore. Ong ME, Ng FS, Anushia P, Tham LP,	Observation study in Singapore (2001-2004) of cardiac arrests with bystander CPR. Bystander CPR with CCC (154) or standard CPR compared (287). Any bystander CPR associated with improved survival. CCC and standard CPR with	3a

		Leong BS, Ong VY, Tiah L, Lim SH, Anantharaman V. Resuscitation. 2008 Aug;78(2):119-26.	ventilations were similar in ROSC (22% vs 48%), Survival to admission (12% vs 30%), and survival to discharge (4% vs 8%). Among patients with VF/VT, ROSC higher in CCC group, but not survival to discharge – Study demonstrates equivalent, though poor overall survival, between bystander standard CPR or CCC.	
19	Bobrow BJ, Clark LL, Ewy GA, Chikani V, Sanders AB, Berg RA, Richman PB, Kern KB	Minimally interrupted cardiac resuscitation by emergency medical services for out-of-hospital cardiac arrest. Bobrow BJ, Clark LL, Ewy GA, Chikani V, Sanders AB, Berg RA, Richman PB, Kern KB. JAMA. 2008 Mar 12;299(10):1158-65.	Prospective before and after study (2005-2007) of a protocol to decrease chest compression interruptions. 2460 patients included. Prehosptial personnel delivered 200 uninterrupted compressions followed by rhythm analysis +/- shock, followed by 200 chest compression then pulse check, rhythm analysis. Intubation delayed until 3 cycles of compressions. Oral-pharyngeal airway placed and high-flow O_2 delivered. Overall survival to hospital discharge greater post-protocol (5.4% vs 1.8%) and for witnessed VF (17.6% vs 4.7%). – Study demonstrates improved survival in 'real world' application of CCC protocol. However, protocol delivered by pre-hospital professionals with oral-pharyngeal airway and high-flow O_2.	2a
20	SOS-KANTO study group	Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an observational study. SOS-KANTO study group. Lancet. 2007 Mar 17;369(9565):920-6.	Prospective observational study (2002-2003) in Japan of patients receiving bystander CPR including compression only (439) and conventional CPR (712). Survival with favorable neurological outcome higher in cardiac only group among patients with apnea (6.2% vs 3.1%), shockable rhythm (19.4% vs 11.2%), and with resuscitation started within 4 minutes of arrest (10.1% vs 5.1%). No benefit of ventilations in any sub-group. – Study demonstrates that 'real world' application of cardiac only CPR by bystander results in overall equivalent survival and improved survival among certain subgroups.	3a
21	Deakin CD, O'Neill JF, Tabor T	Does compression-only cardiopulmonary resuscitation generate adequate passive ventilation during cardiac arrest? Deakin CD, O'Neill JF,	Observational study in ED of 17 patients with OHCA undergoing chest compressions by LUCAS device where respirations were held for 1 minute (central line insertion). Respiratory	3b

		Tabor T. Resuscitation. 2007 Oct;75(1):53-9.	variables collected during this time. Passive ventilation generated from compressions was poor (median TV 42 cc). – Study demonstrates that during advanced stages of cardiac arrest, little gas exchange occurs with passive ventilation from compression. Outcome not of major interest	
22	Heidenreich JW, Berg RA, Higdon TA, Ewy GA, Kern KB, Sanders AB	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 Oct;13(10):1020-6.	Randomized cross-over study of medical students (57) to perform standard CPR or CCC for 9 minutes. CCC resulted in more adequate compressions for the first two minutes only. – Study demonstrates that medical students provide better compressions with CCC for the first two minutes only during an arrest.	4
23	Higdon TA, Heidenreich JW, Kern KB, Sanders AB, Berg RA, Hilwig RW, Clark LL, Ewy GA.	Single rescuer cardiopulmonary resuscitation: can anyone perform to the guidelines 2000 recommendations? Higdon TA, Heidenreich JW, Kern KB, Sanders AB, Berg RA, Hilwig RW, Clark LL, Ewy GA. Resuscitation. 2006 Oct;71(1):34-9.	Simulation cross-over study of 24 paramedics randomly assigned to standard CPR or CCC. Time to first compression (9 vs 27 sec) and number of compressions / min (88 vs 44) favored CCC group. – Study demonstrates improved compression rate per min among paramedics performing CPR on manikins.	4
