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

**Worksheet author(s)**

| Dr Csaba Dioszeghy MD | Date Submitted for review: 24 September 2009 |

**Clinical question.**

"In adult patients suffering from a cardiac arrest (P) does the provision of chest compressions (without ventilation) from bystanders, both trained and untrained, (I) compared with chest compressions plus mouth-to-mouth breathing (C) improve survival to hospital discharge (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:** NEW

**Conflict of interest specific to this question**

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

**Search strategy (including electronic databases searched).**

Search of Medline (Pubmed), Embase, Cochrane Library and AHA Endnote Database for the following textword phrases: “chest compression only” “compression only”, “continuous chest compression”, “CCC CPR”, “CCC-CPR”, “no ventilation AND resuscitation”, “resuscitation without ventilation”, “cardiac-only resuscitation”

Direct search (inc. papers “in press”) for the same textword phrases in the on-line database of “Resuscitation”, “Circulation”, “Lancet”

Search of the references listed in all Review articles and all Clinical Trial articles.

**State inclusion and exclusion criteria**

Inclusion criteria: clinical trials, animal studies, manikin studies and mathematical models with (1) population: in cardiac arrest; (2) intervention: resuscitation with chest compression with either no ventilation or with ventilation with 0% oxygen; (3) by trained or untrained rescuers; with (3) any outcome related to survival (e.g. ROSC; Discharge from hospital, Intact neurological survival; Adverse effects of resuscitation; Haemodynamic effects of chest compressions; Efficacy (rate, depths, force) of chest compressions

Exclusion criteria: abstract only references; population of non cardiac arrest (e.g. critically ill, myocardial infarction, etc.) patients

Duplicate results were removed.

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

No of relevant articles found: 47: 16 reviews/editorial/letters; 15 clinical trials/observational studies or case series; 13 animal studies; 7 manikin trials and 2 computer model. Out of these 33 were included in the summary of evidence.
### Summary of evidence

#### Evidence Supporting Clinical Question

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<thead>
<tr>
<th>Good</th>
<th>Evidence Supporting Clinical Question</th>
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<tr>
<td></td>
<td>Higdon – 2006 /M</td>
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<td>Turner-2002 /E (for 0-2 min)</td>
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<td>Wollard-2003 /M (telephone)</td>
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<td>Heidrenreich-2006 /M (&lt;3min)</td>
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<td>Hallstrom-2000 /C (telephone CPR)</td>
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<td>Nagao-2007 /E</td>
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<td>Virkkunen-2006 /E</td>
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<td>Kern-2002</td>
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<td>Kellum-2006 /D (CCR protocol)</td>
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**Level of evidence**

- **A** = Return of spontaneous circulation
- **B** = Survival of event
- **C** = Survival to hospital discharge
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- **S** – Simulation model

