WORKSHEET for Evidence-Based Review of Science for Veterinary CPCR

1. Basic Demographics

Worksheet author(s)

Tara Hammond	**Date Submitted for review:** 6/14/11

[redacted]

2. Clinical question:

MON12: In dogs and cats with cardiac arrest (P), does the minimization of hands off time after defibrillation for rhythm check (I) as opposed to standard care (C), improve outcome (O) (e.g. ROSC, survival)?

3. Conflict of interest specific to this question:

NONE

4. Search strategy (including electronic databases searched):

4a. Databases

-MEDLINE via PUBMED (1950 to current) (performed on May 1st 2011)
1.) Cardiopulmonary resuscitation AND defibrillation AND chest compressions – 180 hits (24 relevant)
2.) Cardiopulmonary resuscitation AND defibrillation AND EKG rhythm check – 6 hits (2 relevant, no additional references vs. 1)
3.) Cardiopulmonary resuscitation AND chest compressions AND interruption – 46 hits (13 relevant, no additional references vs. 1)
4.) Cardiopulmonary resuscitation AND EKG rhythm interruption – 11 hits (3 relevant, no additional references vs. 1)

-CAB (1910 to current) (performed on May 1st 2011)
1.) Cardiopulmonary resuscitation AND defibrillation AND chest compressions – 2 hits (1 relevant, already included)
2.) Cardiopulmonary resuscitation AND defibrillation AND EKG rhythm check – 0 hits
3.) Cardiopulmonary resuscitation AND chest compressions AND interruption – 0 hits
4.) Cardiopulmonary resuscitation AND EKG rhythm interruption – 0 hits

4b. Other sources

Google scholar: Cardiopulmonary resuscitation AND interruption AND chest compressions AND defibrillation AND veterinary – 117 hits

-In addition all references of identified articles and in particular the references of the following relevant review articles were checked:

American Heart Association: Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science 2010;122 (18;S3)

Begue J, Terndrup T. (2005). Delaying shock for cardiopulmonary resuscitation:does it save lives?. Curr Opin Crit Care 11(3):183-7.

Cole SG, Otto CM, Hughes D. (2002). Cardiopulmonary cerebral resuscitation in small animals--a clinical review (Part I & II). J Vet Emerg Crit Care 12(4):261-267 & 13(1):13-23.

Plunkett SJ, McMichael M. (2008). Cardiopulmonary resuscitation in small animal medicine: an update. J Vet Int Med 22(1):9-25.

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

Inclusion criteria

Adult and pediatric populations, human and animal studies, metanalyses, manikin models

Exclusion criteria

Abstracts only, editorials, journal unavailable in English, single case reports, review articles, device not used in veterinary medicine, letter to the editor

4d. Number of articles/sources meeting criteria for further review: 19

- 11 relevant human studies were identified: (Blouin, 2001), (Eftestol, 2002), (Velenzuela, 2005), (Edelson, 2006), (Garza, 2009), (Gunderson, 2009), (Roessler, 2009), (Sutton, 2009), (Berdowski, 2010), (Meier, 2010), (Krarup, 2011)

- 8 relevant animal studies were identified: (Wingfield, 1992), (Kern, 2002), (Steen, 2003), (Waldrop, 2004), (Kramer-Johanen, 2007), (Ristango, 2008), (Wang YL, 2009), (Li, 2010),

5. Summary of evidence

Evidence Supporting Clinical Question

Ten studies supported the hypothesis that minimization of hands off time after defibrillation for rhythm check as opposed to standard care during CPCR improved outcome (e.g. ROSC, survival, etc).

Good			(Steen, 2003) - A			*(Meier, 2010) - C*
Fair			(Wang YL, 2009) A			*(Eftestol, 2002) - A* *(Edelson, 2006) E – removal of VF for at least 5s after defibrillation*
Poor						*(Valenzuela, 2005) E - interruptions in CPCR efforts* *(Garza, 2009) – A* *(Gunderson, 2009) – A* *(Roessler, 2009) – E –*

						hand off time *(Sutton, 2009) E – pauses in chest compressions*
	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

Six studies neither supported/opposed the hypothesis that minimization of hands off time after defibrillation for rhythm check as opposed to standard care during CPCR improved outcome (e.g. ROSC, survival, etc).

Good			(Ristango, 2008) - D			
Fair			(Kern, 2002) - D (Kramer-Johanen, 2007) – B (Li, 2010) – A (Waldrop, 2004) C (Wingfield, 1992) C			
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

Three studies opposed the hypothesis that minimization of hands off time after defibrillation for rhythm check as opposed to standard care during CPCR improved outcome (e.g. ROSC, survival, etc).

