WORKSHEET for PROPOSED Evidence-Based GUIDELINE RECOMMENDATIONS

Worksheet Author:	Taskforce/Subcommittee: XBLS __ACLS __PEDS __ID __PROAD __Other:
Author's Home Resuscitation Council: XAHA __ANZCOR __CLAR __ERC __HSFC __HSFC __RCSA ___IAHF ___Other:	Date Submitted to Subcommittee: 09/25/2004; revised 12/3/04 & 12/18/04

STEP 1: STATE THE PROPOSAL. State if this is a proposed new guideline; revision to current guideline; or deletion of current guideline.

Existing guideline, practice or training activity, or new guideline:

Existing guideline: Mechanical devices that depress the sternum are not a substitute for manual external chest compression but rather an adjunct to be used by trained personnel to optimize compression and reduce rescuer fatigue in prolonged resuscitative efforts. There is no consistent measurable improvement in hemodynamics and no observed survival outcome data showing that mechanical resuscitators similar to mechanical chest compressors are superior to standard CPR. The mechanical resuscitator is an acceptable alternative to standard manual CPR in circumstances that make manual chest compressions difficult, ie, certain transport situations or lack of adequate personnel (Class IIb).

Step 1A: Refine the question; state the question as a positive (or negative) hypothesis. State proposed guideline recommendation as a specific, positive hypothesis. Use single sentence if possible. Include type of patients; setting (in- /out-of-hospital); specific interventions (dose, route); specific outcomes (ROSC vs. hospital discharge).

The mechanical resuscitator (Thumper) is an acceptable alternative to standard manual CPR in circumstances that make manual chest compressions difficult, (eg, certain transport situations or lack of adequate personnel).

Step 1B: Gather the Evidence; define your search strategy. Describe search results; describe best sources for evidence.

Key words - Mechanical, Thumper, piston, compression, CPR, Resuscitation, Cardiopulmonary resuscitation

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.

Medline, Cochrane, AHA EndNote Library, Embase and manual reference review of published manuscripts.

- State major criteria you used to limit your search; state inclusion or exclusion criteria (e.g., only human studies with control group? no animal studies? N subjects > minimal number? type of methodology? peer-reviewed manuscripts only? no abstract-only studies?)

Searched human and animal studies published in peer-reviewed literature, excluded abstract-only studies.

- Number of articles/sources meeting criteria for further review: Create a citation marker for each study (use the author initials and date or Arabic numeral, e.g., "Cummins-1"). If possible, please supply file of best references; EndNote 6+ required as reference manager using the ECC reference library.

12 articles met criteria for further review

STEP 2: ASSESS THE QUALITY OF EACH STUDY

Step 2A: Determine the Level of Evidence. For each article/source from step 1, assign a level of evidence—based on study design and methodology.

Level of Evidence	Definitions (See manuscript for full details)
Level 1	Randomized clinical trials or meta-analyses of multiple clinical trials with substantial treatment effects
Level 2	Randomized clinical trials with smaller or less significant treatment effects
Level 3	Prospective, controlled, non-randomized, cohort studies
Level 4	Historic, non-randomized, cohort or case-control studies
Level 5	Case series: patients compiled in serial fashion, lacking a control group
Level 6	Animal studies or mechanical model studies
Level 7	Extrapolations from existing data collected for other purposes, theoretical analyses
Level 8	Rational conjecture (common sense); common practices accepted before evidence-based guidelines

Step 2B: Critically assess each article/source in terms of research design and methods.
Was the study well executed? Suggested criteria appear in the table below. Assess design and methods and provide an overall rating. Ratings apply within each Level; a Level 1 study can be excellent or poor as a clinical trial, just as a Level 6 study could be excellent or poor as an animal study. Where applicable, please use a superscripted code (shown below) to categorize the primary endpoint of each study. For more detailed explanations please see attached assessment form.

