WORKSHEET for Evidence-Based Review of Science for Veterinary CPR

1. Basic Demographics

Worksheet author(s)

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[redacted]

2. Clinical question:

In dogs and cats with cardiac arrest (P), does the use of interposed abdominal compressions-CPR (I) compared with standard CPR (C), improve outcome (e.g. ROSC, survival) (O)?

3. Conflict of interest specific to this question:

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet?

No

4. Search strategy (including electronic databases searched):

4a. Databases

-Pubmed :(no date restrictions) (performed August 13, 2011)

1. Dogs and interposed abdominal compressions (12 hits, 9 relevant, exclude review articles)
2. Cats and interposed abdominal compressions (0 hits)
3. Feline and interposed abdominal compressions (0)
4. Cats and CPCR (7 hits, 2 CPCR, 0 interposed abdominal compressions)
5. Swine and interposed abdominal compressions (4 hits, exclude one with Trendelenberg position, exclude review)
6. Note: all animals were part of experimental design, not outcomes of spontaneous arrest.
7. Lack of any data for feline patients who arrest and IAC

-Mendeley: searched “papers”

8. Search Interposed abdominal compressions
9. Exclude humans (see ILCOR ALS-BLS-CPR&A-082A.doc)
10. Excluded reviews
11. Excluded mathematical models
12. Included non-human animals: 11 hits, 4 repeats of Pubmed search yielded articles listed above in number 1.
13. Note: all animals were part of experimental design, not outcomes of spontaneous arrest.

4b. Other sources

-Reviewed human worksheet ALS-BLS-CPR&A-082.DOC (Sunde and Holzer)

-GOOGLE SCHOLAR (performed on August 13th 2011)
Report as for Pubmed; found Cole et al. 2002 (see below). None of the articles had different experimental models in dogs or swine, no models using cats/felines; reviews only.

-In addition, the references of articles of interest from Pubmed, and in particular, the references of the following relevant review/summary articles were reviewed for animal studies: Babbs 2003, Babbs 2004, Sack 1992a and 1992b, Ward 1989, Barranco 1990, Howard 1987, Mateer 1985, Adams 1994. This was to review human evidence and is summarized by the human IAC-CPR worksheet authored by Sunde and Holzer

-In addition reviewed Cole et al. 2002 (JVECC) and found no additional studies

-Reviewed Ward, Sullivan et al. 1989 (A comparison of IAC-CPR and standard CPR by ETCO2) and found dog model (Walker, Bruestle et al. 1984) in references; this was added to above sources.

-Reviewed veterinary reviews of CPCR: Hofmeister et al. 2009, Plunkett and McMichael 2008, Haldane and Marks 2004, Cole et al. 2002; no additional information

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

Inclusion criteria

Dogs, interposed abdominal compressions

Exclusion criteria

Abdominal binding instead of compressions, individual , lower-quality human clinical studies, review of animal models (exclude 1 from Pubmed: Babbs 1985 Abdominal counterpulsation in cardiopulmonary resuscitation: animal models and theoretical considerations; Babb 1984 Preclinical Studies of Abdominal counterpulsation in CPR, Babbs and Tacker 1986 Cardiopulmonary resuscitation with interposed abdominal compression).

4d. Number of articles/sources meeting criteria for further review: 13

-Eight dog experimental studies with induced cardiac arrest were identified: (Babbs, Schoenlein et al. 1985), (Einagle, Bertrand et al. 1988), (Hoekstra, van Lambalgen et al. 1995), (Kern, Carter et al. 1986a), (Kern, Carter et al. 1986b), (Luce, Ross et al. 1983), (Ralston, Babbs et al. 1982), (Voorhees, Niebaur et al. 1983), (Walker, Bruestle et al. 1984).