Good						
Fair						*(Blouin, 2001) E – recurrence of*

						VF (Berdowski, 2010) E – recurrence of VF
Poor						*(Krarup, 2011) E – interruptions in CPCR efforts*
	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:

Summary:
Several studies in human medicine have found that minimization of hands-off time after defibrillation to check rhythm improves outcome (ROSC, survival) and have recommended the interval between discontinuation of chest compressions and delivery of a shock should be kept as short as possible (Steen 2003, Wang YL 2009, Meier 2010, Efestol 2002, Edelson 2006, Valenzuela 2005, Garza 2009, Gunderson 2009, Roessler 2009, Sutton 2009). Interruptions during resuscitative efforts often arise from intubation attempts, rescuer change out, mandatory delay with automatic external defibrillator (AED) use, or attempted adherence to CPCR guidelines. For example, chest compressions were performed only 43% of the time during the resuscitation effort in one study (Valenzuela 2005). In another study, of VF in pigs, it took 2 min of mechanical CPCR to re-establish adequate coronary perfusion pressure, which was lost when the CPCR was interrupted. That same study found that adequate heart massage before and during defibrillation greatly improved the likelihood of return of spontaneous circulation (ROSC) (Steen 2003). However, other studies have neither supported nor opposed the hypothesis that minimization of hands off time after defibrillation for rhythm check during CPCR improved outcome (Ristango 2008, Kern 2002, Kramer-Johanen 2007, Li 2010). In one swine model of cardiac arrest (Kramer-Johanen 2007), it was the quality of the chest compressions, rather than the priority of either initial defibrillation or initial chest compressions, that was the predominant determinant of successful resuscitation. Another study did not advocate chest compressions prior to defibrillation as the researchers felt there was not enough evidence that they improved outcome. They concluded that both treatments were equivalent (Meier 2010). In one experimental swine model of cardiac arrest and cardiopulmonary resuscitation, minimal automated external defibrillation-mandated interruption of chest compressions for a single-shock algorithm did not have adverse effects on postresuscitation myocardial or neurologic function. All animals, whether subjected to cardiopulmonary resuscitation interruptions or not, survived (Ristango 2008). In yet another study of a 4-minute VF canine model of cardiac arrest (Wang, YL 2009), the order of initial defibrillation or initial chest compressions (200) did not affect outcome (ROSC). Another study found that it is the quality of CPCR prior to defibrillation that most directly affects clinical outcomes. Currently the AEDs used in human CPCR efforts require long pre-shock pause for rhythm analysis. It has been found that longer pre-shock pauses and shallow chest compressions are associated with defibrillation failure (Edelson 2006). And yet other studies have opposed the hypothesis that minimization of hands off time after defibrillation for rhythm check during CPCR improved outcome (Blouin 2001, Berdowski 2010, Krarup 2011). In fact, one study found early CPR resumption after defibrillation causes early VF recurrence (Berdowski 2010). One study recommended performing 30 seconds of chest compressions after defibrillation before subsequent AED rhythm analysis would increase AED identification of VF/VT (Blouin 2001).

7. Conclusion

Extrapolation of human research to veterinary patients remains difficult given the paucity of veterinary specific literature and the inherent species differences. In addition, many human studies investigate the use of equipment not used in veterinary CPCR efforts, such as AEDs. Conclusions of such studies should be carefully interpreted in their application to veterinary medicine. Unlike humans, primary VF remains a rare cause of CPA in veterinary patients and AEDs that automatically check rhythm with a mandatory pause are not employed. The large majority of canine and feline CPAs involve initial bradycardia and respiratory arrest. Currently, there is not enough data in the human literature to definitively support the hypothesis that minimization of hands off time after defibrillation for rhythm check improves CPCR outcome (e.g. ROSC, survival). It seems prudent to resume chest compressions in our veterinary species immediately after

defibrillation and rhythm identification during CPCR efforts, and to focus on quality of these compressions. More research is needed.

8. Acknowledgement

9. Citation list

Berdowski J, Tijssen JG, Koster RW. (2010). Chest compressions cause recurrence of ventricular fibrillation after the first successful conversion by defibrillation in out-of hospital cardiac arrest. Circ Arrhythm Electrophysiol 1;3(1):72-8.

Abstract

BACKGROUND:

Unlike Resuscitation Guidelines (GL) 2000, GL2005 advise resuming cardiopulmonary resuscitation (CPR) immediately after defibrillation. We hypothesized that immediate CPR resumption promotes earlier recurrence of ventricular fibrillation (VF).

METHODS AND RESULTS:

This study used data of a prospective per-patient randomized controlled trial. Automated external defibrillators used by first responders were randomized to either (1) perform postshock analysis and prompt rescuers to a pulse check (GL2000), or (2) resume CPR immediately after defibrillation (GL2005). Continuous recordings of ECG and impedance signals were collected from all patients with an out-of-hospital cardiac arrest to whom a randomized automated external defibrillator was applied. We included patients with VF as their initial rhythm in whom CPR onset could be determined from the ECG and impedance signals. Time intervals are presented as median (Q1-to-Q3). Of 361 patients, 136 met the inclusion criteria: 68 were randomly assigned to GL2000 and 68 to GL2005. Rescuers resumed CPR 30 (21-to-39) and 8 (7-to-9) seconds, respectively, after the first shock that successfully terminated VF (P<0.001); VF recurred after 40 (21-to-76) and 21 (10-to-80) seconds, respectively (P=0.001). The time interval between start of CPR and VF recurrence was 6 (0-to-67) and 8 (3-to-61) seconds, respectively (P=0.88). The hazard ratio for VF recurrence in the first 2 seconds of CPR was 15.5 (95% confidence interval, 5.63 to 57.7) compared with before CPR resumption. After more than 8 seconds of CPR, the hazard of VF recurrence was similar to before CPR resumption.

CONCLUSIONS:

Early CPR resumption after defibrillation causes early VF recurrence.

LOE:6

Blouin D, Topping C, Moore S, et al. (2001). Out-of-hospital defibrillation with automated external defibrillators: posthock analysis should be delayed. Ann Emerg Med 38(3):256-61.