Component of Study and Rating	Excellent	Good	Fair	*Poor*	*Unsatisfactory*
Design & **Methods**	Highly appropriate sample or model, randomized, proper controls **AND** Outstanding accuracy, precision, and data collection in its class	Highly appropriate sample or model, randomized, proper controls **OR** Outstanding accuracy, precision, and data collection in its class	Adequate, design, but possibly biased **OR** Adequate under the circumstances	*Small or clearly biased population or model* ***OR*** *Weakly defensible in its class, limited data or measures*	*Anecdotal, no controls, off target end-points* ***OR*** *Not defensible in its class, insufficient data or measures*

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

Step 2C: Determine the <u>direction</u> of the results and the statistics: supportive? neutral? opposed?

DIRECTION of study by results & statistics:	SUPPORT the proposal	NEUTRAL	OPPOSE the proposal
Results	Outcome of proposed guideline superior, to a clinically important degree, to current approaches	Outcome of proposed guideline no different from current approach	Outcome of proposed guideline inferior to current approach

Step 2D: Cross-tabulate assessed studies by a) *level*, b) *quality* and c) *direction* (ie, supporting or neutral/ opposing); combine and summarize. **Exclude the *Poor* and *Unsatisfactory* studies. Sort the *Excellent, Good,* and *Fair* quality studies by both *Level and Quality of evidence,* and *Direction of support* in the summary grids below. Use citation marker (e.g. author/ date/source). In the *Neutral* or *Opposing* grid use bold font for *Opposing* studies to distinguish them from merely neutral studies. Where applicable, please use a superscripted code (shown below) to categorize the primary endpoint of each study.**

Supporting Evidence

The mechanical resuscitator (Thumper) is an acceptable alternative to standard manual CPR in circumstances that make manual chest compressions difficult, (eg, certain transport situations or lack of adequate personnel)

Quality of Evidence									
	Excellent						Wik, 1996 # 11[D]		
	Good		Taylor, 1978 # 9[C] Dickinson , 1998 # 2[B]				Sunde , 1997 # 8[E]		

	Fair		Ward, 1993 # 10[E]			McDonald, 1981 # 5[E] McDonald, 1982 # 6E	Barsan, 1978 # 1[E] Raessler, 1988 # 7[B]		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Level of Evidence							

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

Neutral or Opposing Evidence

The mechanical resuscitator (Thumper) is an acceptable alternative to standard manual CPR in circumstances that make manual chest compressions difficult, (eg, certain transport situations or lack of adequate personnel).

Quality of Evidence	**Excellent**								
	Good								
	Fair					Young, 1983 # 12[E]	Kern, 1985 # 3[D] Kern, 1987 # 4[D]		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Level of Evidence							

A = Return of spontaneous circulation
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E = Other endpoint

REVIEWER'S PERSPECTIVE AND POTENTIAL CONFLICTS OF INTEREST: Briefly summarize your professional background, clinical specialty, research training, AHA experience, or other relevant personal background that define your perspective on the guideline proposal. List any potential conflicts of interest involving consulting, compensation, or equity positions related to drugs, devices, or entities impacted by the guideline proposal. Disclose any research funding from involved companies or interest groups. State any relevant philosophical, religious, or cultural beliefs or longstanding disagreements with an individual.

Assistant Professor of Emergency Medicine at University of Texas Southwestern Dallas and Parkland Hospital. No conflict of interest.

REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK: Summarize your final evidence integration and the rationale for the class of recommendation. Describe any mismatches between the evidence and your final Class of Recommendation. "Mismatches" refer to selection of a class of recommendation that is heavily influenced by other factors than just the evidence. For example, the evidence is strong, but implementation is difficult or expensive; evidence weak, but future definitive evidence is unlikely to be obtained. Comment on contribution of animal or mechanical model studies to your final recommendation. Are results within animal studies homogeneous? Are animal results consistent with results from human studies? What is the frequency of adverse events? What is the possibility of harm? Describe any value or utility judgments you may have made, separate from the evidence. For example, you believe evidence-supported interventions should be limited to in-hospital use because you think proper use is too difficult for pre-hospital providers. Please include relevant key figures or tables to support your assessment.

(There are no new published studies since the last guidelines.)