-Two swine experimental studies (Lindner, Ahnefeld, et al. 1990), (Xavier, Kern et al. 2003)

-One meta-analyses (Babbs 2003a)

-One Controlled human study (Mateer, Stueven et al. 1985)

5. Summary of evidence

Evidence Supporting Clinical Question

Good			**Babbs 1985**; E= significantly higher diastolic arterial pressure **Ralston 1982**; E= Cardiac output, brachial arterial blood pressures **Voorhees, 1983**; E= arterial and central venous blood pressure, oxygen consumption, Fick cardiac output			**Babbs 2003a**; A, C **Babbs 2004;** A, C
Fair			**Walker 1984;** E= perfusion of the cerebral cortex Einangle, **Bertrand 1988;** E= increased carotid blood flow **Hoekstra 1995;** E= higher total forward blood flow			**Xavier 2003;** B, E= aortic diastolic and right atrial diastolic pressures **Lindner 1990**; A, B, E= diastolic arteriovenous pressure difference
Poor						**Ward 1989;** E = $ETCO_2$
	1	**2**	**3**	**4**	**5**	**6**
Level of evidence (P)						

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

Evidence Neutral to Clinical question

Good			**Kern 1986a;** A, B, D, E= aortic diastolic and coronary perfusion pressures **Kern 1986b**; E= trauma from CPR			**Xavier 2003**; B,E= coronary perfusion pressures **Mateer 1985**; A,C
Fair						
Poor						
	1	**2**	**3**	**4**	**5**	**6**
Level of evidence (P)						

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

Evidence Opposing Clinical Question

Good						
Fair						
Poor						
	1	**2**	**3**	**4**	**5**	**6**
Level of evidence (P)						

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

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

IAC-CPR has been trialed in 8 experimental studies in dogs and 2 in swine. These represent otherwise healthy animals induced to arrest for experimental studies. Six of the dog experimental studies show a benefit to IAC-CPR over standard CPR (Babbs 1985, Einagle 1988, Hoekstra 1995, Ralston 1982, Voorhees 1983, Walker 1984) with respect to increasing blood flow, blood pressures, venous return, cerebral blood flow, and cardiac output. Two studies in dogs by the same authors (Kern 1986a, Kern 1986b) concluded 1) no benefit for 24 hour survival and 2) no increase in the trauma (no additional harm to using IAC-CPR). No studies show a benefit of STD-CPR over IAC-CPR for any of the parameters described. The canine experimental studies suggest a possible beneficial effect of IAC in regards to generating an increase in blood flow with the risk of patient injury not different from that of standard CPR.
Two swine experimental models (Lindner 1990, Xavier 2003) show a benefit of IAC-CPR over STD-CPR with respect to better hemodynamic performance during CPR and more subjects surviving the induced arrest and a *trend* towards better 24 hour survival. Two good quality human studies show an increased survival to hospital discharge with IAC-CPR compared to STD-CPR including two meta-analyses (Babbs 2003a, Babbs 2004). One lower quality human study shows improved $EtCO_2$ values with IAC-CPR compared to standard (Ward 1989). One high quality controlled study in humans suggests no advantage (Mateer 1985). These human studies are spontaneous arrest in and out of the hospital. There is no evidence of increased trauma with IAC-CPR in dogs (Kern 1986). There is no evidence opposing the clinical question.
There are no articles describing experimental or clinical use of IAC-CPR in feline patients.
Overall there is evidence to support that IAC-CPR maybe superior to STD-CPR and is unlikely to cause harm. It is important to note that many studies used automated devices to perform IAC-CPR so the ability to generate similar results in clinical veterinary patients using manual techniques is unknown. It is reasonable to consider IAC-CPR in canine and feline patients at this time.