Abstract

STUDY OBJECTIVE:

The American Heart Association protocols for use of automated external defibrillators (AEDs) recommend that a rhythm analysis be done immediately after each defibrillation attempt. However, shock is often followed by electrical silence or marginally organized electrical activity before ventricular fibrillation (VF) or ventricular tachycardia (VT) recurs. The optimal timing of postshock analysis for identification of recurrent VF/VT is unknown. This study examines the time to recurrence of VF/VT after a defibrillation attempt with AED.

METHODS:

Over an 18-month period, all tapes from patients with out-of-hospital cardiac arrest who received shocks at least once with an AED were screened for recurrent VF/VT. All cases come from a single emergency medical services system providing basic life support, defibrillation with AED, and intubation with an esophageal-tracheal twin-lumen airway device (Combitube) for a population of 633,511 individuals. Pediatric and traumatic cases were excluded. When VF/VT recurred within 3 minutes of the defibrillation attempt, rhythm strips were printed and included in the study. Two cardiology fellows, blinded to the study objectives, measured the time from defibrillation to recurrent VF/VT for each strip.

RESULTS:

Over the study period, 222 tapes from 96 patients met the inclusion criteria. Only 44 (20%) occurrences of VF/VT had recurred within 6 seconds of defibrillation, 162 (73%) at 60 seconds, and 200 (90%) at 90 seconds.

CONCLUSION:

Eighty percent of VF/VT recurred more than 6 seconds after defibrillation and were missed when using current American Heart Association AED protocols. Subsequent analysis should be postponed until at least 30 seconds after defibrillation. Performing 30 seconds of chest compressions after defibrillation before subsequent AED rhythm analysis would increase AED identification of VF/VT to 52%.

LOE:6

Edelson DP, Abella BS, Kramer-Johansen. (2006) Effects of compression depth and pre-shock pauses predicts defibrillation failure during cardiac arrest. Resuscitation 71(2):137-45.

Abstract

BACKGROUND:

Cardiopulmonary resuscitation (CPR) and electrical defibrillation are the primary treatment options for ventricular fibrillation (VF). While recent studies have shown that providing CPR prior to defibrillation may improve outcomes, the effects of CPR quality remain unclear. Specifically, the clinical effects of compression depth and pauses in chest compression prior to defibrillation (pre-shock pauses) are unknown.

METHODS:

A prospective, multi-center, observational study of adult in-hospital and out-of-hospital cardiac resuscitations was conducted between March 2002 and December 2005. An investigational monitor/defibrillator equipped to measure compression characteristics during CPR was used.

RESULTS:

Data were analyzed from 60 consecutive resuscitations in which a first shock was administered for VF. The primary outcome was first shock success defined as removal of VF for at least 5s following defibrillation. A logistic regression analysis demonstrated that successful defibrillation was associated with shorter pre-shock pauses (adjusted odds ratio 1.86 for every 5s decrease; 95% confidence interval 1.10-3.15) and higher mean compression depth during the 30s of CPR preceding the pre-shock pause (adjusted odds ratio 1.99 for every 5mm increase; 95% confidence interval 1.08-3.66).

CONCLUSIONS:

The quality of CPR prior to defibrillation directly affects clinical outcomes. Specifically, longer pre-shock pauses and shallow chest compressions are associated with defibrillation failure. Strategies to correct these deficiencies should be developed and consideration should be made to replacing current-generation automated external defibrillators that require long pre-shock pauses for rhythm analysis.

LOE:6

Eftestol T, Sunde K, Steen PA. (2002). Effects of interrupting precordial compressions on the calculated probability of defibrillation success during out-of-hospital cardiac arrest. Circulation 14;105(19):2270-3.

Abstract

BACKGROUND:

Cardiopulmonary resuscitation (CPR) creates artifacts on the ECG and, with automated defibrillators, a pause in CPR is mandatory during rhythm analysis. The rate of return of spontaneous circulation (ROSC) is reduced with increased duration of this hands-off interval in rats. We analyzed whether similar hands-off intervals in humans with ventricular fibrillation causes changes in the ECG predicting a lower probability of ROSC.

METHODS AND RESULTS:

The probability of ROSC after a shock was continually determined from ECG signal characteristics for up to 20 seconds of 634 such hands-off intervals in patients with ventricular fibrillation. In hands-off intervals with an initially high (40% to 100%) or median (25% to 40%) probability for ROSC, the probability was gradually reduced with time to a median of 8% to 11% after 20 seconds ($P<0.001$). In episodes with a low initial probability (0% to 25%; median, 5%), there was no further reduction with time.

CONCLUSIONS:

The interval between discontinuation of chest compressions and delivery of a shock should be kept as short as possible.

LOE:6

Garza AG, Gratton MC, Salomone JA, et al. (2009). Improved patient survival using a modified resuscitation protocol for out-of-hospital cardiac arrest. Circulation 19;119(19):2597-605.

Abstract

BACKGROUND:

Cardiac arrest continues to have poor survival in the United States. Recent studies have questioned current practice in resuscitation. Our emergency medical services system made significant changes to the adult cardiac arrest resuscitation protocol, including minimizing chest compression interruptions, increasing the ratio of compressions to ventilation, deemphasizing or delaying intubation, and advocating chest compressions before initial countershock.