#### Evidence Neutral to Clinical question

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<td>Iwami-2007 /D (&lt;15 min)</td>
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<td>Olasveengen-2008 /C</td>
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<td>Turner-2002 /S (for 3-4 min)</td>
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<td>Heidrenreich-2006 /M (&gt;3min)</td>
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<td>Van Hoeyweghen-1993 /B</td>
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<td>Waalewijn-2001 /C</td>
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<td>Nagao-2007 /E (non VF/VT)</td>
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<td>Bohm-2007 /E</td>
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<tr>
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<td>Iwami-2007 /D (&gt;15 min)</td>
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<td>Abe-2009 /D</td>
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<td>Dorph-2004</td>
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<td>Holmberg-2001/C</td>
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The clinical hypothesis that chest-compression only CPR (CC-CPR) delivered by trained or untrained lay rescuers during the out-of-hospital cardiac arrest was superior over the conventional (e.g. chest compression plus mouth-to-mouth ventilation (CPR+MMV) resuscitation is supported only by some evidences. The most important supporting clinical evidence is coming from the SOS-KANTO trial (LOE2), which is an observational study (Nagao-2007) of witnessed OOHCA resuscitations showing that CC-CPR by lay rescuers resulted a better 30 days neurologically good survival in subgroups of patients (apnea, shockable rhythm, and where BLS were initiated within 4 minutes). We must however emphasize that this “subgroup” of patients meant actually 90% of the study population. Moreover, there was no any benefit attached to the use of mouth-to-mouth ventilation for any other subgroup of patients. Limitation of this study is that it was done before the 30:2 compression-ventilation ratio was recommended. Also important to note that the Standard CPR group had received BLS from off duty health care professionals significantly more often (p<0.001) than the CC-CPR group and this is most likely an important confounder modifying the results. Another important limitation is that patients suffered a re-arrest before admission to hospital were all excluded from the multivariate analysis. Consequently the differences were only demonstrated on the 74% of all patients originally included. There are other clinical trials which are in favor of this hypothesis however they are either only investigating a special population or just providing indirect evidences showing the increased side effects of mouth-to-mouth ventilation by lay rescuers. Hallstrom et al showed (Hallstrom-2000) that dispatcher guided telephone-CPR has a better outcome if only chest compressions are instructed compared to standard CPR instructions but this is obviously a special subset of patients / interventions and hardly applicable for all OOH bystander resuscitations, moreover, the EMS response time was <5 min in average (LOE5). Virkkunen’s clinical study (Virkkunen – 2006) demonstrated that CPR+MMV causes significantly more regurgitations than CC-CPR but there is no follow up showing the impact of regurgitation on overall survival (LOE2). Recent animal studies by Ewy and Kern (Ewy-2007, Kern-2002) showed better survival with CC-CPR than CPR+MMV in swine models (LOE5), however the quality of these studies are hindered by the fact that in both had the pigs airway secured by an open ET tube causing a considerable passive ventilation during compressions (as demonstrated by the blood gases). Also in these studies the animals were allowed to continue gasping after cardiac arrest and this is believed to be an important factor of passive ventilation maintaining a surprisingly good level of oxygenation in the non-ventilated animals. In similar swine models where gasping is not permitted (by either closing the ET tube or paralyzing the animals) the arterial and mixed venous oxygenation get significantly worse during CC-CPR compared to the standard CPR (Cavus-2008,LOE5). Virkkunen’s 2006 study showed better survival with CC-CPR compared to the standard CPR (Cavus-2008,LOE5 and Dorph-2008, LOE5). There are different manikin studies demonstrating that CC-CPR can be possibly superior in providing effective/more compressions compared to the CPR-MMV however Heidrenreich showed that this advantage might disappear with time (only as short as 3 minutes) as rescuer fatigue results more compressions but lower quality (Heidrenreich-2006, LOE5). Another manikin study with lay volunteers actually showed poorer quality of chest compressions when CC-CPR was performed compared to the 30:2 or the 15:2 compression-ventilation ratio BLS (Odegaard-2006, LOE5). Higdon demonstrated that even trained first responders need much longer time to deliver two mouth-to-mouth breaths then recommended (Higdon-2006), which finding is in favor to the idea that MMV causes too long hand-off time from chest compression during a single rescuer BLS (LOE5). Wollard’s manikin study demonstrated that if CPR was instructed over the phone, lay rescuers were doing a better performance if only CC-CPR was instructed compared to CPR-MMV (Wollard-2003, LOE5). This is in line with Hallstrom’s clinical findings. There is one clinical observational study with a historical control (Kellum-2006) which has demonstrated a better survival with a resuscitation protocol incorporating CC-CPR instead of the conventional (AHA 2000 guideline) approach (LOE3). Kellum et al showed that if the cardiocerebral resuscitation (CCR) protocol was introduced in the community, the survival has been increased. CCR protocol actually incorporates CC-CPR for the first stage of resuscitation but carried out by professional responders (EMTs) and not the by lay public. For this reason it is not feasible to draw the conclusion about the effect of CC-CPR or CPR+MMV by lay rescuers before the arrival of professional help without considering a great deals of confounder effects.