24	Williams JG, Brice JH, De Maio VJ, Jalbuena T	A simulation trial of traditional dispatcher-assisted CPR versus compressions--only dispatcher-assisted CPR. Williams JG, Brice JH, De Maio VJ, Jalbuena T. Prehosp Emerg Care. 2006 Apr-Jun;10(2):247-53.	Randomized simulation study of healthy volunteers (54) randomized to mock 911 dispatcher giving instruction on standard CPR vs CCC. Study ended after 4 cycles of CPR (at least 3 minutes). CCC initiated compressions earlier (72 vs 117 sec), completed 4 cycles of CPR earlier (168 vs 250 sec), and had fewer pauses (13% vs 36%). Only 9% of ventilations were of correct TV. Depth of compressions poor in both groups (15%-16%) – Study demonstrates that dispatcher instructions of CCC improved compressions rate among healthy volunteers on mannequins. Ventilations were of poor quality.	4
25	Heidenreich JW, Sanders AB, Higdon TA, Kern KB, Berg RA, Ewy GA	Uninterrupted chest compression CPR is easier to perform and remember than standard CPR. Heidenreich JW, Sanders AB, Higdon TA, Kern	Simulation study of medical students (n=53) given course of standard CPR and CCC. Subjects were tested on mannequins for 90 sec of CPR immediately after course, at 6 months	4

		KB, Berg RA, Ewy GA. Resuscitation. 2004 Nov;63(2):123-30.	(n=49) and 18 months (n=29) later. Only 28 subjects with all time points included in analysis. Percentage of correct chest compressions and decreased over time in standard CPR group but not in CCC group. Total chest compressions at all time periods higher in CCC group. – Simulation study demonstrates that CCC can be performed by medical students on mannequins up to 18 months after training with better results than standard CPR.	
26	Dorph E, Wik L, Strømme TA, Eriksen M, Steen PA	Oxygen delivery and return of spontaneous circulation with ventilation:compression ratio 2:30 versus chest compressions only CPR in pigs. Dorph E, Wik L, Strømme TA, Eriksen M, Steen PA. Resuscitation. 2004 Mar;60(3):309-18.	Randomized study in swine (n=13) model of VF arrest. Swine fibrillated for 3 minutes than randomized to 10 min of BLS with chest compressions + ventilations (30:2) or compression only. ALS then performed. More pigs in 30:2 group had ROSC at 2 min ,but no difference on overall ROSC. Hemodynamic data similar between groups, but Oxygenation higher in 30:2 group (arterial saturation at 9 minutes 4 in CCC group and 67 in 30:2 group) – Study demonstrates improved oxygenation with 30:2 in swine model. Neurological outcome or longer survival outcome not assessed.	4
27	Woollard M, Smith A, Whitfield R, Chamberlain D, West R, Newcombe R, Clawson J	To blow or not to blow: a randomised controlled trial of compression-only and standard telephone CPR instructions in simulated cardiac arrest. Woollard M, Smith A, Whitfield R, Chamberlain D, West R, Newcombe R, Clawson J. Resuscitation. 2003 Oct;59(1):123-31.	Randomized study of telephone instructions of standard CPR (n=30) vs CCC (n=29) in simulated model of cardiac arrest. Volunteers performed CPR on a manikin for 10 minutes. CCC had shorter time to first compressions and increased number of compressions delivered. Hand position was more often correct in the standard CPR group. Similar percentage of compressions at correct depth. Few ventilations were of adequate TV in standard CPR group (17%). – Study demonstrates that instructions for CCC improved number of compressions given by 'bystander' to a manikin in simulated cardiac arrest model.	4
28	Sanders AB, Kern KB, Berg RA, Hilwig RW, Heidenrich J, Ewy	Survival and neurologic outcome after cardiopulmonary resuscitation with four different chest	Swine model of VF arrest. 40 swine fibrillated for 3 minutes, then CPR for 12 minutes in one of four groups. No ventilation (CCC), 15:2 (compressions :	4

	GA	compression-ventilation ratios. Sanders AB, Kern KB, Berg RA, Hilwig RW, Heidenrich J, Ewy GA. Ann Emerg Med. 2002 Dec;40(6):553-62.	ventilations), 50:5, 100:2. The 100:2 group had 4 minutes of compressions only before the 100:2 ratio started. After 12 minutes of CPR, ACLS instituted. Overall 24hr survival not different. 100:2 had significantly less neurologic deficit than the standard CPR and CCC group. Coronary perfusion pressure higher and PaO_2 and minute ventilation were lower in the CCC group. – Study demonstrates that 4minutes of compression only CPR followed by 100:2 compression to ventilation ratio resulted in superior neurologically intact survival compared to standard CPR (15:2) in a swine model of VF arrest.	