METHODS AND RESULTS:

This retrospective observational cohort study reviewed all adult primary ventricular fibrillation and pulseless ventricular tachycardia cardiac arrests 36 months before and 12 months after the protocol change. Primary outcome was survival to discharge; secondary outcomes were return of spontaneous circulation and cerebral performance category. Survival of out-of-hospital arrest of presumed primary cardiac origin improved from 7.5% (82 of 1097) in the historical cohort to 13.9% (47 of 339) in the revised protocol cohort (odds ratio, 1.80; 95% confidence interval, 1.19 to 2.70). Similar increases in return of spontaneous circulation were achieved for the subset of witnessed cardiac arrest patients with initial rhythm of ventricular fibrillation from 37.8% (54 of 143) to 59.6% (34 of 57) (odds ratio, 2.44; 95% confidence interval, 1.24 to 4.80). Survival to hospital discharge also improved from an unadjusted survival rate of 22.4% (32 of 143) to 43.9% (25 of 57) (odds ratio, 2.71; 95% confidence interval, 1.34 to 1.59) with the protocol. Of the 25 survivors, 88% (n=22) had favorable cerebral performance categories on discharge.

CONCLUSIONS:

The changes to our prehospital protocol for adult cardiac arrest that optimized chest compressions and reduced disruptions increased the return of spontaneous circulation and survival to discharge in our patient population. These changes should be further evaluated for improving survival of out-of-hospital cardiac arrest patients.

LOE:6

Gunderson K, Kvaloy JT, Kramer-Johnson J, et al. (2009) Development of the probability of return of spontaneous circulation in intervals without chest compressions during out-of-hospital cardiac arrest: an observational study. BMC Med 6;7:6.

Abstract

BACKGROUND:

One of the factors that limits survival from out-of-hospital cardiac arrest is the interruption of chest compressions. During ventricular fibrillation and tachycardia the electrocardiogram reflects the probability of return of spontaneous circulation associated with defibrillation. We have used this in the current study to quantify in detail the effects of interrupting chest compressions.

METHODS:

From an electrocardiogram database we identified all intervals without chest compressions that followed an interval with compressions, and where the patients had ventricular fibrillation or tachycardia. By calculating the mean-slope (a predictor of the return of spontaneous circulation) of the electrocardiogram for each 2-second window, and using a linear mixed-effects statistical model, we quantified the decline of mean-slope with time. Further, a mapping from mean-slope to probability of return of spontaneous circulation was obtained from a second dataset and using this we were able to estimate the expected development of the probability of return of spontaneous circulation for cases at different levels.

RESULTS:

From 911 intervals without chest compressions, 5138 analysis windows were identified. The results show that cases with the probability of return of spontaneous circulation values 0.35, 0.1 and 0.05, 3 seconds into an interval in the mean will have probability of return of spontaneous circulation values 0.26 (0.24-0.29), 0.077 (0.070-0.085) and 0.040(0.036-0.045), respectively, 27 seconds into the interval (95% confidence intervals in parenthesis).

CONCLUSION:

During pre-shock pauses in chest compressions mean probability of return of spontaneous circulation decreases in a steady manner for cases at all initial levels. Regardless of initial level there is a relative decrease in the probability of return of spontaneous circulation of about 23% from 3 to 27 seconds into such a pause.

LOE:6

Kern B, Hilwig RW, Berg RA, et al. (2002). Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. Circulation 5;105(5):645-9.

Abstract

BACKGROUND:

Interruptions to chest compression-generated blood flow during cardiopulmonary resuscitation (CPR) are detrimental. Data show that such interruptions for mouth-to-mouth ventilation require a period of "rebuilding" of coronary perfusion pressure to obtain the level achieved before the interruption. Whether such hemodynamic compromise from pausing to ventilate is enough to affect outcome is unknown.

METHODS AND RESULTS:

Thirty swine (weight 35 +/- 2 kg) underwent 3 minutes of untreated ventricular fibrillation before 12 minutes of basic life support CPR. Animals were randomized to receive either standard airway (A), breathing (B), and compression (C) CPR with expired-gas ventilation in a 15:2 compression-to-ventilation ratio or continuous chest compression CPR. Those randomized to the standard 15:2 group had no chest compressions for a period of 16 seconds each time the 2 ventilations were delivered. Defibrillation was attempted at 15 minutes of cardiac arrest. All resuscitated animals were supported in an intensive care environment for 1 hour, then in a maintenance facility for 24 hours. The primary end point of neurologically normal 24-hour survival was significantly better in the experimental group receiving continuous chest compression CPR (12 of 15 versus 2 of 15; $P<0.0001$).

CONCLUSIONS:

Mouth-to-mouth ventilation performed by single layperson rescuers produces substantial interruptions in chest compression-supported circulation. Continuous chest compression CPR produces greater neurologically normal 24-hour survival than standard ABC CPR when performed in a clinically realistic fashion. Any technique that minimizes lengthy interruptions of chest compressions during the first 10 to 15 minutes of basic life support should be given serious consideration in future efforts to improve outcome results from cardiac arrest.

LOE:3

Kramer-Johanen J, Edelson DP, Abella BS, et al. (2007). Pauses in chest compression and inappropriate shocks: a comparison of manual and semi-automatic defibrillation attempts. Chest. 132(1):70-5.

Abstract

BACKGROUND:

We address the quality of chest compressions and the impact on initial defibrillation or initial chest compressions after sudden death.