Automated mechanical devices such as the Thumper that depress the sternum by means of a compressed gas-powered plunger mounted on a backboard are not a substitute for manual external chest compression. They are rather an adjunct to be used by trained personnel to optimize compression, allow the rescuer to perform other tasks, and reduce rescuer fatigue in prolonged resuscitative efforts.

The devices can be programmed to deliver standard CPR in a compression-ventilation ratio of 5:1, with a compression duration that is 50% of the cycle length, or other ratios. Most animal and clinical studies have shown variable hemodynamic results compared with other CPR techniques (standard, ACD, and SVC CPR). Results of the 2 most recent clinical trials both showed improved expired end-tidal CO_2 compared with standard manual CPR. The limited clinical data has thus far shown no improvement in survival outcome when mechanical CPR was compared with standard CPR in patients with cardiac arrest. (LOE 2)

Specific studies reviewed include:

Barsan, 1978 # 1 – No significant difference in hemodynamic parameters between standard and mechanical CPR in dogs.

Dickinson , 1998 # 2 – Thumper CPR produced higher $ETCO_2$ values than did manual CPR, however there was no difference in survival.

Kern, 1985 # 3 – All endpoints (hemodynamic, survival and neurological) were similar between the standard and the mechanical CPR groups.

Kern, 1987 # 4 – All endpoints (hemodynamic, survival and neurological) were similar between the standard and the mechanical CPR groups.

McDonald, 1981 # 5 - Chest compression by a mechanical device produces higher mean arterial pressures in humans that have undergone > 30 minutes of resuscitation compared with manual CPR.

McDonald, 1982 # 6 - Chest compression by a mechanical device produces higher mean arterial pressures in humans that have undergone > 30 minutes of resuscitation compared with manual CPR.

Raessler, 1988 # 7 - Hemodynamics, ROSC and 24-hour survival were similar between large dogs receiving both standard and Thumper CPR.

Sunde , 1997 #8 –Compression rates are more consistent on mannequins during transport with mechanical CPR than with manual CPR, but there are some inherent delays with mechanical CPR due to the time needed to apply the device.

Taylor, 1978 # 9 – No difference in short term or long term survival in humans. No difference in overall complications.

Ward, 1993 # 10 – Human patients who experienced a long trial of unsuccessful standard resuscitation show a higher mean $PETCO_2$ with mechanical compressions than with manual compressions.

Wik, 1996 # 11 – Mechanical chest compressions in canine VF model provided improved hemodynamics compared with manual compressions, but survival rates and neurologic outcomes were the same.

Young, 1983, # 12 – Three case reports of patients suffering from esophageal rupture after receiving Thumper CPR with an esophageal obturator airway in place.

The efficacy and safety of these devices have not been demonstrated in infants and children; there use should be limited to adults.

Problems and complications related to the use of automatic mechanical chest compressors include sternal fracture, esophageal rupture, expense, size, weight, restrictions on mobility, and dislocation of the plunger in relation to the sternum. (LOE 5)

Ventilation or chest compression, or both, may be inadequate when these devices are improperly positioned or operated.

In addition, the weight of the compressor on the chest may limit chest wall recoil and venous return during decompression.

Summary Comments

The mechanical resuscitator is an acceptable alternative to standard manual CPR in circumstances that make manual chest compressions difficult (e.g., certain transport situations or lack of adequate personnel). (LOE 2, 5, 6).

There is no human data showing consistent improvement in either hemodynamics or survival when comparing mechanical versus standard CPR. (LOE 2, 5).

Proposed Consensus on Science Recommendations

Based on three LOE 2 studies, two LOE 5 studies, and six LOE 6 studies there is no consistent measurable improvement in hemodynamics and no observed survival outcome data showing that automated mechanical chest compressors are superior to standard CPR.