Many of the clinical studies published in this field proved to be neutral showing that CC-CPR is neither better nor worse than CPR+MMV provided by lay rescuers. However, it is important to mention that all these clinical observational studies used the control CPR+MMV done according to the pre-2005 protocols, meaning 5:1 or 15:2 compression-ventilation ratio instead of the currently recommended 30:2. Had the new protocol been implemented limiting the hand-off time there is a theoretical chance that the CPR+MMV survival would be better while the CC-CPR survival wouldn’t be affected at all. With all these in mind, interpretation of currently available clinical trials should be careful. A recent clinical trial from Singapore (LOE2) showed no difference in survival to discharge between patients receiving CC-CPR or CPR+MMV (Ong - 2008). The same result was published by Iwami et al (LOE2) in an other population based prospective cohort study with a one year neurologically favorable survival; the only difference was that resuscitations lasted longer than 15 minutes seemed to have somewhat better chance with MMV compared to the
compression-only – but this has resulted only a very few survivors anyway (Iwami-2007). Other clinical observational studies which investigated the effect of bystander interventions on survival found that the effect of CC-CPR was not worse than CPR+MMV when carried out by trained or untrained lay persons during OOHCA (LOE2, Van Hoeyweghen-1993, Waalewijn-2001). Bohm et al did not find difference in the 1 month survival rate among OHCA patients resuscitated by bystanders with CC-CPR or CPR+MMV in the Swedish Cardiac Arrest Register but both group had better survival compared to those received only MMV without compressions (Bohm-2007, LOE2). Olasveengen et al published another observational study (LOE2) of 809 OHCA cases out of which 695 were included. There was no statistically significant difference between the CC-CPR and CPR+MMV group in terms of outcome (discharge from hospital with favorable neurologic outcome); nevertheless they found some tendency in favor of the CC-CPR group (Olasveengen-2008). All these studies had unselected patient population suffering out of hospital cardiac arrests and undergoing lay rescuer resuscitations without assessing the quality of resuscitation apart from the fact if there were any MMV (or rather MMV attempts) with the chest compressions or not.

A number of animal studies (LOE5) also demonstrated that during induced VF arrests in a swine model the CC-CPR was at least as effective as CPR plus ventilation (Berg 1993, Berg 1995, Berg 1997, Kern 1998) with or without the possibility of passive ventilation during CPR. It is interesting however, that in a case series Deakin et al showed that passive ventilation during chest compressions in humans would be inadequate to provide oxygenation (LOE5, Deakin-2007) therefore the interpretation of animal studies where passive ventilation was more effective should be careful.

There are some opposing evidence against the hypothesis. A subgroup of survivors of the SOS-KANTO study was analysed to determine the predictors of survival with good neurologic outcome (Abe, 2009). This found that conventional resuscitation (e.g. CPR with ventilation) was a predictor of good (CPC-1) neurologic outcome but not the cardiac-only resuscitation (LOE2). The observational cohort study by Iwami and coworkers has showed that resuscitations lasting longer than 15 minutes has a very low survival rate but if CC-CPR was performed without ventilation, this survival is even worse (LOE2). Analyzing the Swedish Cardiac Arrest Registry, Holmberg has demonstrated that the 1 month neurologically intact survival was better for those patients where the bystander CPR was combined with ventilation compared to those of chest compressions only (LOE2). The EMS response time here was an average 13 min (Holmberg-2001).

In animal studies the importance of oxygenation during resuscitation were also demonstrated. In a rat model of resuscitation (Yeh, 2009) the ventilation with 0% oxygen (100% nitrogen) precluded the ROSC as opposed to ventilation with either 100% or 21% oxygen (LOE5). Kill and co-workers (Kill-2009) demonstrated that in a pig model the resuscitation was more likely to achieve ROSC with either 30:2 or 100:5 compression:ventilation ratio than with the 100:2 or compression only resuscitation (LOE5).