METHODS:

Ventricular fibrillation was induced by occlusion of the left anterior descending coronary artery in 24 domestic pigs with a mean (+/- SD) weight of 40 +/- 2 kg. Cardiac arrest was left untreated for 5 min. Animals were then randomized to receive chest compressions-first or defibrillation-first and were further randomized to "optimal" or "conventional" chest compressions. A total of four groups of animals were investigated using a factorial design. For optimal chest compressions, the anterior posterior diameter of the chest was reduced by 25%, representing approximately 6 cm. Only 70% of this depth, or approximately 4.2 cm, represented conventional chest compressions. Chest compressions were delivered with a mechanical chest compressor. Defibrillation was attempted with a single biphasic 150-J shock. Postresuscitation myocardial function was echocardiographically assessed.

RESULTS:

Coronary perfusion pressures and end-tidal Pco(2) were significantly lower with conventional chest compressions. With optimal chest compressions, either as an initial intervention or after defibrillation, each animal was successfully resuscitated. Fewer shocks were required prior to the return of spontaneous circulation after initial optimal chest compressions. No animals were resuscitated when conventional chest compressions preceded the defibrillation attempt. When defibrillation was attempted as the initial intervention followed by conventional chest compressions, two of six animals were resuscitated.

CONCLUSIONS:

In this animal model of cardiac arrest, it was the quality of the chest compressions, rather then the priority of either initial defibrillation or initial chest compressions, that was the predominant determinant of successful resuscitation.

LOE:6

Krarup NH, Terkelsen CJ, Johnsen SP, et al. (2011). "Quality of cardiopulmonary resuscitation in out-of-hospital arrest is hampered by interruptions in chest compressions—a nationwide feasibility study." Resuscitation 82(3):263-9.

Abstract

AIM OF THE STUDY:

Quality of cardiopulmonary resuscitation (CPR) is a critical determinant of outcome following out-of-hospital cardiac arrest. The aim of our study was to evaluate the quality of CPR provided by emergency medical service providers (Basic Life Support (BLS) capability) and emergency medical service providers assisted by paramedics, nurse anesthetists or physician-manned ambulances (Advanced Life Support (ALS) capability) in a nationwide, unselected cohort of out-of-hospital cardiac arrest cases.

METHODS:

We conducted a prospective, observational study of out-of-hospital cardiac arrest with non-traumatic etiology (>18 years of age) occurring from the 1st to the 31st of January 2009 and treated by the primary Danish emergency medical service operator, covering approximately 85% of the population. One hundred and ninety-one cases were eligible for analysis. Follow-up was up to one year or death. Quality of CPR was evaluated using measurements of transthoracic impedance.

RESULTS:

The majority of patients were treated by ambulances with ALS capability (54%). Interruptions in CPR related to loading of the patient into the emergency medical service vehicle were substantial, but independent of whether patients were managed by ALS or BLS capable units (222s versus 224s, P = 0.76) as were duration of interruptions during rhythm analysis alone (20s versus 22s, P = 0.33) and defibrillation (24s versus 26s, P = 0.07).

CONCLUSIONS:

Nationwide, routine monitoring of transthoracic impedance is feasible. CPR is hampered by extended interruptions, particularly during loading of the patient into the emergency medical service vehicle, rhythm analysis and defibrillation.

LOE:6

Li Y, Yu T, Ristagno G, et al. (2010) The optimal phasic relationship between synchronized shock and mechanical chest compressions. Resuscitation 81(6):724-9

Abstract

OBJECTIVE:

Pauses for shock delivery in chest compressions are detrimental to the success of resuscitation and may be eliminated with the use of mechanical chest compressors. However, the optimal phasic relationship between mechanical chest compression and defibrillation is still unknown. We therefore undertook a study to assess the effects of timing of defibrillation in the mechanical chest compression cycle on the defibrillation threshold (DFT) using a porcine model of cardiac arrest.

METHODS:

Ventricular fibrillation was electrically induced and untreated for 10s in 8 domestic pigs weighing between 26 and 30 kg. Mechanical chest compression was then continuously performed for 25s, followed by a biphasic electrical shock which was delivered to the animal at 6 randomized coupling phases, including a control phase, with a pre-determined energy setting. The control phase was chosen at a constant 2s following discontinued chest compression. A novel grouped up-and-down DFT testing protocol was used to compare the success rate at different coupling phases. After a recovery interval of 4 min, the testing sequence was repeated, resulting in a total of 60 test shocks delivered to each animal.

RESULTS:

No difference between the delivered shock energy, voltage and current were observed among the 6 study phases. The defibrillation success rate, however, was significantly higher when shocks were delivered in the upstroke phase of mechanical chest compression.

CONCLUSION:

Defibrillation efficacy is maximal when electrical shock is delivered in the upstroke phase of mechanical chest compression.

LOE:3

Meier P, Baker P, Jost D. (2010) Chest compressions before defibrillation for out-of-hospital cardiac arrest: a meta-analysis of randomized controlled clinical trials. BMC Med 9;8:52.

Abstract

BACKGROUND:

Current 2005 guidelines for advanced cardiac life support strongly recommend immediate defibrillation for out-of-hospital cardiac arrest. However, findings from experimental and clinical studies have indicated a potential advantage of pretreatment with chest compression-only cardiopulmonary resuscitation (CPR) prior to defibrillation in improving outcomes. The aim of this meta-analysis is to evaluate the beneficial effect of chest compression-first versus defibrillation-first on survival in patients with out-of-hospital cardiac arrest.