29	Waalewijn RA, Tijssen JG, Koster RW.	Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARRESUST). Waalewijn RA, Tijssen JG, Koster RW. Resuscitation. 2001 Sep;50(3):273-9	Prospective observational study (1995 – 1997) of all bystander witnessed cardiac arrests in Amsterdam. Of 922 arrests, 41 had compression only by bystander with 33% survival to hospital and 15% discharged alive. This was similar to the 437 that received compressions and ventilations. Outcome was better in patients that received any bystander CPR. – Study adds 'real world' experience with compression only CPR resulting in similar survival as compressions with ventilations when given by bystanders waiting for EMS. Given small number of compression only CPR, the study may not have been powered to see a difference.	3b
30	Berg RA, Sanders AB, Kern KB, Hilwig RW, Heidenreich JW, Porter ME, Ewy GA	Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. Berg RA, Sanders AB, Kern KB, Hilwig RW, Heidenreich JW, Porter ME, Ewy GA. Circulation. 2001 Nov 13;104(20):2465-70.	Randomized study of swine model of VF arrest. Swine (n=14) randomized to CCC vs 15:2 for 12 minutes after 3 min of untreated VF. All but one animal survived with good neurological outcome. Coronary perfusion pressure was lower for first two compressions after ventilation then for the last two before ventilation. The CCC group had higher integrated coronary perfusion for the first 8 minutes of the resuscitation. However, LV O_2 delivery did not differ– Study demonstrates the CCC resulted in improved coronary perfusion pressures over 15:2 with similar survival and LV O_2	4

			delivery in swine model of VF arrest.	
31	Holmberg M, Holmberg S, Herlitz J	Factors modifying the effect of bystander cardiopulmonary resuscitation on survival in out-of-hospital cardiac arrest patients in Sweden. Holmberg M, Holmberg S, Herlitz J; Swedish Cardiac Arrest Registry. Eur Heart J. 2001 Mar;22(6):511-9.	Prospective observational study in Sweden (1983 – 1995) of 9877 arrests of which 278 (3%) were compression only by bystanders. Survival better in patients with complete CPR (with ventilations) compared to incomplete CPR (only compressions or only ventilations). Compression only CPR not compared to CPR with ventilations. Any bystander CPR associated with improved survival. – Study cannot comment on outcome of compression only CPR as this group was lumped with ventilation only CPR. This group overall had worse survival than standard CPR group.	3a
32	Berg RA, Hilwig RW, Kern KB, Ewy GA	"Bystander" chest compressions and assisted ventilation independently improve outcome from piglet asphyxial pulseless "cardiac arrest". Berg RA, Hilwig RW, Kern KB, Ewy GA. Circulation. 2000 Apr 11;101(14):1743-8.	Randomized trial in piglet model of asphyxial model of arrest. Piglets (n=40) underwent endotracheal tube clamping until aortic pressure < 50 mmHg, and randomized to one of four groups (no CPR, compression only CPR, ventilation only, compression + ventilation). ROSC by 2 minutes higher in compression + ventilation group and ventilation group compared to control (no CPR). 24 survival lower in controls compared to other groups. – Study demonstrates that in piglet model of asyphyxial arrest, compressions, ventilations, or both are superior to no CPR.	4
