WORKSHEET for Evidence-Based Review of Science for Veterinary CPCR

1. Basic Demographics

Worksheet author(s)

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[redacted]

2. Clinical question:

In dogs and cats with suspected cardiac arrest (P), is the evaluation of a doppler pulse (I) vs. assessment for other signs of life (e.g. pupil size, agonal breathing, femoral pulse) (C) a reliable tool for diagnosis of cardiac arrest?(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

Medline (via Pub-Med, searched 7-13-11)

1. "heart arrest" AND "doppler": 157 results, 3 relevant articles (search details: "heart arrest"[All Fields] AND "doppler"[All Fields])
2. "cardiopulmonary resuscitation" AND "doppler": 79 results, 3 relevant articles (search details: "cardiopulmonary resuscitation"[All Fields] AND "doppler"[All Fields])
3. "heart arrest" AND blood pressure determination/methods [MeSH Terms]: 10 results, 1 relevant article (search details: ("heart arrest"[MeSH Terms] OR ("heart"[All Fields] AND "arrest"[All Fields]) OR "heart arrest"[All Fields]) AND "blood pressure determination/methods"[Mesh Terms])

Total relevant articles found in all four searches (some overlap): 5

CAB Abstracts (searched 7-13-11)

1. "heart arrest" AND doppler: 0 results (search details: (heart arrest and doppler).mp. [mp=abstract, title, original title, broad terms, heading words])
2. "cardiopulmonary resuscitation" AND doppler: 1 result, 0 relevant articles (search details: (cardiopulmonary resuscitation and doppler).mp. [mp=abstract, title, original title, broad terms, heading words])
3. "heart arrest" AND blood pressure: 3 results, 0 relevant articles (search details: (heart arrest and blood pressure).mp. [mp=abstract, title, original title, broad terms, heading words])

Total relevant articles found in all three searches: 0

4b. Other sources

Review of references cited in veterinary CPCR reviews:

- Berg RA, Hemphill R, et al. American Heart Association: Part 5: Adult Basic Life Support: 2010 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2010:122:S685-S705. *294 references, 0 relevant articles.*
- Cole SG, Otto CM, et al. Cardiopulmonary cerebral resuscitation in small animals – a clinical practice review (Part 1). J Vet Emerg Crit Care 2002; 12(4):261-267. *47 references, 0 relevant articles.*
- Cole SG, Otto CM, et al. Cardiopulmonary cerebral resuscitation in small animals – a clinical practice review. Part II J Vet Emerg Crit Care 2003; 13(1):13-23. *48 references, 0 relevant articles.*
- Haldane S, Marks S, et al. Cardiopulmonary cerebral resuscitation: emergency drugs and postresuscitative care. Comp Contin Educ Pract Vet 2004;26(10): 791-799. *65 references, 0 relevant articles.*
- Haldane S, Marks SL. Cardiopulmonary resuscitation: techniques Comp Contin Educ Pract Vet 2004;26(10): 780-790. *54 references, 0 relevant articles.*

- Holowaychuk M, Martin L. An In-depth look: misconceptions about emergency and critical care: cardiopulmonary cerebral resuscitation, fluid therapy, shock, and trauma. Comp Contin Educ Pract Vet 2006; 420-433. *73 references, 0 relevant articles*.
- Plunkett SJ, McMichael M. Cardiopulmonary resuscitation in small animal medicine: an update. J Vet Intern Med 2008;22(1):9-25. *297 references, 0 relevant articles.*
- Travers AH, Rea TD et al. American Heart Association: Part 4: CPR Overview: 2010 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2010;122:S676-684. *52 references, 0 relevant articles.*

Total relevant articles found using other searches (some overlap): 0

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

Inclusion criteria
- Peer reviewed journal articles
- Clinical or experimental studies
- Animal studies (any species) or human studies
- Articles pertaining to the use of Doppler to find peripheral pulses during cardiac arrest

Exclusion criteria
- Review articles
- Clinical practice guidelines
- Editorials/letters
- Case reports
- Abstracts/posters
- Articles pertaining to transcranial Doppler use (since this is not routinely done in clinical veterinary practice)
- Articles pertaining to transesophageal Doppler use in humans

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

5 ARTICLES

5. Summary of evidence

Evidence Supporting Clinical Question

Good						
Fair						
Poor			Spreng 1995 E			
	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						
Fair						
Poor						*Grunau, 1978 E* *Lichti, 1971 E* *O'Keeffe, 1976 E* *Ryan, 1991 E*
	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:

No clinical veterinary or experimental controlled animal studies have been performed to investigate the reliability of a Doppler pulse to diagnose cardiac arrest. There is also a paucity of human or experimental animal models documenting the usefulness of Doppler pulse sounds to document cardiac arrest.

The human literature review in this worksheet is comprised of case reports detailing the use of Doppler pulse sounds and blood pressure measurements during and after cardiac arrest and successful resuscitation, not for the diagnosis of cardiac arrest. The human literature reviewed is neutral to the clinical question posed since the studies did not describe the use of Doppler to diagnose cardiac arrest and are LOE 6 as they are all case reports.