Berg has showed that in the animal model of asphyxiated cardiac arrest (PEA) the survival was better with ventilation and compression than with compression-only (Berg-2000, LOE5), while Dorph et al demonstrated that when the passive breathing was eliminated during the compression only resuscitations, the animals needed longer time to achieve ROSC after the induced VF arrest (Dorph-2004, LOE5). In an other animal model by Idris the prolonged duration of untreated VF arrest caused significant acidosis and hypoxia and the survival was better with compression plus ventilation compared to those with chest compression only resuscitation (Idris-1994, LOE5). Cavus has demonstrated a significant decrease in oxygenation and increase in lactate levels in a paralyzed (non-gasping) swine model with CC-CPR compared to the CPR + ventilation (Cavus-2008, LOE5).

The main similarity in the opposing evidences are that they are either dealing with a longer no-flow time or relatively long EMS response time or investigating cardiac arrest of a non-cardiac origin.

Chrest compressions without ventilation also increases the atelectasis developing during CPR in the lungs as was demonstrated by dynamic CT on a swine model of resuscitation by Markstaller (Markstaller-2008, LOE5). Furthermore he demonstrated that this alveolar collapse leads to impaired gas exchange and haemodynamics and was difficult to reverse after the positive pressure ventilation started.

One manikin study (LOE5) by Odegaard demonstrated a poorer quality of chest compressions when lay people were asked to perform compression only CPR compared to the 15:2 or 30:2 compression – ventilation ratio BLS (Odegaard – 2006). Similar results were demonstrated by Trowbridge in a cross-over designed manikin study (Trowbridge-2009) where both the fatigue and the compression force and depth were significantly poorer during compression-only resuscitation compared to the conventional (30:2) basic life support (LOE5).

There is a mathematical model published by Turner which demonstrates that in case of ideal compression with or without an ideal ventilation the chance for survival is better without ventilation during the first 2 min; there is an equal chance during the 2-4 minutes but thereafter the ventilation cannot be omitted (Turner-2002, LOE5).

There are theories that leaving MMV out from the basic life support would actually increase the willingness for BLS and ultimately increased the number of victims receiving bystander life support hence increasing the survival. Questionnaire based studies usually show some reluctance among potential rescuers to perform MMV however a study with actual
bystanders who called 991 for a cardiac arrest showed that only 1.1% of those who were trained to do BLS but did not perform it mentioned MMV as a reason (SWOR-2006, LOE5). There is no any supporting evidence for the theory that omitting MMV from the BLS protocol would increase the willingness of lay person resuscitation, however likely (or unlikely) it would sound.

At the time there is no convincing evidence that adding MMV to the basic life support with a ratio of 30:2 performed by trained or untrained bystander would actually decrease the chance for survival either, however the chance of regurgitation is higher.

Acknowledgements:

Citation List

ABE – 2009

LOE2, Good quality, Opposing
A post-hoc analysis of SOS-KANTO patients to determine the predictors of survival with a good neurologic outcome. The analysis shows that conventional bystander CPR (with ventilation) is one of the predictors for the GP-CPC Class 1 (good neurologic function) outcome. Patients received conventional CPR (e.g. with ventilation) was more likely to survive with CPC-1 than with a CPC-2 performance category while patients receiving cardiac-only resuscitation had similar chance to survive with either the CPC-1 or the CPC-2 outcome. This study basically implies that if patients survived the resuscitation they had better chance for a good neurologic outcome (CPC-1) when received conventional CPR then those received compression only CPR. However it gives no data about the overall chance of survival between the compression-only and conventional CPR groups.

BERG - 2000

LOE 5, Good quality, Opposing for asphyxia
Animal study of asphyxiated PEA: ET tube clamped and PEA defined when Aortic systolic pressure<50 mmHg. 8 min BLS according to the randomized groups: compression+ventilation; compression only; ventilation only or no BLS; endpoint: ROSC. Result: CPR+Ventilation is better than CPR alone for pigs with a cardiac arrest due to asphyxia. CPR alone or Ventilation alone was better than no BLS.