7. Conclusion

DISCLAIMER:
CONSENSUS ON SCIENCE: Eight canine experimental studies and two swine experiemental studies evaluating IAC-CPR were identified. Six of the canine studies (LOE 3)(Babbs 1985, Einagle 1988, Hoekstra 1995, Ralston 1982, Voorhees 1983, Walker 1984) reported superiority in hemodynamic performance during IAC-CPR compared to STD-CPR. The two swine studies (LOE6)(Lindner 1990, Xavier 2003) also reported improved hemodynamic performance as well as increased ROSC and survival of the event. Two of the canine studies (LOE3) (Kern 1986a, Kern 1986b) demonstrated no benefit of IAC-CPR and no evidence of harm either. Two human studies (LOE6) (Babbs 2003a, Babbs 2004) of out of hospital arrest reported increased survival to hospital discharge with IAC-CPR. One human study (LOE6)(Ward 1989) reported higher ETCO2 during IAC-CPR compared to STD-CPR and one human study (LOE6) (Mateer 1985) reported no benefit of IAC-CPR over STD-CPR.
Overall there is evidence to support that IAC-CPR maybe superior to STD-CPR and is unlikely to cause harm. It is important to note that many studies used automated devices to perform IAC-CPR so the ability to generate similar results in clinical veterinary patients using manual techniques is unknown. It is reasonable to consider IAC-CPR in canine and feline patients at this time.

8. Acknowledgement

9. Citation list

Babbs, C. (2003). “Simplified meta-analysis of clinical trials in resuscitation.” Resuscitation 57(3): 245-55.
Presents a simplified method of synthesizing the results of multiple clinical trials and uses IAC-CPR and active compression-decompression (ACD) CPR as examples. Author concludes that retrospectively there is a difference in the benefit of IAC-CPR between three in-hospital study and one pre-hospital study (see Mateer et al.) even though each study did not conclude a benefit.
Level 6, supportive, funding: not mentioned
Key point: no new data presented but demonstrates in Table 2 how the date from four studies can be reexamined to reach a conclusion that IAC-CPR is beneficial to outcomes.

Babbs, C. (2004). “Meta-analysis of 2-treatment clinical trials including both continuous and dichotomous results.” Med Decis Making 24: 299.
This meta-analytic review of multiple human studies concludes that there is evidence that IAC-CPR has an increase in survival, including ROSC and survival to discharge.
Level 6, supporting, funding: none mentioned
Key points: when used properly, a meta-analysis of clinical response ratios is a tool to expedite early research findings in clinical medicine, especially for “orphan” clinical studies, i.e. ones without large funding. No new data.

Babbs, C, W. Schoenlein, et al. (1985). "Gastric insufflation during IAC-CPR and standard CPR in a canine model.” Am J Emerg Med 3(2): 99-103.
Gas entering the stomach and lungs was measured during standard and IAC-CPR. IAC-CPR had hemodynamic benefits and reduced gastric insufflations and its attendant complications.
Level 3, supporting, funding not mentioned
Key point: hemodynamic benefits of IAC-CPR as compared to standard CPR.

Einagle, V., F. Bertrand, et al. (1988). “Interposed abdominal compressions and carotid blood flow during cardiopulmonary resuscitation. Support for a thoracoabdominal unit.” Chest 98(6): 1206-12.
Carotid blood flow was measured with an electromagnetic flow probe. Also, right atrial, thoracic aortic, and abdominal aortic blood flow was measured with catheters. Standard CPR or IAC-CPR was performed early or late at three vascular volumes in 9 dogs. Carotid blood flow showed a significant increase whether IAC was performed early or late as compared to standard CPR.
Level 3, supporting, funding Canadian Lung association and the Quebec heart association.
Key point: IAC-CPR showed better carotid blood flow in the dog, whether initiated early or late in resuscitation.

Hoekstra, O., A. van Lambalgen, et al. (1995). “Abdominal compressions increase vital organ perfusion during CPR in dogs: relation with efficacy of thoracic compressions. Ann Emerg Med 25(3): 375-85.
In a crossover design, total and regional blood flow was measured using radioactive microspheres during standard and IAC-CPR. The ascending aortic-right atrial pressure gradient was increased in IAC-CPR. Thus, IAC-CPR improves total and vital oxygen delivery through enhanced venous return and perfusion pressures.
Level 3, supporting, funding: Dutch Heart foundation
Key point: better hemodynamics when IAC are included in CPR.

Kern, K., A. Carter et al. (1986a). “Twenty-four hour survival in a canine model of cardiac arrest comparing three methods of manual cardiopulmonary resuscitation.” J Am Coll Cardiol 7(4): 859-67.