Proposed Consensus Treatment Recommendations

Automated mechanical devices such as the Thumper that depress the sternum by means of a compressed gas-powered plunger mounted on a backboard have not been proven to be a superior substitute for manual external chest compression. They are rather an adjunct to be used by trained personnel to optimize chest compression during transport, allow the rescuer to perform other tasks, and reduce rescuer fatigue in prolonged resuscitative efforts. (LOE 2, 5, 6)

Preliminary draft/outline/bullet points of Guidelines revision: Include points you think are important for inclusion by the person assigned to write this section. Use extra pages if necessary.

Citation List

Citation Marker	Full Citation*
Barsan, 1981 #1	Barsan, W. G. and R. C. Levy (1981). "Experimental design for study of cardiopulmonary resuscitation in dogs." Ann Emerg Med **10**(3): 135-7. Many different designs for studies of various aspects of cardiopulmonary resuscitation (CPR) in dogs are described in the literature. No single technique is generally accepted. We present a systematized approach to the study of CPR in the canine model. Cardiac output, arterial blood pressure, and electrocardiogram were recorded for three different methods. The methods studied were closed chest compression, closed chest compression with an automatic gas-powered chest compressor, and open chest manual cardiac massage. Cardiac output for both types of external chest compression were less than 17% of control in all cases. With open chest cardiac massage, systemic arterial blood pressures were in the 50 mm Hg to 100 mm Hg range and cardiac output of up to 70% of control was achieved. Using a metronome to obtain compression rate and the arterial blood pressure to guide the efficacy of compression, consistent levels of cardiac output could be achieved for up to 30 minutes using open chest cardiac massage. Closed chest massage in man results in a cardiac output of 25% to 30% of normal when performed under optimal conditions. A cardiac output of 25% to 30% of control cannot be achieved in large dogs with external chest compression, and hence is not a good model to stimulate CPR in man. *LOE 6, Good Quality, Supportive*
Dickinson, 1998 #2	Dickinson, E. T., V. P. Verdile, et al. (1998). "Effectiveness of mechanical versus manual chest compressions in out-of-hospital cardiac arrest resuscitation: a pilot study." Am J Emerg Med **16**(3): 289-92. A prospective, randomized effectiveness trial was undertaken to compare mechanical versus manual chest compressions as measured by end-tidal CO2 (ETCO2) in out-of-hospital cardiac arrest patients receiving advanced cardiac life support (ACLS) resuscitation from a municipal third-service, emergency medical services (EMS) agency. The EMS agency responds to approximately 6,700 emergencies annually, 79 of which were cardiac arrests in 1994, the study year. Following endotracheal intubation, all cardiac arrest patients were placed on 100% oxygen via the ventilator circuit of the mechanical cardiopulmonary resuscitation (CPR) device. Patients were randomized to receive mechanical CPR (TCPR) or human/manual CPR (HCPR) based on an odd/even day basis, with TCPR being performed on odd days. ETCO2 readings were obtained 5 minutes after the initiation of either TCPR or HCPR and again at the initiation of patient transport to the hospital. All patients received standard ACLS pharmacotherapy during the monitoring interval with the exception of sodium bicarbonate. CPR was continued until the patient was delivered to the hospital emergency department. Age, call response interval, initial electrocardiogram (ECG) rhythm, scene time, ETCO2 measurements, and arrest outcome were identified for all patients. Twenty