BERG - 1997

LOE 5, Good quality, Neutral
Animal study. Induced VF for 5 min followed by 8 min ideal quality chest compression +/- ventilation. Airway patent, non-paralyzed. Outcome: 24 hrs survival. Initial ventilation is with room air. Limitation: gasping caused 1.89 L/min minute ventilation due to the specific anatomy of the pigs’ upper airways. However, blood gases were different in the two groups as expected. Result: CPR alone was the same as CPR+Ventilation.

BERG - 1993

LOE5 Fair quality (study design), Neutral
Animal study. Induced VF, no-flow for 30 sec than ideal quality CPR +/- ventilation. Endpoint: 24 hrs survival with favorable neurology. Airway patent, non-paralyzed. Limitations: used 100% FIO2 for ventilation before the induction of VF.; passive breathing was allowed (and not measured). Blood gases however changed in both groups as expected. Result: CPR alone was the same as CPR+Ventilation
BERG - 1995

LOE 5, Good quality, Neutral
Animal study. Induced VF, 2 min no-flow than 10 min BLS – ideal quality CPR +/- ventilation (15:2) than ALS. Outcome: haemodynamics and 48 hrs neurologic intact survival. Result: no difference between CPR and CPR+V groups.

BOHM-2007

LOE2, Fair quality (confounders), Neutral
Retrospective observational study of the Swedish CPR Registry between 1992-2005. OHCA with bystander BLS were included. The 1 month survival was not statistically different between the compression only and standard CPR groups, however there are significant differences between the two groups: 1) the bystander rescuers in the Standard CPR group was significantly more often health care providers; and 2) the ambulance response time was significantly shorter in the CC-CPR group (6 minutes vs. 8 minutes).

CAVUS-2008

LOE5 Good quality, Opposing to arterial oxygenation, lactate and mixed venous oxygenation
Swine model of induced VF for 4 minutes, then CC-CPR or Standard CPR with 15:2 or 30:2 compression-ventilation ratio for 10 minutes before commencing ALS. Animals were intubated but paralyzed to exclude gasping. Arterial and mixed venous gases and lactate taken 6 minutes after initiating the CPR were measured. The CC-CPR group had a significantly reduced arterial and mixed venous oxygenation and higher lactate levels compared to the Standard CPR groups. All these changes were statistically significant. There was no ROSC in the CC-CPR group (0/8) and 2/8 and 4/8 of the 30:2 and 15:2 groups respectively (NS). This study demonstrates that during CC-CPR the oxygenation is rapidly deteriorating when gasping is prevented in pigs hence the positive results or other animal studies where gasping was allowed should be more carefully evaluated.

DEAKIN-2007

LOE5 poor quality (no follow up, confounder), Neutral
Case series observations proving that with airways maintained and chest compressions carried out with the good quality (LUCAS) the passive ventilation is inadequate to maintain oxygenation. However this study was carried out in the advanced stage of resuscitation when chest/lung compliance is not the same as earlier. Excellent study, but gives only poor quality evidence for the hypothesis of this worksheet.

DORPH - 2004

LOE 5, Good quality, Opposing
Animal Study. Induced VF, 3 min no-flow followed by CPR alone with obstructed airway (with a valve) or CPR+ventilation (30:2) for 10 min followed by ALS. Outcome: time to ROSC. Result: CPR+Ventilated pigs had ROSC sooner than CPR only. CPR only group needed more DC shocks than CPR+Ventilated group.

EWY - 2007

LOE: 5, Fair quality, Supportive
Animal model, induced VF, no-flow for 3, 4, 5 and 6 minutes, than CPR +/- Ventilation (30:2) for altogether 12 minutes. ET tube in place. Endpoint: 24 hr neurologically normal survival. Result: CPR only group was significantly better than CPR+Ventilation (30:2) in all. Important limitation is that the arterial PO2 and PCO2 are identical in both groups after 12 min of BLS, which can be due to an important internal bias of the design (e.g. passive breathing due to the open ET tube).

