Clinical question:
ALS-CPR&A-004B - In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P) does the use of open-chest CPR (I) compared with standard CPR (C), improve any outcomes (eg. ROSC, survival) (O).

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention
State if this is a proposed new topic or revision of existing worksheet: Revision of 2005 W81B_Wiklund_Rubertsson.doc Open-chest CPR improves outcome when compared with standard closed-chest CPR.

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

Search strategy (including electronic databases searched).
The search strategy of 2005 W81B_Wiklund_Rubertsson.doc was repeated, and the focus of this worksheet was on any new data since 2004.

List electronic databases searched (at least AHA EndNote 7 Master library [http://ecc.heart.org/], Cochrane database for systematic reviews and Central Register of Controlled Trials [http://www.cochrane.org/], MEDLINE [http://www.ncbi.nlm.nih.gov/PubMed/], and Embase), and hand searches of journals, review articles, and books.
AHA EndNote 7 Master library, Cochrane database (reviews and trials), PubMed, MEDLINE and references from previous articles, review articles and Embase search were performed.

Database: Ovid MEDLINE(R) <1950 to September Week 2 2009>
Search Strategy:
--------------------------------------------------------------------------------
1 open chest cpr.mp. (77)
2 from 1 keep 1-2 (2)
3 exp Cardiopulmonary Resuscitation/ (9164)
4 exp Heart Massage/ or open chest.mp. (7286)
5 4 and 3 (360)
6 from 5 keep 1,17,19,21,105-106,155 (7)

Combine 3 and 4 resulted in 6 relevant references since 2004 of which 5 were reviews

PubMed search of open chest CPR returned 114 references, of which no new relevant articles was found.

I could find no Cochrane Reviews on this subject

Thus far I could only find one new study on this topic, an animal study published in 2005 (Benson, et al). I did find several reviews on this topic, all of which are listed below in the citation list.

State inclusion and exclusion criteria
Inclusion: Human and animal studies of open chest CPR
Review articles of open chest CPR
Studies included in the 2005 worksheet

Exclusion: cardiac arrests after cardiac surgery
Cardiac arrests after trauma

Number of articles/sources meeting criteria for further review:
8 since 2004, including 7 reviews
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Good</th>
<th>DeBehnke 1991; 754&lt;sup&gt;A,E&lt;/sup&gt;</th>
<th>Angelos 1992; 1302&lt;sup&gt;A&lt;/sup&gt;</th>
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<td>Bircher 1985; 185&lt;sup&gt;B,D&lt;/sup&gt;</td>
<td>Kern 1987; 498&lt;sup&gt;A,D&lt;/sup&gt;</td>
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<td>Raessler 1988; 1021&lt;sup&gt;A,E&lt;/sup&gt;</td>
<td>Weiser 1962; 555&lt;sup&gt;A,E&lt;/sup&gt;</td>
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<td>Benson, 2005, 209&lt;sup&gt;ABE&lt;/sup&gt;</td>
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<th>Fair</th>
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<td>Boczar 1995; 498&lt;sup&gt;E&lt;/sup&gt;</td>
<td>Fleisher 1985; 305&lt;sup&gt;E&lt;/sup&gt;</td>
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<td>Hachimi-Idrissi C : 1997; 151</td>
<td>Jackson 1984; 657&lt;sup&gt;E&lt;/sup&gt;</td>
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<td>Sanders1985;113&lt;sup&gt;A,E&lt;/sup&gt;</td>
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<td>Poor</td>
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<td>Barnett 1986; 408&lt;sup&gt;E&lt;/sup&gt;</td>
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<td>Emerman 1988; 1138&lt;sup&gt;E&lt;/sup&gt;</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

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Evidence Opposing Clinical Question

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

Reviewer’s Final Comments

The data on open chest CPR for non-traumatic, non post-surgical patients is limited to animal studies, with the exception of a few human retrospective analysis. Animal studies have consistently shown improved outcome with open chest CPR. One of the human studies (Boczar 1995; 498) was in 10 patients who failed standard ACLS techniques in the ED and were deemed unsalvageable (ie dead). Open chest CPR was shown to improve coronary perfusion pressure. In a Japanese retrospective analysis (Takino, 1993, 69) 26 consecutive patients were treated by open chest CPR and compared to 69 historical controls. In the open chest CPR group 15 of 26 patients had ROSC, compared to 2 patients with standard CPR. Yet only 3 survived to hospital discharge. A predictor of ROSC was open chest CPR within the first 5 minutes of hospital arrival. In the most recent non-traumatic, non post-surgical patients I could find (Hachimi-Idrissi C, 1997; 151) found that in a highly selected group of 33 patients out of 2212 OOH cardiac arrest, open chest CPR was performed resulting in ROSC in 13, and hospital discharge in 2.