	patients were entered into the study, with 10 in each treatment group. Three patients in the TCPR group were excluded. Measurements in the HCPR group revealed a decreasing ETCO2 during the resuscitation in 8 of 10 patients (80%) and an increasing ETCO2 in the remaining 2 patients. No decrease in ETCO2 was noted in the TCPR group, with 4 of 7 patients (57%) actually showing an increased reading and 3 of 7 patients (43%) showing a constant ETCO2 reading. The differences in the ETCO2 measurements between TCPR and HCPR groups were statistically significant. Both groups were similar with regards to call response intervals, patient ages, scene times, and initial ECG rhythms. One patient in the TCPR group was admitted to the hospital but later died, leaving no survivors in the study. TCPR appears to be superior to standard HCPR as measured by ETCO2 in maintaining cardiac output during ACLS resuscitation of out-of-hospital cardiac arrest patients. *LOE 2, Good Quality, Supportive*
Kern, 1985 #3	Kern, K. B., A. B. Carter, et al. (1985). "Manual versus mechanical cardiopulmonary resuscitation in an experimental canine model." Crit Care Med **13**(11): 899-903. Manual and mechanical chest compressions during CPR were compared in the canine model. Endpoints were hemodynamics produced during CPR, resuscitation success at 30 min, 24-h survival, neurologic function of survivors, and CPR-produced trauma. Ten animals in each group underwent 20 min of ventricular fibrillation, during which CPR was performed for 17 min. Hemodynamics produced with manual and mechanical chest compressions were similar. Seven of ten animals in each group were resuscitated. Five animals from the manual group and four animals from the mechanical group survived for 24 h. Neurologic function of survivors was excellent and similar in each group. There was no significant difference in trauma between the two types of chest compression. The similar results for manual and mechanical chest compression in this canine model suggest that different experimental CPR studies can be compared regardless or whether manual or mechanical chest compressions were performed. *LOE 6, Fair Quality, Neutral*
Kern, 1987 #4	Kern, K. B., A. B. Carter, et al. (1987). "Comparison of mechanical techniques of cardiopulmonary resuscitation: survival and neurologic outcome in dogs." Am J Emerg Med **5**(3): 190-5. Three currently available mechanical devices for cardiopulmonary resuscitation (CPR) were compared using a canine cardiac arrest model. Twenty-four-hour survival without neurologic deficit was the goal. A group of 30 large mongrel dogs was divided equally among Thumper CPR, simultaneous compression and ventilation (SCV) CPR, and vest CPR. Ventricular fibrillation was induced electrically, and after 3 minutes of no intervention, one of the three types of mechanical CPR was performed for 17 minutes. SCV CPR and vest CPR produced significantly greater aortic and right atrial systolic pressures than Thumper CPR (P less than .03). The SCV CPR technique also produced significantly higher aortic diastolic pressure and right atrial diastolic pressure than either of the other methods (P less than .03). However, coronary perfusion pressure was not different among the three mechanical methods. No differences in immediate resuscitation, 24-hour survival, or neurologic deficit scores at 24 hours were found. Neither SCV nor the vest techniques of CPR appear better for survival or neurologic outcome than standard cardiopulmonary resuscitation performed with the Thumper. *LOE 6, Fair Quality, Neutral*
McDonald, 1981 #5	McDonald, J. L. (1981). "Systolic and mean arterial pressures during manual and mechanical CPR in humans." Crit Care Med **9**(5): 382-383. There was no abstract with this paper. *LOE 5, Fair Quality, Supportive*
McDonald, 1982 #6	McDonald, J. L. (1982). "Systolic and mean arterial pressures during manual and mechanical CPR in humans." Ann Emerg Med **11**(6): 292-295. The standard manual method of performing chest compression during cardiopulmonary resuscitation (CPR) was compared with a pneumatic compression device for the ability to generate systolic arterial pressure (SAP) and mean arterial pressure (MAP) in the same person. Fifteen patients, all in the late stages of the resuscitative effort, were studied. In 14, manual chest compression resulted in SAPs which were either higher than (13 cases) or equivalent to (1 case)