33	Berg RA, Hilwig RW, Kern KB, Babar I, Ewy GA	Simulated mouth-to-mouth ventilation and chest compressions (bystander cardiopulmonary resuscitation) improves outcome in a swine model of prehospital pediatric asphyxial cardiac arrest. Berg RA, Hilwig RW, Kern KB, Babar I, Ewy GA. Crit Care Med. 1999 Sep;27(9):1893-9.	Randomized trial in piglet model of single rescuer asphyxial model of arrest. Piglets (n=39) underwent endotracheal tube clamping until aortic pressure < 2 mmHg, and randomized to one of four groups (no CPR, compression only CPR, ventilation only, compression + ventilation) for 8 minutes. 24 hour survival and neurologically normal survival higher in compression + ventilation group than all other groups. – Study suggests in single-rescuer piglet model of asphyxial arrest compression + ventilation results in 24 hour survival and neurologically normal survival.	4
34	Kern KB, Hilwig RW, Berg RA,	Efficacy of chest compression-only BLS CPR in the presence of	Randomized study in swine VF model (n=20). Animals fibrillated for 20 sec	4

	Ewy GA	an occluded airway. Kern KB, Hilwig RW, Berg RA, Ewy GA. Resuscitation. 1998 Dec;39(3):179-88.	followed by 6 min CPR with 15:2 or CCC. Airway occluded in CCC group. After six minutes ACLS performed. No difference in overall 24 hour survival or neurologically normal survival. Similar hemodynamics but worse blood gases in CCC group. – Study demonstrates equivalent neurologically normal and overall survival in swine model of VF arrest with CCC in the presence of occluded airway compared to standard CPR.	
35	Berg RA, Kern KB, Hilwig RW, Ewy GA	Assisted ventilation during 'bystander' CPR in a swine acute myocardial infarction model does not improve outcome. Berg RA, Kern KB, Hilwig RW, Ewy GA. Circulation. 1997 Dec 16;96(12):4364-71.	Randomized trial in swine model (n=43) of single rescuer resuscitation of MI. LAD occluded and VF induced. After two minutes of VF animals randomized to standard CPR, CCC, or no CPR (controls) for 10 minutes. This was followed by ACLS. Survival at 24hr 36% in CCC, 20% in standard CPR, and 7% on controls (p=0.07 in CCC vs control). – Study demonstrates similar survival with CCC and standard CPR in swine model of simulated single rescuer resuscitation of MI.	4
36	Berg RA, Kern KB, Hilwig RW, Berg MD, Sanders AB, Otto CW, Ewy GA.	Assisted ventilation does not improve outcome in a porcine model of single-rescuer bystander cardiopulmonary resuscitation. Berg RA, Kern KB, Hilwig RW, Berg MD, Sanders AB, Otto CW, Ewy GA. Circulation. 1997 Mar 18;95(6):1635-41.	Randomized trial in swine model (n=26) of single rescuer resuscitation of VF arrest. Animals fibrillated for 5 minutes then randomized to 8 minutes of CPR with CC only (CCC), standard CPR (15:2), or no CPR (control) followed by ACLS. ROSC occurred in 100% of CCC, 90% of 15:2, and 67% of controls. 24 hr survival occurred in 50% of CCC, 60% of 15:2, and 0% of controls (CCC vs control p=0.058; 15:2 vs controls p<0.03). – Study demonstrates similar survival with compression only CPR and standard CPR in swine VF model of simulated single rescuer resuscitation.	4
37	Berg RA, Wilcoxson D, Hilwig RW, Kern KB, Sanders AB, Otto CW, Eklund DK, Ewy GA	The need for ventilatory support during bystander CPR. Berg RA, Wilcoxson D, Hilwig RW, Kern KB, Sanders AB, Otto CW, Eklund DK, Ewy GA. Ann Emerg Med. 1995 Sep;26(3):342-50.	Randomized trail in swine model (n=18) of VF. Animals were fibrillated for 2 minutes and randomized to 10 minutes of standard CPR or compression only (CCC) then ACLS performed. Similar neurologically normal survival at 48hr (8/10 in CCC group and 7/8 in standard CPR group). – Study demonstrates	4

			similar neurologically intact survival at 48 hr with CCC or standard CPR in swine model of VF arrest.	