Acknowledgements:
Worksheet authors in 2005:
Sten Rubertsson MD, PHD, EDIC, FCCM, Assoc. Professor, Lars Wiklund, MD, PhD, FRCA, Professor

Citation List


Comment:
On the basis of 15 dogs studied they concluded that OC-CPR was far superior to CC-CPR as regards cerebral perfusion. Correctly estimated cerebral perfusion pressures for the two groups were 22 and 60 mm Hg, respectively. ICP was elevated to 30 and 36 MM Hg, respectively. The perfusion pressures resulted in a sinus blood flow of 18 and 42% of control prearrest values, respectively.
Level 5. Fair. Positive.


Comment:
Different positions of the hand and fingers were tested to assess the kind of open chest-CPR that gave most blood pressure and common carotid blood flow and ICP.
Level 5. Fair. Positive.


Comment:
Fifteen mongrel anaesthetized dogs of approx. 25 kg were studied. All received CC-CPR before OC-CPR. CC-CPR resulted in a cardiac output of 19% while OC-CPR gave 52% of control prearrest values, simultaneously mean arterial blood pressure was 19 and 45%, respectively, of prearrest control values.
Level 5. Good. Positive.

Benkhadra M. Honnart D. Lenfant F. Trouilloud P. Girard C. Freysz M. Open chest cardiopulmonary resuscitation: is there an interest in France?. [Review] [54 refs] [French] Annales Francaises d Anesthesie et de Reanimation. 27(11):920-33, 2008 Nov.


Comment:
The only new experimental study since 2004. In a dog model of cardiac arrest, dogs randomized to open chest CPR had improved 72 hour survival.
Good quality, LOE 5, supporting


Comment:
Thirty-two dogs in 4 groups studied to compare OC-CPR with immediate defibrillation, standard CC-CPR and simultaneous ventilation-compression. OC-CPR yielded higher mean arterial and lower central venous pressures than external method. Six out of 8 dogs in the OC-CPR group were resuscitated while 7 out of 8 dogs in OC-CPR survived with a neurologic outcome not significantly different from the controls (immediate defib). All but one of the dogs in the simultaneous ventilation-compression group died, either as non-ROSCs (2) or as severe brain damage that did not survive 24h.
Level 5. Excellent. Positive.


Comment:
Human clinical study on 10 out-of hospital arrests who failed ACLS. The coronary perfusion pressure (CPP) was 7.3±5.7 and 32.6±17.8 mm Hg, in the CC-CPR and OC-CPR groups, respectively, thus confirming what repeatedly has been found in animal studies. Furthermore all patients had a CPP exceeding 15 mm Hg during OC-CPR.


Comment:
Canine myocardial infarct VF model. Survival was 9/9 after CPB, 6/9 after OC-CPR, and 2/8 after CC-CPR after 4 min down-time and 8 min of CC-CPR. There was a ratio of necrotic/ischemic myocardium at 4h of 015±0,31, 0,39±0,25 and 1,16±0,31 in the CPB, OC-CPR and CC-CPR groups, respectively, that can be explained by differences in the CPP achieved during CPR.
Level 5. Excellent. Positive.

Comment:
Eight dogs were studied 115 times to determine the circulation time from injection of dye to the carotid artery. After approx 75 minutes CC-CPR, OC-CPR was performed for 35 min. This protocol tends to underestimate the differences between the two different sorts of CPR. Anyway, while the circulation time was $62.7 \pm 19.6$ after central injection it was in the order of $85-95$ sec after more peripheral injection during CC-CPR. During OC-CPR the circulation time was $21.3 \pm 5.7$ after central injection and 30-35 sec after more peripheral injection, thus confirming the more rapid blood flow generated during OC-CPR in comparison to CC-CPR.
Level 5. Fair. Positive.


Comment:
Two groups, 5 animals each. Pediatric CPR model with determination of CBF according to Kety-Schmidt. OC-CPR generated a CBF 3-4 times as high as CC-CPR.
Level 5. Good. Positive.


Comment:
In a highly selected group of 33 patients out of 2212 OOH cardiac arrest, open chest CPR was performed resulting in ROSC in 13, and hospital discharge in 2.
LOE 4, fair, supportive.