METHODS:

Main outcome measures were survival to hospital discharge (primary endpoint), return of spontaneous circulation (ROSC), neurologic outcome and long-term survival. Randomized, controlled clinical trials that were published between January 1, 1950, and June 19, 2010, were identified by a computerized search using SCOPUS, MEDLINE, BIOS, EMBASE, the Cochrane Central Register of Controlled Trials, International Pharmaceutical Abstracts database, and Web of Science and supplemented by conference proceedings. Random effects models were used to calculate pooled odds ratios (ORs). A subgroup analysis was conducted to explore the effects of response interval greater than 5 min on outcomes.

RESULTS:

A total of four trials enrolling 1503 subjects were integrated into this analysis. No difference was found between chest compression-first versus defibrillation-first in the rate of return of spontaneous circulation (OR 1.01 [0.82-1.26]; P = 0.979), survival to hospital discharge (OR 1.10 [0.70-1.70]; P = 0.686) or favorable

neurologic outcomes (OR 1.02 [0.31-3.38]; P = 0.979). For 1-year survival, however, the OR point estimates favored chest compression first (OR 1.38 [0.95-2.02]; P = 0.092) but the 95% CI crossed 1.0, suggesting insufficient estimate precision. Similarly, for cases with prolonged response times (> 5 min) point estimates pointed toward superiority of chest compression first (OR 1.45 [0.66-3.20]; P = 0.353), but the 95% CI again crossed 1.0.

CONCLUSIONS:

Current evidence does not support the notion that chest compression first prior to defibrillation improves the outcome of patients in out-of-hospital cardiac arrest. It appears that both treatments are equivalent. However, subgroup analyses indicate that chest compression first may be beneficial for cardiac arrests with a prolonged response time

LOE:6

Ristango G, Tang W, Russell JK, et al. (2008). Minimal interruption of cardiopulmonary resuscitation for a single shock as mandated by automated external defibrillations does not compromise outcomes in a porcine model of cardiac arrest and resuscitation. Crit Care Med 36(11):3048-53.

Abstract

OBJECTIVES:

Current automated external defibrillations require interruptions in chest compressions to avoid artifacts during electrocardiographic analyses and to minimize the risk of accidental delivery of an electric shock to the rescuer. The earlier three-shock algorithm, with prolonged interruptions of chest compressions, compromised outcomes and increased severity of post-resuscitation myocardial dysfunction. In the present study, we investigated the effect of timing of minimal automated external defibrillation-mandated interruptions of chest compressions on cardiopulmonary resuscitation outcomes, using a single-shock algorithm. We hypothesized that an 8-sec interruption of chest compressions for a single shock, as mandated by automated external defibrillations, would not impair initial resuscitation and outcomes of cardiopulmonary resuscitation.

DESIGN:

Randomized prospective animal study.

SETTING:

University affiliated research laboratory.

SUBJECTS:

Domestic pigs.

MEASUREMENTS AND MAIN RESULTS:

In 24 domestic male pigs weighing 41 +/- 2 kg, ventricular fibrillation was induced by left anterior descending coronary artery occlusion and untreated for 7 min. Cardiopulmonary resuscitation, including chest compressions and ventilation with oxygen, was then performed for an interval of 2 min before attempted defibrillation. Animals were randomized into three groups: A) interruption immediately before defibrillation; B) interruption after 1 min of cardiopulmonary resuscitation; or C) no interruption. Chest compressions were delivered with the aid of a mechanical chest compressor at a rate of 100 compressions/min and compression/ventilation ratio of 30:2. Defibrillation was attempted with a single biphasic 150-J shock. Each animal was successfully resuscitated and survived for >72 hr. No differences in the number of shocks before return of spontaneous circulation, frequency of recurrent ventricular fibrillation, duration of cardiopulmonary resuscitation, and severity of postresuscitation myocardial dysfunction were observed.

CONCLUSIONS:

In this experimental model of cardiac arrest and cardiopulmonary resuscitation, minimal automated external defibrillation-mandated interruption of chest compressions for a single-shock algorithm did not have adverse effects on postresuscitation myocardial or neurologic function. All animals, whether subjected to cardiopulmonary resuscitation interruptions or not, survived.

LOE:3

Roessler B, Fleischhackl R, Losert H, et al. (2009). Reduced hands-off-time to first shock in CPR according to the ERC Guidelines in 2005. Resuscitation 80(1):104-8.

Abstract

BACKGROUND AND AIM:

Chest compressions and early defibrillation are crucial in cardiopulmonary resuscitation (CPR). The Guidelines 2005 brought major changes to the basic life support and automated external defibrillator (BLS-AED) algorithm. We compared the European Resuscitation Council's Guidelines 2000 (group '00) and 2005 (group '05) on hands-off-time (HOT) and time to first shock (TTFS) in an experimental model.

METHODS:

In a randomised, cross-over design, volunteers were assessed in performing BLS-AED over a period of 5min on a manikin in a simulated ventricular fibrillation cardiac arrest situation. Ten minutes of standardised teaching and 10min of training including corrective feedback were allocated for each of the guidelines before evaluation. HOT was chosen as the primary and TTFS as the secondary outcome parameter.