38	Berg RA, Kern KB, Sanders AB, Otto CW, Hilwig RW, Ewy GA	Bystander cardiopulmonary resuscitation. Is ventilation necessary? Berg RA, Kern KB, Sanders AB, Otto CW, Hilwig RW, Ewy GA. Circulation. 1993 Oct;88(4 Pt 1):1907-15.	Randomized trial in swine model (m=24) of VF arrest to simulated bystander CPR. Animals fibrillated for 30 sec and randomized to 12 minutes of CPR with either compression only (CCC), standard CPR with ventilations, or no CPR (control). ACLS then provided. Neurologically normal survival higher in CCC (100%) and standard CPR (100%) compared to no CPR (13%). – Study demonstrates similar survival with CCC and standard CPR in VF model of bystander CPR in pigs.	4
39	Van Hoeyweghen RJ, Bossaert LL, Mullie A, Calle P, Martens P, Buylaert WA, Delooz H.	Quality and efficiency of bystander CPR. Belgian Cerebral Resuscitation Study Group. Van Hoeyweghen RJ, Bossaert LL, Mullie A, Calle P, Martens P, Buylaert WA, Delooz H. Resuscitation. 1993 Aug;26(1):47-52.	Prospective observational study in Belgium (1983 to 1989) of 3306 out-of-hospital arrests, of which 885 received bystander CPR of which 31% received compression only. 14 day survival 10% in compression only group, 16% with ‘correct’ CPR, and 7% with no bystander CPR.- Study demonstrates in ‘real world’ experience with bystander CPR, compression only CPR results in similar survival to standard CPR and better than no CPR.	3a
40	Bossaert L, Van Hoeyweghen R	Bossaert L, Van Hoeyweghen R, and the Cerebral Resuscitation Study Group: Bystander cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest. Resuscitation 1989; 56:S55-S69.	Prospective observational study in Belgium (1983 to 1987). 3053 out-of-hospital cardiac arrests with 998 (33%) having bystander CPR. Bystander CPR with chest compressions (with or without ventilations) resulted in improved survival over no CPR. Compression only CPR did not have a benefit if CPR quality poor. – Study demonstrates ‘real world’ experience with compression only CPR with improved survival over no CPR .	3a
41	Iwami T, Kawamura T, Hiraide A, Berg RA, Hayashi Y, Nishiuchi T, Kajino K, Yonemoto N, Yukioka H,	Iwami T, Kawamura T, Hiraide A, Berg RA, Hayashi Y, Nishiuchi T, Kajino K, Yonemoto N, Yukioka H, Sugimoto H, Kakuchi H, Sase K, Yokoyama H, Nonogi H. Effectiveness of bystander-initiated cardiac-only	Prospective observation study in Kanto region of Japan (1998 to 2003). 4902 witnessed cardiac arrests, 544 received cardiac only resuscitation. Bystander compression only CPR (< 15 min) had increased 1 yr survival with favorable neurological outcome than no CPR (4.3% vs 2.5%) and similar to conventional CPR	3a

	Sugimoto H, Kakuchi H, Sase K, Yokoyama H, Nonogi H.	resuscitation for patients with out-of-hospital cardiac arrests. Circulation. 2007 Dec 18;116(25):2894-6.	(4.1%). For long duration of arrests > 15 minutes, conventional CPR had increased survival (2.2%) over no CPR (0.3%) and compression only CPR (0%). – Study demonstrates equivalent survival with compression only CPR compared to conventional CPR with shorter duration arrests (< 15 min) and better survival than no CPR in 'real world' experience. Poor survival in arrests > 15 minutes, but survival favored by conventional CPR.	
42	Hallstrom A, Cobb L, Johnson E, Copass M.	Hallstrom A, Cobb L, Johnson E, Copass M. Cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation. N Engl J Med. 2000 May 25;342(21):1546-53.	Prospective randomized trial where telephone dispatchers were randomized to give instructions for compressions alone or compressions + ventilations for apparent cardiac arrest. 241 patients randomized to compression only with 14.6% survival to hospital discharge and 279 randomized to standard CPR with survival of 10.4% (p=0.18). Dispatchers were able to deliver complete instructions more often for compression only CPR. – Study demonstrates in 'real world' trial of CPR instructions to bystanders that compression only CPR results in equivalent survival to hospital discharge.	1b