HALLSTROM - 2000

LOE 5, Good quality, Supportive for telephone assisted CPR
Clinical study, dispatcher telephone instructed CPR randomized to either CPR only or CPR+MMV. The EMS response time is <5 min. However in this study, the intervention is not Compression-only CPR but rather Telephone assisted Compression-only CPR compared to telephone assisted CPR+MMV. Result: survival is better (but not sign) with CPR only compared to those with CPR+MMV.

HEIDRENRECH - 2006

LOE: 5, Good quality, Supportive for the first 3 minutes than Neutral
Manikin study (randomized, cross-over) for compare the quality of chest compressions of CCC-CPR and Standard CPR. Outcome variables: depth, rate, no of total compressions. The overall quality of CC is considered as the total number of compressions x adequate depth and rate. Result: CCC-CPR was better during the first 3 minutes than the same as STD-CPR as the decreasing quality due to fatigue equalizes with the higher number of total compressions.

HIGDON - 2006

LOE 5, Good evidence, Supportive
Manikin study (randomized, cross-over) comparing the number of chest compressions delivered during CCC-CPR and Standard CPR. However it is not wildly surprising that CCC-CPR delivers more compressions this study demonstrates that even trained rescuers needs longer time (10 sec) to deliver two MMV hence the very long hand-off times during STD-CPR BLS.

HOLMBERG - 2001

LOE2, Fair quality (confounders), Opposing
Clinical, prospective observational cohort study of the Swedish Cardiac Arrest registry. Endpoint was the outcome (1 month alive) after OOHCA resuscitations by bystanders (trained and untrained), the observed variables are the different factors modifying the outcome. The chest compression only CPR by bystanders had slightly worse outcome (6.8%) than the CPR+Ventilation (9.7%) (but better than nothing or mouth-to-mouth without ventilation (4.3%).) (NB: EMS response time 13 min)

IDRIS - 1994

LOE 5, Good quality, Opposing
Animal study, Induced VF for 6 min followed by 10 min CPR +/- Ventilation then attempted Defibrillation and ALS. Animals were paralyzed and tracheostomized. Endpoint: ROSC. Result: CPR+Ventilated animals had significantly higher chance for ROSC.

IWAMI - 2007
LOE 2. Good quality, Neutral for CPR < 15 min, Opposing for cardiac arrest > 15 min
Prospective, non-randomized cohort study. OOHCA CPR between 1998 and 2003, excluding arrests lasting >15 min. Endpoint: 1 year favorable neurological outcome. Result: 1 y survival of compression-only bystander CPR (4.3%) and conventional CPR (4.1%) were better than no bystander CPR (2.5%). The long lasting cardiac arrest group was significantly better with conventional CPR than CCC-CPR (0% vs. 2.2%). Conclusion: CCC-CPR and standard CPR are similarly effective but for prolonged cardiac arrest, ventilation may be beneficial. (However this later finding based on only very few survivors)

KELLUM - 2006

LOE 5 Fair quality (confounders), Supportive
Non-randomized clinical observational study with historical control; the intervention is a different CPR protocol as compared with the 2000 AHA guideline. The study group involves CCC-CPR for the first 12 minutes without ventilation and only basic airway maneuver and passive oxygen delivery afterwards (witnessed arrests and trained first responders and EMS personnel). Results confirm significantly better survival with this protocol compared to the historical control (before 2003). Important limitations: Control group was treated according to AHA 2000 Protocol; the intervention arm has many more differences and not only the omission of ventilation; the rescuers are trained first-responders and EMT professionals.

KERN - 1998

LOE 5, Good quality, Neutral
Animal study. Induced VF, 30 sec no-flow, than 6 min of CPR +/- ventilation (15:2). The non-ventilated animals had their ET tubes clamped to occlude the airway. Blood gases as expected. Endpoint: 2 and 24 hrs neurologically favorable survival. Results: CPR alone was as good as CPR with ventilation.