Thirty dogs were divided into three groups and each treated with one of three types of manual cardiopulmonary resuscitation: high impulse compression (120/mi), standard compression (60/min), or standard compression (60/min) plus interposed abdominal compressions at 60/min. There was no difference in initial resuscitation success, 24 hour survival or neurological deficit among the dogs that survived. Each method performed equally well in induced ventricular fibrillation in dogs anesthetized with morphine and halothane.
Level 3, neutral, funding: National Heart, Lung and Blood institute, American Heart Association, and Physio-Control corporation
Key points: none of the methods outperformed the other for goals of survival or neurological deficits. Twenty of thirty dogs were able to be resuscitated.

Kern, K., A. Carter et al. (1986b). "CPR-induced trauma: comparison of three manual methods in an experimental model. Ann Emerg Med 15(6): 674-9.
The thirty dogs described in Kern et al. 1986a were necropsied after the study. The trauma was noted: fractured ribs and myocardial contusion being the most common (53%), pulmonary contusion (40%), and liver laceration (13%). Only 13% of the animals had no CPR induced injury. IAC-CPR did not produce any more injuries than standard CPR. Only 20 of the 30 animals were successfully resuscitated. One died from a technical "mishap", four had progressive neurologic dysfunction, and all died after grand mal seizures, four died from pulmonary injuries, one died from hemorrhage from a liver laceration, and the remaining ten were sacrificed.
Level 3, neutral, funding: National Heart, Lung and Blood institute, American Heart Association, and Physio-Control corporation
Key points: There was no significant difference in trauma from the three types of CPR performed. There was liver injury in all three of the types of CPR.

Lindner, K., F. Ahnefeld et al. (1990). "Cardiopulmonary resuscitation with interposed abdominal compression after asphyxia or fibrillatory cardiac arrest in pigs." Anesthesiology 72(4): 675-81.
Twenty-eight pigs weighing 19-27 kg were randomly allocated to two arrest groups (asphyxial versus VF). Each of these was then subdivided into a treatment group (IAC-CPR) and a control group (STD-CPR) (4 groups 7 pigs each). In each group, standard CPR (STD-CPR) was administered with the use of a pneumatically driven chest compressor (Thumper® model 1004). In the other group, STD-CPR was compared to that with interposed abdominal compression using a folded blood pressure cuff with a pressure of 100-120 mmHg (IAC-CPR). None of the pigs were resuscitated successfully with STD-CPR. All were successful with IAC-CPR.
Level 6, supporting, funding: none mentioned
Key point: IAC-CPR is more effective in small pigs than STD-CPR

Mateer, J., H. Stueven, et al. (1985). "Pre-hospital IAC-CPR versus standard CPR: paramedic resuscitation of cardiac arrests." Am J Emerg Med 3(2): 143-6.
Two hundred ninety-one human patients were allocated randomly into two groups, one of which received IAC-CPR and the other STD-CPR. Twenty-eight % were successfully resuscitated in the IAC-CPR and 31% in the STD-CPR, which was statistically insignificant.
Level 6, neutral, funding: none mentioned.
Key point: No difference in successful resuscitation and no difference in regurgitation.

Ralston, S., C. Babbs, et al. (1982). "Cardiopulmonary resuscitation with interposed abdominal compression in dogs." Anesth Analg 61(8): 645-51.
Ten dogs were used to compare central venous pressure, brachial arterial blood pressure and cardiac output (using indicator dilution method). Dogs had free access to food and water before anesthesia for the experiment (pentobarbital sodium). Ventricular fibrillation was induced electrically and either IAC-CPR or STD-CPR was

performed for three minutes and then alternated over a 30 minute period. Cardiac output and brachial arterial blood pressures were higher with IAC-CPR.
Level 3, supporting, funding: American heart Association and National Heart, Lung, and Blood institute
Key point: The IAC CPR was administered by a blood pressure cuff inflating to a 120- 150 mm Hg.