	those generated by the mechanical technique. In 13 of the 15 cases, mechanical compression resulted in MAPs which were either higher than (11 cases) or equivalent to (2 cases) MAPs generated by the manual method. Mechanical chest compression is superior to manual chest compression in generating higher MAPs. Direct measurement of arterial pressure and the use of mechanical chest compression results in a more informed and a less frenetic environment during CPR. *LOE 5, Fair Quality, Supportive*
Raessler, 1988 #7	Raessler, K. L., K. B. Kern, et al. (1988). "Aortic and right atrial systolic pressures during cardiopulmonary resuscitation: a potential indicator of the mechanism of blood flow." Am Heart J **115**(5): 1021-9. The absolute difference between aortic and right atrial systolic pressure (systolic pressure gradient) and the difference between the aortic diastolic and right atrial diastolic pressure (coronary perfusion pressure) were evaluated in a series of 63 adult mongrel dogs undergoing five different methods of cardiopulmonary resuscitation (CPR). Fluid-filled pressure monitoring catheters were placed in the ascending aorta and right atrium in each of the animals after induction of anesthesia with morphine sulfate and 1% halothane and oxygen. The animals were then fibrillated with a transvenous electrode catheter that had been introduced into a ventricle. After a "down time" of 3 minutes during which no CPR was performed, the animals' lungs were ventilated, and one of five methods of CPR was initiated. The systolic pressure gradient and coronary perfusion pressure were measured in all animals 1 minute after CPR was begun, and in all but the group undergoing open-chest cardiac massage after 7 minutes and 17 minutes of CPR. The systolic pressure gradient and coronary perfusion pressure were greatest during open-chest cardiac massage (true cardiac compression), intermediate in external mechanical CPR (Thumper) and standard CPR (greater in small dogs than large dogs), and lowest in CPR performed with a combined thoracic and abdominal vest apparatus (predominantly thoracic pump). The observation that the systolic pressure gradient between intrathoracic chambers is largest in open-chest cardiac massage and smallest in vest CPR suggests that similar measurements recorded during the performance of human cardiac resuscitation may be useful in determining the mechanism of blood flow. *LOE 6, Fair Quality, Supportive*
Sunde, 1997 #8	Sunde, K., L. Wik, et al. (1997). "Quality of mechanical, manual standard and active compression-decompression CPR on the arrest site and during transport in a manikin model." Resuscitation. **34**(3): 235-42. The quality of mechanical CPR (M-CPR) was compared with manual standard CPR (S-CPR) and active compression-decompression CPR (ACD-CPR) performed by paramedics on the site of a cardiac arrest and during manual and ambulance transport. Each technique was performed 12 times on manikins using teams from a group of 12 paramedic students with good clinical CPR experience using a random cross-over design. Except for some lost ventilations the CPR effort using the mechanical device adhered to the European Resuscitation Council guidelines, with an added time requirement of median 40 s for attaching the device compared with manual standard CPR. Throughout the study, in comparison with mechanical CPR the quality of CPR with either manual method was significantly worse. In particular, there were considerable individual variations during stretcher transport. With S-CPR and ACD-CPR the median compression times were 38 and 31%, significantly lower than the recommended 50%, and 46-98% of the decompression efforts with ACD-CPR were too weak, particularly during transport on the stairs. With both manual methods, there were no significant differences in the CPR effort between the site of the arrest and the ambulance transport. However, compression rates were reduced and became more erratic during stretcher transport to the ambulance. When walking horizontally, a median of 19% of S-CPR compressions and 84% of ACD-CPR compressions were to weak. On the stairs, 68% of S-CPR compressions and 100% of ACD-CPR compressions were too weak. In conclusion, when evaluated on a manikin, in comparison with manual standard and ACD-CPR, mechanical CPR adhered more closely to ERC guidelines. This was particularly true when performing CPR during transport on a stretcher. *LOE 6, Good Quality, Supportive*
Taylor,1978 #9	Taylor, G. J., R. Rubin, et al. (1978). "External cardiac compression. A randomized comparison of mechanical and manual techniques." JAMA **240**(7): 644-6. To compare the effectiveness of manual and mechanical chest compression during cardiopulmonary resuscitation, 50 patients who suffered cardiac arrest were randomly allocated to