KERN - 2002

LOE 5, Fair quality (study design), Supporting
Animal study. 3 minutes of untreated induced VF followed by 12 min of CPR +/- Ventilation (15:2). The 2 inhalation was deliberately delivered slowly, causing 16 sec interruption for mimicking the bystander resuscitation better. Blood gases are different in the two groups, however after 14 min of no-flow+Compression only CPR the PaO2 is still >60 mmHg! This seems to be an effect of the considerable amount of passive ventilation through an open ET tube which definitely affects the end result. Endpoint: 24 hrs neurologically normal survival. Result: CCC-CPR was better than CPR + Ventilation.

KILL-2009

LOE 5, Good quality, opposing
Animal study, pigs were resuscitated from induced VF with either 30:2; 100:5, 100:2 compression:ventilation ration or Compression-only resuscitation with ROSC as endpoint. Results show a better ROSC with 30:2 or 100:5 compression:ventilation ratio compared to the 100:2 or no ventilation groups. In this animal model the lack of ventilation reduced the chance of ROSC significantly.

MARKSTALLER-2008

LOE5, Good quality (opposing)
Animal study, pigs are resuscitated with CC-CPR or CPR+IPPV inside a dynamic CT scan and lung volumes and
haemodynamics were monitored. The result shows a significant increase in atelectasis in the non-ventilated pigs’ lungs. Moreover this has accompanied by an impaired haemodynamics and – understandably – lower arterial oxygenation. The other important finding was that this atelectasis remained clinically relevant even after the IPPV ventilation has started (as should happen during the ALS and post resuscitation care).

NAGAO - 2007

LOE 2, Fair quality (confounders), Supportive for apnoea and VF/VT and if CPR initiated within 4 min, Neutral for others Prospective observational study. Data collected between 2002-2003, OOH bystander witnessed cardiac arrests. Endpoint is 30 day survival with good neurological outcome. Results showed better outcome with CC-CPR in cases of apnoea or VF/VT or if resuscitation started within 4 minutes compared to CPR+V. Moreover, there was no any benefit demonstrated in any groups of patient from having CPR+MMV. Limitation of the quality is that the rescuers of the CC-CPR group was more often off-duty health professionals than the conventional CPR group (p<0.001). This statistically significant difference in the two groups is an important confounder. (The quality of BLS is better if done by off duty health care workers and increases the chance for survival, as demonstrated by Holmberg et al (LOE2) in 2001).

ODEGAARD-2006

LOE5 Good quality, opposing (the quality of chest compressions)
This is a manikin study where lay volunteers were asked to carry out 5 minutes of BLS. The quality of chest compressions was monitored. They were randomized into three groups: CC-CPR, Standard CPR with 15:2 or 30:2 compression ventilation ratios. There was no difference among the groups in terms of rescuers’ age, gender or previous BLS training / experience. The main result is that the CC-CPR group demonstrated a poorer quality of chest compressions throughout the 5 minutes compared to the other two groups. However, the measured depth of chest compressions were smaller, this has not reached statistically significant difference compared to the other groups. Not surprisingly, the number of chest compressions carried out altogether was more in the CC-CPR group. Nevertheless the paper concludes that continuous chest compression without ventilation provided by a single lay rescuer results in a lower quality of chest compressions than the standard CPR which is interrupted during ventilation.

ONG – 2008

LOE 2 Good quality, Neutral
Clinical Trial – Prospective, observational, controlled cohort study. OOHCA resuscitations between 2001 and 2004, bystander interventions are reported by the attending paramedics. Endpoints: ROSC, survival to admission and survival to discharge. Results: no statistically significant difference between CPR-only and CPR+Ventilation groups in regards to ROSC, admission or discharge.

OLASVEENGEN – 2008

LOE2 Good quality, Neutral
Retrospective observational study of 809 out-of-hospital adult cardiac arrest with bystander CPR in Olso, between May 2003 and December 2006. 695 cases were included, 40% received standard (S-CPR) and 21% compression only CPR (CCC). The results showed no statistically significant difference between the two groups with regards of discharge from hospital with favorable outcome either analyzing the whole group or the subgroups of VF/VT arrests only.