Level 5. Good. Positive.


Comment:
Dogs were assigned to 2 min of either CC-CPR, or OC-CPR after 15 min unsuccessful CC-CPR and defibrillation attempts. A follow-up revealed an immediate resuscitation success in all animals of the OC-CPR group vs. 4/14 in the CC-CPR group, and a follow-up after 7 days a survival of 11/14 vs 4/14, respectively. That means a significantly better 7 days survival after OC-CPR compared to CC-CPR after 15 min down-time.
Level 5. Excellent. Positive.


Comment:
Although OC-CPR produced significantly better coronary perfusion pressure after 20 min down-time than CC-CPR, dogs did not survive 40 min down-time (all non-ROSCs). OC-CPR was equally effective after 10 and 20 min down-time, all had ROSC. Survival after CC-CPR was just 1 of 5 dogs after 20 min down-time.
Level 5. Good. Positive.

Comment.
A technique of diastolic rhythmic squeeze of the aorta during open chest CPR. No data are reported.
LOE 5, Neutral


Comment:
Large series of dog studies, small and large anesthetized dogs. Three min down-time. Coronary perfusion pressure (CPP) determined in CC-CPR and OC-CPR (and vest-CPR) during VF. CPP was highest (64±4 mm Hg) in OC-CPR, somewhat smaller in small dogs in CC-CPR and still smaller in large dogs (21±2) in CC-CPR, and least in vest-CPR. This resulted in ROSC of all dogs in OC-CPR and small dogs in CC-CPR, but only 7/10 in groups given CC-CPR (and 8/10 in vest-CPR). Thus the CPP was 3 times higher in OC-CPR and 24h survival in CC-CPR approx 50% compared to approx 95% after OC-CPR.
Level 5. Excellent. Positive.


Comment:
Old canine study of 20 anaesthetized dogs, rather small ones, 6-12 kg. Carotid blood flow measure by bubble flowmeter. CC-CPR preceded OC-CPR in 10 dogs in the others OC-CPR was begun immediately. Downtime only a few seconds. The mean arterial blood pressure and carotid blood flow was greater in during OC-CPR.
Level 5. Good. Positive.


Comment:
Greater perfusion pressure and systemic blood flow =cardiac output was generated during OC-CPR compared to CC-CPR. Cardiac output is somewhat smaller than has been determined previously with other methods depending upon perfect mixing of indicator or dye. During relaxation phase some retrograde blood flow occurred in the pulmonary artery and the aorta.
Level 5. Good. Positive.

Comment:
A rather large pig study determining perfusion pressures and blood flows measured by a more unexceptional and modern technique that does not depend upon perfect mixing of indicator or dye (transit-time ultrasound flowmetry). The cardiac output during OC-CPR is at least double that during CC-CPR, the systemic blood flow is, however, less than determined with older methods (CC-CPR results in a flow of 5-10% and OC-CPR in 20% of prearrest control values). Epinephrine increases perfusion pressures both in CC-CPR and OC-CPR but temporarily decreases cardiac output.
Level 5. Good. Positive.

Level 5. Good. Positive.

Comment:
Although all the dogs receiving OC-CPR all had a significant increase in CPP the outcome of CPR depended upon the time of inadequate CPP before OC-CPR was initiated. After 15 min, 20 min and 25 min the incidence of ROSC was 6/8, 3/8 and none of eight dogs, respectively.
Level 5. Good: Positive.

Comment:
A non-randomized uncontrolled study although a control group is involved. Totally 95 adult non-traumatic out-of-hospital patients were included out of which 26 consecutive patients had OC-CPR. Patient characteristics were similar in the two groups. Of the 26 patients with open chest CPR 15 had ROSC, but only 3 were discharged alive. On the basis of time statistics and experience the authors recommend OC-CPR to be undertaken within 5 min of arrival to hospital and unsuccessful preceding CC-CPR.

No Abstract
Comment:
Old, but an excellent canine study. In the first study it was clearly proven that CCCPR gives a cardiac output of 22% as opposed to OC-CPR that gives 55% of control prearrest values. In six dogs OC-CPR was preceded by CC-CPR and in all these cases there were higher mean arterial blood pressure in four and equal in 2. Diastolic arterial blood pressure was very low during CC-CPR. There was a difference both with small and big dogs but the difference was less for the small. In a second group with myocardial infarct, CC-CPR gave a cardiac output of 15% while OC-CPR rendered a mean cardiac output of 67% of control prearrest values.
Level 5. Excellent. Positive.