RESULTS:

Forty participants were enrolled; one participant dropped out after group allocation. During the 5-min evaluation period of adult BLS-AED, HOT was significantly ($p<0.001$) longer in group '00 [273+/-3s (mean+/-standard error)] than in group '05 (188+/-3s). The TTFS was significantly ($p<0.001$) longer in group '00 (91+/-3s) than in group '05 (71+/-3s).

CONCLUSION:

In this manikin setting, HOT and TTFS improved with BLS-AED performed according to Guidelines 2005.

LOE:6

Steen S, Liao Q, Pierre L, et al. (2003). The critical importance of minimal delay between chest compressions and subsequent defibrillation: a hemodynamic explanation. Resuscitation 58(3):249-58.

Abstract

Outcome after prehospital defibrillation remains dire. The aim of the present study was to elucidate the pathophysiology of cardiac arrest and to suggest ways to improve outcome. Ventricular fibrillation (VF) was induced in air-ventilated pigs, after which ventilation was withdrawn. After 6.5 min of VF, ventilation with

100% oxygen was initiated. In six pigs (group I), defibrillation was the only treatment carried out. In another six pigs (group II), mechanical chest compression-decompression CPR (mCPR) was carried out for 3.5 min followed by a 40-s hands-off period before defibrillation. If unsuccessful, mCPR was resumed for a further 30 s before a second or a third, 40-s delayed, shock was given. In a final six pigs (group III) mCPR was applied for 3.5 min after which up to three shocks (if needed) were given during on-going mCPR. Return of spontaneous circulation (ROSC) occurred in none of the pigs in group I (0%), in 1 of six pigs in group II (17%) and in five of six pigs in group III (83%). During the first 3 min of VF arterial blood was transported to the venous circulation, with the consequence that the left ventricle emptied and the right ventricle became greatly distended. It took 2 min of mCPR to establish an adequate coronary perfusion pressure, which was lost when the mCPR was interrupted. During 30 s of mCPR coronary perfusion pressure was negative, but a carotid flow of about 25% of basal value was obtained. In this pig model, VF caused venous congestion, an empty left heart, and a greatly distended right heart within 3 min. Adequate heart massage before and during defibrillation greatly improved the likelihood of return of spontaneous circulation (ROSC).

LOE:3

Sutton RM, Maltese MR, Niles D, et al. (2009). "Quantitative analysis of chest compression interruptions during in-hospital resuscitation of older children and adolescents. Resuscitation 80(11):1259-63.

AIM:

To quantitatively describe pauses in chest compression (CC) delivery during resuscitation from in-hospital pediatric and adolescent cardiac arrest. We hypothesized that CPR error will be more likely after a chest compression provider change compared to other causes for pauses.

METHODS:

CPR recording/feedback defibrillators were used to evaluate CPR quality for victims >/=8 years who received CPR in the PICU/ED. Audiovisual feedback was supplied in accordance with AHA targets. Etiology of CC pauses identified by post-event debriefing/reviews of stored CPR quality data.

RESULTS:

Analysis yielded 205 pauses during 304.8 min of CPR from 20 consecutive cardiac arrests. Etiologies were: 57.1% for provider switch; 23.9% for pulse/rhythm analysis; 4.4% for defibrillation; and 14.6% "other." Provider switch accounted for 41.2% of no-flow duration. Compared to other causes, CPR epochs following pauses due to provider switch were more likely to have measurable residual leaning (OR: 5.52; CI(95): 2.94, 10.32; p<0.001) and were shallower (43+/-8 vs. 46+/-7 mm; mean difference: -2.42 mm; CI(95): -4.71, -0.13; p=0.04). Individuals performing continuous CPR>or=120 s as compared to those switching earlier performed deeper chest compressions (42+/-6 vs. 38+/-7 mm; mean difference: 4.44 mm; CI(95): 2.39, 6.49; p<0.001) and were more compliant with guideline depth recommendations (OR: 5.11; CI(95): 1.67, 15.66; p=0.004).

CONCLUSIONS:

Provider switches account for a significant portion of no-flow time. Measurable residual leaning is more likely after provider switch. Feedback systems may allow some providers to continue high quality CPR past the recommended switch time of 2 min during in-hospital resuscitation attempts.

LOE:6

Valenzuela TD, Kern KB, Clark LL, et al. (2005). Interruptions in chest compressions during emergency medical systems resuscitation. Circulation 30;112(9):1259-65.

Abstract

BACKGROUND:

Survival after nontraumatic out-of-hospital (OOH) cardiac arrest in Tucson, Arizona, has been flat at 6% (121/2177) for the decade 1992 to 2001. We hypothesized that interruptions of chest compressions occur commonly and for substantial periods during treatment of OOH cardiac arrest and could be contributing to the lack of improvement in resuscitation outcome.

METHODS AND RESULTS:

Sixty-one adult OOH cardiac arrest patients treated by automated external defibrillator (AED)-equipped Tucson Fire Department first responders from November 2001 through November 2002 were retrospectively reviewed. Reviews were performed according to the code arrest record and verified with the AED printout. Validation of the methodology for determining the performance of chest compressions was done post hoc. The

median time from "9-1-1" call receipt to arrival at the patient's side was 6 minutes, 27 seconds (interquartile range [IQR, 25% to 75%], 5 minutes, 24 seconds, to 7 minutes, 34 seconds). An additional 54 seconds (IQR, 38 to 74 seconds) was noted between arrival and the first defibrillation attempt. Initial defibrillation shocks never restored a perfusing rhythm (0/21). Chest compressions were performed only 43% of the time during the resuscitation effort. Although attempting to follow the 2000 guidelines for cardiopulmonary resuscitation, chest compressions were delayed or interrupted repeatedly throughout the resuscitation effort. Survival to hospital discharge was 7%, not different from that of our historical control (4/61 versus 121/2177; P=0.74).

