**Clinical question.**

"In adult patients suffering from a cardiac arrest (P) does the calling of EMS and the provision of chest compressions (without ventilation) by trained laypersons or professionals (I) compared with calling EMS only (C) improve survival to hospital discharge (O)?"

**Is this question addressing an intervention/therapy, prognosis or diagnosis?** Intervention/therapy.

**State if this is a proposed new topic or revision of existing worksheet:** Revision

**Conflict of interest specific to this question**

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? None

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

PubMed and AHA EndNote Database; (1) ("heart arrest" OR "cardiac arrest") AND "CPR" AND "ventilation", as text word.  (2) ("heart arrest" OR "cardiac arrest") AND "CPR" AND ("cardiac only" OR "compression only") as text word yielding 78 hits.  Cochrane Database of Systematic Reviews searched using terms “chest compression”, “chest compression only”, “only chest compression”, “ventilation” OR “mouth to mouth ventilation” yielding a total of 150 hits.  A total of 228 titles (excluding those by hand-searched) were screened leaving 32 articles for full text review.

**State inclusion and exclusion criteria**

Inclusion: 1) All animal studies with outcome measures of ROSC or better, or all human studies with outcome measures of hospital discharge or equivalent.

2) outcome compared to conventional CPR (with ventilation, all C:V ratios) or no CPR.

Pubmed and Cochrane Database searches limited to publication year of 2005 or later, but no limit to AHA EndNote searches and hand search.

Exclusion: Review articles (except for the reference portion which was used for a source of hand search for the relevant articles). 

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

After full text review of 32 articles, 19 studies were relevant and met criteria for further review. Of these, 6 were LOE-2 and 13 were LOE-5.
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
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<tr>
<td>Good</td>
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<td>Berg, 1993 D Kern, 2002 D</td>
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<tr>
<td>Fair</td>
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<td>Iwami, 2007 D</td>
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### Level of evidence

- **A** = Return of spontaneous circulation
- **B** = Survival of event
- **C** = Survival to hospital discharge
- **D** = Intact neurological survival
- **E** = Other endpoint

*Italics = Animal studies*
### Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Study Details</th>
<th>References</th>
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| **Good**          |               | Berg, 1997(A) D  
Berg, 1997(B) D  
Berg, 1999 D  
Berg, 2000 D |
| **Fair**          | Bossaert, 1989 E (awake 14-d)  
Van Hoeyweghen, 1993 E (awake 14-d) (study population overlap partially) | |
| **Poor**          | Waalewijn, 2001 C | Idris, 1994 A |

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  
*Italics = Animal studies*

### Evidence Opposing Clinical Question

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**Level of evidence**

A = Return of spontaneous circulation  
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*Italics = Animal studies*
A total of 11 animal experiments examined benefit of simulated bystander cardiopulmonary resuscitation (CPR) performed only with chest compressions (CC-only CPR) on electrically induced ventricular fibrillation model. Nine of such animal experiments were done with patent airway with or without endotracheal tube. Most of those studies suggest that chest compressions of laboratory-level quality without ventilation improve neurologically intact survival. A direct comparison of CC-only CPR to no CPR is lacking in a few of those studies, but outcomes of animals with CC-only CPR are nearly equivalent to that of animals with conventional CPR.

Researchers of those experiments using open airway model reported considerable amount of lung ventilation passively along with chest compressions and/or actively with agonal breathing, with average ventilation volume, where measured, ranging 5 L/min (Sanders 2002) to 7 L/min (Kern 2002) with endotracheal tube, and ranging 1.85 L/min (Berg 1997 A) to 2.65 L/min (Berg 2001) without endotracheal tube. The associated PaO2 were 50-60 mmHg during CC-only CPR. Although agonal breathing is also reported to be present in ~40% at initiation of CPR on human subjects, the rate and volume of chest ventilation have not been determined. Neither has been evaluated volume of passive ventilation associated with chest compressions in human. A few studies suggest that passive ventilation in human may be negligible, making it difficult to directly extrapolate the results from those animal experiments to human subjects.