In an experimental canine model (Spreng, 1995) (LOE 3) that evaluated the use of an esophageal Doppler and other measures of cardiac function to detect pseudo-electromechanical dissociation, femoral pulses and a radial artery Doppler signal were no longer detectable before an esophageal Doppler signal and thoracic aorta blood movement were no longer perceptible. The time from clamping the endotracheal tube to induce arrest to loss of femoral pulse was 622 +/- 96 seconds, until loss of radial artery Doppler signal was 616 +/- 92 seconds, until loss of esophageal Doppler signal was 728 +/- 88 seconds, and until loss of aortic fluctuations measured with a catheter in the thoracic aorta was 728 +/- 82 seconds. There was a significant difference in the time from loss of femoral pulse to loss of esophageal Doppler sounds and loss of aortic fluctuations. The time from loss of radial artery Doppler sounds to loss of esophageal Doppler sound or aortic fluctuations was not assessed. Given that there was minimal difference in the amount of time to loss of femoral pulses and radial artery Doppler sounds, but a mean difference of approximately 100 seconds before aortic root fluctuations and esophageal Doppler sounds were no longer detectable, it is possible that loss of radial artery Doppler signal may be a clinically relevant means of detecting impending cardiac arrest. However, caution must be exercised if attempting to extrapolate this experimental data to clinical veterinary patients, as the dogs in this study were healthy, a standardized anesthetic protocol was used, and the dogs were instrumented while their cardiovascular status was stable before arrest was induced. In clinical veterinary practice, arrest may not always be predicted with enough advance warning that there would be sufficient time to secure placement of a Doppler probe, although in anesthetized patients who experience a cardiac arrest while monitored with a Doppler, the loss of Doppler pulse sounds may be a reasonable mechanism to indicate a cardiac arrest.

Based on lack of clinical evidence, controlled animal studies in target species and clinical trials evaluating at risk patients monitored by Doppler pulse probe are recommended before Doppler pulse sounds can be recommended as a reliable tool for the diagnosis of cardiac arrest.

7. Conclusion

DISCLAIMER: Potential possible wording for a Consensus on Science Statement. Final wording will differ due to other input and discussion.
CONSENSUS ON SCIENCE:
Evidence is lacking in the human literature regarding the use of Doppler pulse sounds as a method to diagnose cardiac arrest. In an experimental pseudo-electomechanical dissociation model in dogs, a non-palpable femoral pulse and loss of radial artery Doppler signal occurred before loss of esophageal Doppler sounds and aortic fluctuations as detected by an aortic catheter, indicating that peripheral Doppler sounds are lost before complete cardiac arrest. However, this finding may not be clinically applicable since arrests are often not predictable such that a Doppler can be placed in advance.

TREATMENT RECOMMENDATIONS:
Based on lack of clinical and experimental evidence, Doppler pulse sounds cannot be safely recommended as a reliable tool for the diagnosis of cardiac arrest at this time, except in anesthetized patients who are monitored continuously for a Doppler pulse.

8. Acknowledgement

None

9. Citation list

Grunau, C. (1978). "Doppler ultrasound monitoring of systemic blood flow during CPR." Journal of the American College of Emergency Physicians. 7(5): 180-5.
Abstract: During cardiopulmonary resuscitation in 12 patients, Doppler ultrasound monitoring of radial arterial flow provided an audible, instantaneous flow sound to which the resuscitation team referred, along with the monitor electrocardiogram (EKG), in determining hemodynamic status. Incidental to the resuscitation effort, a separate analog flow signal and the monitor EKG were simultaneously recorded in eight patients. Doppler blood flow monitoring allowed evaluation of effectiveness of cardiac massage; immediate recognition of electromechanical dissociation; rapid determinations of blood pressure, often during profound hypotension, and estimates of changes in cardiac output. When the hemodynamic consequences were immediately obvious, both ineffective chest compression and pauses longer than five seconds during effective chest compression were not tolerated by those in attendance, for whom the Doppler flow signal often became the primary reference in determining the patient's cardiac status.
Keywords: ultrasonics, Doppler effect, monitoring blood flow; Doppler
Level 6, neutral, no comment on funding
Key Points: After cardiopulmonary arrest, Doppler blood flow monitoring allowed for evaluation of effectiveness of compression, blood pressure assessment, auditory recognition of EMD, and estimation of cardiac output in 12 clinical patients.

Lichti E, Willets P, et al. (1971). "Cardiac massage efficacy monitored by Doppler ultrasonographic flowmeter." Missouri Medicine. 68(5): 317-20.
No abstract or keywords available.
Level 6, neutral, no comment on funding
Key Points: In 3 cases of post-operative cardiac arrest that had Doppler ultrasonographic flow of a peripheral vessel measured during resuscitative efforts, the authors felt Doppler flow provided an objective observation of effectiveness of cardiac massage and permitted calculation of a perfusion index.