CONCLUSIONS:

Frequent interruption of chest compressions results in no circulatory support during more than half of resuscitation efforts. Such interruptions could be a major contributing factor to the continued poor outcome seen with OOH cardiac arrest.

LOE:6

Waldrop JE, Rozanski EA, Swanke ED, et al. (2004). "Causes of cardiopulmonary arrest, resuscitation management, and functional outcome in dogs and cats surviving cardiopulmonary arrest." J Vet Emerg Crit Care 14(1):22-29.

Abstract

Objective: To describe the functional outcome of canine and feline survivors of cardiopulmonary arrest (CPA) and the clinical characteristics surrounding their resuscitation.

Design: Retrospective study.

Setting: Veterinary teaching hospital.

Animals: Client-owned dogs (15) and cats (3) with CPA.

Interventions: None.

Measurements and main results: Eighteen animals were identified to have survived to discharge following CPA. Cardiopulmonary arrest was associated with anesthesia with or without pre-existing disease in 10 animals, cardiovascular collapse in 5 animals, and chronic disease with an imposed stress in 3 animals. All CPAs were witnessed in the hospital. The most common initial rhythm at CPA was asystole (72%). Return of spontaneous circulation (ROSC) was achieved in less than 15 minutes from the onset of cardiopulmonary cerebral resuscitation (CPCR) in all animals. No animals had a recurrence of CPA after the initial CPA.

Animals were of a wide range of ages (0.5–16 years) and breeds. Two animals were neurologically abnormal at discharge, one of which was normal at 2 months following CPA.

Conclusions: A good functional recovery after CPCR was documented in the small number of CPA survivors presented in this study. This may be due to the reversible nature of their inciting cause of CPA, early detections of CPA ('witnessed'), and/or the animal's underlying normal health status.

LOE:4

Wang YL, Zhong JQ, Tao W, et al. (2009). Initial defibrillation versus initial chest compression in a 4-minute ventricular fibrillation canine model of cardiac arrest. Crit Care Med 37(7):2250-2.

Abstract

OBJECTIVE:

Previous laboratory and clinical studies have demonstrated that chest compression preceding defibrillation in prolonged ventricular fibrillation (VF) increases the likelihood of successful cardiac resuscitation. The lower limit of VF duration when preshock chest compression provides no benefit has not been specifically studied. We aimed to study the effect of order of defibrillation and chest compression on defibrillation and cardiac resuscitation in a 4-minute VF canine model of cardiac arrest.

DESIGN:

Prospective, randomized animal study.

SETTING:

Key Laboratory of Cardiovascular Remodeling and Function Research and Department of Cardiology, QiLu Hospital.

SUBJECTS:

Twenty-four domestic dogs.

INTERVENTIONS:

VF was induced in anesthetized and ventilated canines. After 4 minutes of untreated VF, animals were randomly assigned to receive shock first or chest compression first. Animals in the shock-first group received an immediate single countershock of 360 J for <10 seconds, then 200 immediate compressions before pulse check or rhythm reanalysis. The ratio of compression to ventilation was 30:2. Interruptions to deliver rescue breaths were eliminated in this study. Animals in the chest compression-first group received 200 chest compressions before a single countershock; the other interventions were the same as for the shock-first group. End points were restoration of spontaneous circulation (ROSC), defined as spontaneous systolic arterial pressure >50 mm Hg, when epinephrine (0.02 mg/kg intravenously) was given, and resuscitation, defined as maintaining systolic arterial pressure >50 mm Hg at the 24-hour study end point.

MEASUREMENTS AND MAIN RESULTS:

In the shock-first group, all animals achieved ROSC, and ten of 12 survived at the 24-hour study end point. In the chest compression-first group, 11 of 12 animals achieved ROSC, and nine of 12 survived at the 24-hour study end point.

CONCLUSIONS:

In this 4-minute VF canine model of cardiac arrest, the order of initial defibrillation or initial chest compression does not affect cardiac resuscitation.

LOE:3

Wingfield WE, VanPelt DR. (1992). "Respiratory and cardiopulmonary arrest in dogs and cats:256 cases (1986-1991)." J Am Vet Med Assoc 200(12):1993-1996.

Summary: Outcomes of cardiopulmonary arrest and resuscitation in clinically affected dogs and cats have not been adequately studied. We examined the records from 200 dogs and 65 cats that had received cardiopulmonary resuscitation for respiratory or cardiopulmonary arrest; none of the animals had been anesthetized or intubated at the time of arrest, and all had been hospitalized in a veterinary critical care facility. Cardiopulmonary arrest was found to be more common that respiratory arrest in dogs and cats. Hospital discharge rates for animals with cardiopulmonary arrest ranged from 4.1% for dogs to 9.6% for cats, and were consistent with those reported from studies of human beings with cardiopulmonary arrest. Hospital discharge rates for dogs and cats with respiratory arrest were 28% and 58.3%, respectively.

LOE:4