Voorhees, W., M. Niebauer, et al. (1983). "Improved oxygen delivery during cardiopulmonary resuscitation with interposed abdominal compressions." Ann Emerg Med 12(3): 128-35.
Ten dogs anesthetized with pentobarbital sodium and induced to ventricular fibrillation electrically were used to compare IAC-CPR to STD-CPR. Arterial and central venous blood pressures, oxygen consumption, and Fick cardiac output were monitored for the dogs. Each group was administered IAC-CPR (blood pressure cuff) and STD-CPR (using Thumper®) alternately every five minutes over a thirty minute period. Oxygen delivery, arterial systolic blood pressure and cardiac output increased with the administration of IAC-CPR. Postmortem exam of all dogs showed no significant gross trauma to intraabdominal organs.
Level 3, supporting, funding: American Heart Association and National Heart, Lung, and Blood Institute.
Key point: Similar to the Ralston and Linder studies in administration of IAC-CPR. No evidence of trauma to abdomen.

Ward, K., R. Sullivan, et al. (1989) "A comparison of interposed abdominal compression CPR and standard CPR by monitoring End-Tidal PCO_2." Ann Emerg Med 18(8): 831-7.
This prospective, randomized human trial of 33 adult humans in cardiac arrest demonstrated that $ETPCO_2$ was higher in the IAC-CPR. Abdominal compressions were applied with a blood pressure cuff to which hands were applied. These results suggest that cardiac output is increased in humans administered IAC-CPR during non-traumatic cardiac arrest.
Level 6, supporting, funding: Novametrix donated the capnometer used in this study.
Key point: Humans in non-traumatic cardiac arrest may benefit from IAC-CPR.

Walker, J., J. Bruestle, et al. (1984) "Perfusion of the cerebral cortex by use of abdominal counterpulsation during cardiopulmonary resuscitation." Am J Emerg Med 2(5): 391-3.
Twenty-four large dogs were allocated to three groups of eight to study cerebral perfusion after cardiac arrest was induced with a central bolus of KCl. The dogs were induced to anesthesia with a bolus of thiamylal sodium and then masked induced with halothane, and then intubated and maintained on halothane. The left femoral artery and the right jugular vein were cannulated. Craniotomies were performed, an arterial catheter was inserted into the dura, and a thermal probed was inserted. In the first group, STD-CPR was performed; in the second, IAC-CPR, and in the third IAC-CPR plus an IV dose of 50 μg/kg of epinephrine. The Cerebral Cortical Blood Flow (rCCBF) was measured in the craniotomy site as a change in the temperature of injected cold saline infusion. The r CCBF was best for the IAC-CPR plus epinephrine (equal to normal, pre-arrest), then the rCCBF was significantly better for IAC-CPR versus STD-CPR (51% versus 11%).
Level 3, supporting, funding: Pharmacia
Key points: This invasive study may have altered the rCCBF from normal as the dogs were anesthetized and then had surgery and two vascular with cut downs. This study lacks a control group of STD-CPR with epinephrine.

Xavier, L., K. Kern, et al. (2003). "Comparison of standard CPR versus diffuse and stacked hand position interposed abdominal compression-CPR in a swine model." Resuscitation 59(3): 337-44.
Two different had positions were studied: open hands, placed side by side, resulting in diffuse abdominal compression ad stacked hands, with one on top of the other, producing a more focal compression of the abdomen. Thirty-nine swine weighing 20-30 kg were anesthetized with isoflurane and ventilated. They were induced to ventricular fibrillation with a 5F pacing wire in the right vertical. Doppler tipped catheters were placed into the descending thoracic aorta and inferior vena cava (IVC). Swine were randomized to one of three

groups: STD-CPR, IAC-CPR diffuse hand position, or IAC-CPR stacked hands (sIAC-CPR). Both forms of IAC-CPR produced greater aortic diastolic and right atrial diastolic pressures than STD-CPR. Blood flow was similar in all three groups and there was no trauma in all three groups. Hand position did not affect blood flow in the aorta, or the IVC, or resuscitation success. Authors noted a *trend* toward better outcomes with sIAC-CPR as compared to STD-CPR but not a statistical significant difference.
Level 6, neutral, funding: not mentioned
Key points: This study would need to be repeated to see if greater numbers could elucidate if the trend was significant.