SWOR-2006
LOE5 Poor quality (opposing)
This study is opposing the common opinion that mouth-to-mouth ventilation would contribute hugely to the reluctance of performing bystander BLS. Telephone interviews were carried out with actual bystanders who witnessed a cardiac arrest. Those who were trained in BLS but did not perform were asked for the possible reasons. Only 1.1% mentioned the MMV as a reason for not starting BLS. Of course this study has all the limitations of a telephone interview about a sensitive issue ("why did you not perform resuscitation?" is hardly a neutral question in any form asked) but it has the greatest advantage over other papers that it has asked actual bystanders and not students, health care workers or lay persons who never been in a situation like that.

TROWBRIDGE-2009

LOE5, Good quality, Opposing
Manikin study to compare the efficacy of chest compressions (as described by rate, depth and force) and the fatigue of rescuers using the 30:2 or compression-only resuscitation. Cross-over design with 20 healthy volunteers. The results show a significant deterioration in compression force and depth in both groups during the 10 minutes of CPR but with a significantly pronounced deterioration in the compression-only group compared to the 30:2 group. The fatigue was also greater in the compression-only group.

TURNER - 2002

LOE 5, Good quality, Supportive for 2 min, Neutral for 3-4 min and Opposing for longer than 4 min
Mathematical simulation model of oxygen delivery for different C:V ratios and compression-only CPR. Result shows that CCC-CPR provides the best oxygen delivery during the first 2 min, than similar during the 3rd -4th min but then becomes worse than 5:1 or 15:2 or 50:5.

VAN HOEYWEGHEN - 1993

LOE 2, Fair quality (confounders), Neutral
Observational study investigating the effects of bystander resuscitations on OOHCA survivals. (The BLS standards used 5:1 or 15:2, as per the protocol before 1993!) Good quality BLS, CC-only BLS, only ventilation and no-BLS groups were identified. Endpoint: 2 weeks survival. Result: CC-only CPR and "correct" CPR are both beneficial (10% and 16% survival respectively) – difference is not significant.

VIRKKUNEN - 2006

LOE: 2 Fair quality (lack of follow up), Supportive
Prospective observational study investigating the relationship between bystander resuscitation interventions and the frequency of regurgitation. Regurgitation was observed by the attending EMS team. Three interventional groups: no bystander CPR, Compression-only CPR, standard CPR. Result: Regurgitation is fairly common (cca 25%), and significantly more common with bystander mouth-to-mouth ventilation + CPR than without ventilation. CCC-CPR has less regurgitation. Unfortunately, there is no follow up to see the impact of regurgitation on survival.

WAALLEWIJN-2001

LOE2, Fair quality (confounders); Neutral
Observational prospective cohort study from the ARREST (Amsterdam Cardiac Arrest) study. Bystander OOHCA resuscitations are investigated, endpoints are: admission and discharge alive. Result: CPR only (15%) and
CPR+Ventilation (14%) by bystander (both trained and untrained) has same survival as opposed to MMV alone (7%). However, the No of the CPR alone group is much smaller (n=41) compared to the Standard CPR group (n=437).

WOOLLARD – 2003

LOE 5, Good quality, Supportive
Manikin study of volunteers instructed over the phone. Video evaluation of performance during 10 min scenario. Hand position, rate, depth and delays in initiation of resuscitation were recorded. Results: CC-only CPR instructed over the phone resulted better overall performance compared to when CPR+MMV was taught over the phone.

Yeh – 2009

LOE5, Good quality, Opposing
Animal study, rats are resuscitated from induced asystole with chest compression and ventilation with either 100% oxygen, 21% oxygen or 0% oxygen (100% nitrogen). Endpoint was ROSC and neurologic recovery. Results show that ROSC was not achieved without oxygen ventilation while the ventilation with either 100% or 21% oxygen resulted in similarly good outcome.