The effect of CC-only CPR when passive or agonal ventilation was impeded is equivocal. In a VF model of adult swine with active breathing efforts blocked with pancuronium, Idris et al (Idris 1994) showed that only 1 of 12 animals regained spontaneous circulations when the animal received 10 minutes of CC-only CPR following 6 min of untreated VF. Although they observed 3.8 L/min of passive ventilation, the PaO2 was 38 mmHg at 9 min into CC-only CPR. Similarly, when passive ventilation was blocked with impedance threshold device on the endotracheal tube, PaO2 declined to ~16 mmHg within 3 min into CC-only CPR and duration of ALS required before return of spontaneous circulation (ROSC) was significantly longer than with conventional CPR, although the eventual rate of ROSC was not different between the groups of CC-only CPR and conventional CPR (Dorph 2004).

The PaO2 during CC-only CPR declined more slowly in a similar experiment by Kern et al (Kern 1998) where ventilation was completely blocked by clamping the endotracheal tube. Reference group (no CPR) was lacking, but the excellent rate of neurologically intact survival (9/10) at 24 hours post-resuscitation seems to indicate that CC-only CPR is better than no CPR. However, the very short down time (30 sec, untreated VF) and short duration of CPR (6 min) before defibrillation attempts make the interpretation of those results somewhat ambiguous.

Effect of bystander CPR on asphyxial cardiac arrest was investigated in 2 animal experiments by a single group of researchers. When animals were asphyxiated for ~9 min with aortic pulse pressure dropping to <2 mmHg, the outcome of animals given CC-only CPR was dismal and was no better than that received no CPR: Only 1 out of 7 animals given CC-only CPR had neurologically intact survival at 24 h, compared to none of 8 animals with no CPR (Berg 1999).

However, when resuscitation attempt was started in the early stage of asphyxial cardiac arrest (defined as aortic pulse pressure <50 mmHg), CC-only CPR affected the outcome favorably with 4 out of 10 animals surviving neurologically intact for 24 hours (Berg 2000). The outcome tended to be better than animals with no CPR (no neurologically intact survival in 10 animals), but the difference did not reach statistical significance (p=0.087).

In 2007, 3 LOE-2 registry surveys were published that addressed effects of bystander CPR on subjects under cardiac arrest (Bohm 2007, Iwami 2007, SOS-KANTO 2007). In all studies, the primary objective was to compare long-term outcome between subjects who received CC-only CPR and those who received conventional CPR with ventilation. In the ancillary analysis, those studies have shown that patients who received CC-only CPR have better long-term outcome compared to those who received no CPR (Iwami 2007, SOS-KANTO 2007) or those who received only mouth-to-mouth rescue breathing without chest compressions (Bohm 2007), all in a statistically significant way. However, potential and obvious confounders were not accounted for specifically in such comparison except in one by Iwami et al. The type of bystander CPR was evaluated and recorded as a routine reporting procedure by the EMTs on site. Nor registered was the quality of CPR. A survey on Belgium registry has revealed that CC-only CPR is better than no CPR only when the quality of compressions are good (Bosasaert 1989).

Two of the recent clinical studies have focused on adult victims of cardiac arrest with bystander witness. Iwami et al (Iwami 2007) have reported a total of 17244 cardiac arrests that were not bystander-witnessed and/or with noncardiac etiology during their study period, but those subjects were not included in the analysis. Out of such group not analyzed, they have reported 3.8 L/min of passive ventilation, the PaO2 during CC-only CPR declined more slowly in a similar experiment by Kern et al (Kern 1998) where ventilation was completely blocked by clamping the endotracheal tube. Reference group (no CPR) was lacking, but the excellent rate of neurologically intact survival (9/10) at 24 hours post-resuscitation seems to indicate that CC-only CPR is better than no CPR: Only 1 out of 7 animals given CC-only CPR had neurologically intact survival at 24 h, compared to none of 8 animals with no CPR (Berg 1999).