O'Keeffe K, Bookman L. (1976). "The portable Doppler: practical applications in EMS care." Journal of the American College of Emergency Physicians. 5(2): 987-91.
Abstract: The practical application of a new, commercially available, portable Doppler ultrasound device to the operation of a busy city-county emergency department and ambulance service was investigated. An initial evaluation using healthy volunteers confirmed accuracy and reproducibility of the Doppler blood pressure readings comparable to that of auscultatory and palpatory measurement. In selected patients, the Doppler readings correlated well with readings from patients who had intra-arterial lines. When used in several low flow states, such as testing adequacy of cardiopulmonary resuscitation (CPR) and verification of electromechanical dissociation, the Doppler aided the clinical evaluation and treatment in many cases where traditional methods were useless. The Doppler was also helpful in the evaluation of local arterial injury but this unit was not found sensitive enough for venous disease. Finally, the Doppler enhanced the obtaining of vital signs in the noisy environment of our ambulances.

Keywords: Doppler, portable; blood pressure, Doppler
Level 6, neutral, no comment on funding
Key Points: A Doppler flowmeter was used to detect blood flow during CPR in an unspecified number of cases without discussion of how the Doppler impacted treatment decisions and outcome.

Ryan B., Redmond, A, et al. (1991). "When to stop resuscitation – the significance of cuff blood pressure." Archives of Emergency Medicine. 8: 177-81.
Abstract: Fifteen consecutive patients who had been resuscitated from cardiac arrest and transferred immediately to an Intensive Care Unit were studied. Measurements of intraarterial pressure, cardiac output and systemic vascular resistance demonstrate that 'cuff' blood pressure may not always be related to intraarterial pressure or cardiac output and cannot be used for diagnostic, therapeutic, or prognostic purposes. Following resuscitation, a palpable pulse was present in each of these patients, but did not correlate with adequacy of cardiac output. Too often we hear during a cardiac arrest the question 'Does the patient have an output?', when we should really be asking 'Does the patient have a pulse?'. The palpation of a pulse is a simple and important indication of spontaneous cardiac activity. However cardiac output must be measured and its adequacy cannot be inferred from this basic clinical measurement.
Level 6, neutral, no comment on funding
Key Points: The method of how cuff blood pressure was obtained was not specified. After cardiac arrest, five patients had an un-recordable blood pressure when measured on the arm but did have an adequate mean arterial blood pressure via direct measurements.
I am not even sure if this paper should be included since it is not clear if Doppler is used, and it is assessing the use of blood pressure in comparison with more invasive measurements of cardiac output after cardiac arrest and resuscitation.

Spreng D., DeBehnke D, et al. (1995). "Evaluation of an esophageal Doppler probe for the identification of experimental pseudo-electromechanical dissociation: a preliminary study." Resuscitation. 29: 153-56.
Abstract: Study objective: To determine the effectiveness of an esophageal doppler device to non-invasively detect experimental pseudo-electromechanical dissociation (pseudo-EMD). Design: Prospective, controlled, laboratory investigation using an asphyxial canine cardiac arrest model and a newly-developed esophageal flat-flow probe doppler unit. Interventions: Mongrel dogs (20) were instrumented for hemodynamic monitoring. The esophageal doppler probe was placed in the distal esophagus of each animal. Electromechanical dissociation (EMD) was induced by clamping the endotracheal tube. Measurements and main results: A period of pseudo-EMD was defined as the time where cardiac contractility was present, measured by a micromanometer tipped thoracic aortic catheter, without concurrent femoral pulses by palpation. The pseudo-EMD period could be produced consistently in all 20 animals. The characteristic doppler flow sounds were easily heard using the esophageal device in all animals. The time from endotracheal tube clamping until loss of femoral pulses was 622 ± 96 s; until loss of radial artery doppler signals was 616 ± 92 s; until loss of esophageal doppler signals was 728 ± 88 s; and until loss of aortic fluctuations by thoracic aortic catheter was 728 ± 82 s. The times to loss of esophageal doppler sounds and loss of aortic fluctuations were not significantly different. However, they were significantly longer than the time to loss of femoral pulses ($P <$ 0.02). Conclusions: The canine asphyxial EMD model can be used for short experimental studies of pseudo-EMD. Pseudo-EMD can be consistently and non-invasively detected with this esophageal doppler device. The device is as reliable as a micromanometer tipped aortic arch catheter in detecting pseudo-EMD. The doppler device could potentially be useful in improving recognition of near cardiac arrest in pre-hospital and emergency department settings. Further research on the utility of this device in other models of low-flow states should be performed.
Author Keywords: Heart arrest; Resuscitation; Blood flow velocity
Level 3, supportive, no comment on funding

Key Points: Esophageal Doppler sounds were no longer heard at approximately the same time as aortic fluctuations were no longer detectable in a canine experimental pseudo-electromechanical dissociation study. However, the loss of Doppler sounds and aortic fluctuations occurred after the loss of a palpable femoral pulse and radial artery Doppler signal. Therefore, peripheral Doppler signals were no longer heard before the loss of aortic fluctuations and esophageal Doppler sounds, and therefore lost before the occurrence of complete cardiac arrest.