	receive manual or mechanical chest compression. Randomization was performed after failure of initial resuscitative measures but within ten minutes after the onset of cardiac arrest (mean, 6.4 +/- 1.2 min). Ten patients from each group survived longer than one hour following resuscitation. Three from the mechanical group and two from the manual group were eventually able to leave the hospital. Thus mechanical compression appears comparable with manual compression when manual compression is performed under ideal conditions. Mechanical chest compression may be employed when trained personnel are not readily available or where manual compression is technically difficult to perform. *LOE 2, Good Quality, Supportive*
Ward, 1993 #10	Ward, K. R., J. J. Menegazzi, et al. (1993). "A comparison of chest compressions between mechanical and manual CPR by monitoring end-tidal PCO2 during human cardiac arrest." Ann Emerg Med **22**: 669-74. STUDY OBJECTIVE: To compare the use of mechanical and manual chest compressions during cardiac arrest based on continuous monitoring of end-tidal PCO2 (PETCO2). DESIGN: Prospective, randomized, crossover design. SETTING AND PARTICIPANTS: Fifteen consecutive adults ranging in age from 33 to 78 years who presented in nontraumatic cardiac arrest to the emergency department of a large teaching hospital. INTERVENTIONS: Study protocols were begun late in the resuscitation after initial resuscitation attempts were unsuccessful. Patients received four alternating five-minute trials (two manual and two mechanical), being randomized to begin with either technique. Mechanical compressions were performed by a mechanical device at a compression depth of 2 in. Both mechanical and manual compressions were delivered at a rate of 80 with a ventilation delivered after every fifth compression. Persons performing manual CPR were experienced American Heart Association basic life support providers, and no person performed manual CPR more than once during the study period. No resuscitative drugs were administered during the study period. PETCO2 was monitored continuously; those performing manual CPR were blinded to the PETCO2 monitor. Data were analyzed with repeated-measures analysis of variance and Scheffe multiple comparisons with the alpha error rate set of .05. MEASUREMENTS AND RESULTS: Mean PETCO2 during mechanical CPR was 13.6 +/- 4.14 mm Hg compared with 6.9 +/- 2.42 mm Hg during manually performed CPR (P < .001), a difference of 97%. Average mechanical CPR PETCO2 was higher in all cases. No patient was resuscitated successfully. Capnography also indicated that most CPR providers were inconsistent in their chest compressions. CONCLUSION: This study suggests that cardiac output produced with mechanical chest compressions is greater than that produced with manual compressions as demonstrated by the significantly higher PETCO2 levels during mechanical CPR. Reasons for this are unclear. In addition, monitoring of PETCO2 may help optimize chest compressions during CPR. *LOE 2, Fair Quality, Supportive*
Wik, 1996 #11	Wik, L., N. G. Bircher, et al. (1996). "A comparison of prolonged manual and mechanical external chest compression after cardiac arrest in dogs." Resuscitation **32**(3): 241-50. The effects of manual and a new mechanical chest compression device (Heartsaver 2000) during prolonged CPR with respect to haemodynamics and outcome were tested in a prospective, randomized, controlled experimental trial during ventricular fibrillation in 12 dogs of 9-13 kg body weight after 1 min of cardiac arrest. During the first 10 min of CPR the dogs were resuscitated according to the Basic Life Support (BLS) algorithm, followed by 20 min of Advanced Life Support (ALS) algorithm. After 30 min of CPR both manual and mechanical CPR groups were resuscitated following a standardized ALS protocol. During CPR, coronary perfusion pressure and end tidal CO2 were greater with mechanical CPR. All animals were successfully resuscitated and neurological deficit scores were not different. The CPR trauma score was less in the mechanical group. Mechanical external chest compression provided better haemodynamics than the manual technique, though outcome did not differ. Both optimally performed manual and mechanical techniques produce flow sufficient to maintain organ viability for 30 min of CPR after a 1 min arrest interval. *LOE 6, Excellent Quality, Supportive*
Young, 1983 #12	Young, C. D. (1983). "Esophageal perforation associated with combined use of the Thumper Resuscitator and esophageal airway." South Med J **76**(3): 332-4. Esophageal perforation is an uncommon but catastrophic complication of resuscitation with the esophageal obturator airway. Three cases of esophageal perforation are reported associated with combined use of an obturator airway and Thumper mechanical resuscitator. The possibility of

	increased risk when these devices are used together has not been previously discussed in the literature. This risk may be reduced by using lower balloon volumes, less aggressive compressor settings, and obturator airways modified for nasogastric drainage. *LOE 5, Fair Quality, Opposes Hypothesis*