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In summary, evidence from 6 LOE-2 historical cohort studies and 13 LOE-5 animal studies suggests that properly performed chest compressions without ventilation, performed either by trained or untrained bystanders before professional rescuers arrive, may benefit at least a portion of cardiac arrest patients. Among such potential beneficiaries that currently available data suggest are, but not limited to, adult patients with sudden cardiac arrest of cardiac etiology with bystander witness, preferably with open airway. There is no evidence that giving chest compressions does harm to victims of cardiac arrest or is worse than giving no CPR at all.
Acknowledgements:
Technical and administrative assistance by Hiroko NOGUCHI, RN, CP is gratefully acknowledged.

**Citation List**


   LOE-5, Good, Supportive
   24 h survival with CPC=1: 8/8 with CC-only vs 1/8 with no-CPR (p=0.01)

   Swine, Downtime 30 sec (VF), CPR time 12 min
   Animals preoxygenated (FiO2=1.0) before VF induction.
   Airway not protected in CC-only CPR (no remarks on ventilation during CC-only CPR).
   PaO₂=58 mmHg at 10 min into CC-only CPR.


   LOE-5, Poor (no reference), Supportive
   48 h survival with CPC=1: 8/10 with CC-only CPR (no reference)

   Swine, Downtime 2 min (VF), CPR time 10 min
   Airway not protected in CC-only CPR, but authors note obvious ventilation (passive/active).
   PaO₂=54 mmHg at 4 min into CC-only CPR.


   LOE-5, Good, Neutral (underpowered)
   Survived 24 h with CPC=1: 5/10 with CC-only vs 0/6 with no-CPR (p=0.058)

   Swine, Downtime 5 min (VF), CPR time 8 min
   Airway not protected, 1.85 L/min of passive/active ventilation during CC-only CPR.
   PaO₂=58 mmHg at 6 min into CC-only CPR


   LOE-5, Good, Neutral (underpowered)
   24 h survival with CPC=1: 4/14 with CC-only vs 1/14 with no-CPR (p=0.33)

   Swine, Downtime 2 min (VF), CPR time 10 min
   Airway not protected, passive/active ventilation noted during CC-only CPR.
   PaO₂=61 mmHg at 8 min into CC-only CPR

LOE-5, Good, Neutral
24 h survival with CPC=1; 1/14 with CC-only vs 0/8 with no-CPR

Piglet, Downtime ~9 min (Asphyxia), CPR time 8 min
Airway not protected, 1.5 L/min of passive ventilation (no agonal breathing) noted during CC-only CPR.
SaO₂= 26% (at 1 min) and 17% (at 7 min) into CC-only CPR.


LOE-5, Good, Neutral (underpowered)
24 h survival with CPC=1; 4/10 with CC-only vs 0/10 with no-CPR (p=0.09)

Piglet, Downtime ~6.8 min (Asphyxia), CPR time 8 min
Airway not protected, no remarks on passive/active ventilation.
SaO₂= 34% at 1 min into CC-only CPR.


LOE-5, Poor (no reference), Supportive
24 h survival with CPC=1; 6/7 with CC-only (no reference)

Swine, Downtime 3 min (VF), CPR time 12 min
Airway not protected, 2.65 L/min of passive/active ventilation (41% owing to agonal breathing) noted during CC-only CPR.
SaO₂= 67% (at 2 min) and 70% (at 12 min) into CC-only CPR.


LOE-2, Poor (Groups not well defined, MtoM rescue breathing as surrogate for no-CPR, not adjusted for confounders), Supportive
1-month survival: 6.7% (CC-only, n=1145) vs 4.5% (MtoM-only, n=1921), p=0.009

Swedish registry, 1990-2005, 11275 O-o-H cardiac arrest
Witness & Nonwitness

LOE-2, Fair (not adjusted for confounders), Neutral (underpowered)
Awake at 14 day post-resus.:
CC-only: 24/258 (9%)
  w/ good quality: 17/116 (15%)
  w/ bad quality: 7/142 (5%)
no-CPR: 123/2055 (6%)
(p=0.054 vs overall CC-only, p=0.003 vs good CC-only)

Belgian registry, 1983-1987, 3053 O-o-H cardiac arrest
All age group, Witness & Nonwitness, Cardiac & Noncardiac
Type and quality of CPR well defined and evaluated on scene
Estimated downtime=4.5 min, Estimated time before EMS=14.8 min


LOE-5, Poor (no reference), Supportive
ROSC: 5/6 with CC-only vs 6/6 with CC+V (no reference)

Swine, Downtime 3 min (VF), CPR time 10 min
Inspiration blocked with impedance threshold device in CC-only group.
PaO₂=~16 mmHg at 3 min into CC-only CPR
Time before ROSC and hemodynamic data were dismal with CC-only, but the eventual rate of ROSC was similar between CC-only and CC+V.


LOE-5, Poor (no reference), Supportive
Survived 24 h with CPC=1; 13/31 with CC+V vs 23/33 with CC-only (no reference)

Swine, Downtime 3-6 min (VF), CPR time 6-9 min
Airway protected with endotracheal tube.
PaO₂=59 mmHg at the end of CC-only


LOE-5, Poor (no reference), Neutral
ROSC: 9/12 with CC+V vs 1/12 with CC-only (no reference)

Swine, Downtime 6 min (VF), CPR time 10 min
Animals paralyzed, 3.8L/min of passive ventilation via tracheal tube in CC-only CPR.
PaO₂=38 mmHg at 9 min into CC-only CPR


**LOE-2, Fair (Groups not well defined), Supportive**

CPC=1 or 2 at 1 year post-resus: 19/441 (4.3%) with CC-only vs 70/2817 (2.5%) with no-CPR. Adjusted OR: 1.72 (1.01 - 2.95)

**Osaka-Japan registry**
1 May 1998 - 30 Apr 2003
4902 O-o-H CA
Adult (> 18 years), Witnessed, Cardiac
CC-only significantly better than no-CPR after adjusting for confounders.


**LOE-5, Poor (no reference), Supportive**

CPC=1 at 24 h: 9/10 with CC-only vs 10/10 with CC+V (no reference)

Swine, Downtime 30 sec (VF), CPR time 6 min
Endotracheal tube clamped in CC-only CPR.
PaO2=29 mmHg at the end of (6 min into) CC-only CPR.
Excellent outcome for both groups of CC-only and CC+V


**LOE-5, Poor (no reference), Supportive**

CPC=1 at 24h: 12/15 with CC-only vs 2/15 with CC+V (no reference)

Swine, Downtime 3 min (VF), CPR time 12 min
Passive/active ventilation of 6-8 L/min during CC-only.
PaO2=58-64 mmHg during CC-only CPR.


**LOE-5, Poor (no reference), Supportive**

CPC=1 at 24h: 6/10 with CC-only vs 5/10 with CC+V (no reference)

Swine, Downtime 3 min (VF), CPR time 12 min
~5 L/min of passive/active ventilation during CC-only CPR.
PaO2=50-60 mmHg during CC-only CPR


**LOE-2, Poor (Groups not well defined, not adjusted for confounders), Supportive**
OR (95%CI) for CC-only vs no-CPR (not adjusted for confounders):
  cardiac etiology: 3.0 (1.9-4.7)
  noncardiac etiology: 0.9 (0.1-7.1)

Tokyo-Japan registry
1 Sept 2002 - 31 Dec 2003
4068 O-o-H CA
Adult (> 18 years), Witness, Cardiac & Noncardiac


  LOE-2, Fair (not adjusted for confounders), Neutral (underpowered)
  Conscious 14 day post-resus: 75/541 (13.9%) with CC+V, 26/263 (10%) with CC-only and 153/2180 (7%) with no-CPR
  \( p=0.119 \) CC-only vs no-CPR, crude data, not adjusted for confounders

Belgian registry
1 Sept 2002 - 31 Dec 2003
3306 O-o-H CA
All age groups, Witness & Nonwitness, Cardiac


  LOE-2, Poor (Groups not well defined, not adjusted for confounders), Neutral (underpowered)
  Survival to hospital discharge: 14%(11-17) with conventional CPR, 15%(4-25) with CC-only, 6% (4-8) with no-CPR (CC-only vs no-CPR, \( p=0.079 \), crude data, underpowered)

Amsterdam registry
1 Jun 1995 - 1 Aug 1997
922 O-o-H CA
All age group
Witness, Cardiac & Noncardiac