**WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care**

**Worksheet author(s)**

| Reylon Meeks | Date Submitted for review: 10/01/2009 |

**Clinical question.**

In the absence of a manual defibrillator for infants (<1 year, not including newly born) in cardiac arrest (pre-hospital (OCHA), in-hospital (IHCA) (p), does the use of AED’ (I) compared with standard management (which does not include the use of AEDs) (C), improve outcomes (e.g. termination of rhythm, ROSC, survival) (O)?

**Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention/therapy**

| State if this is a proposed new topic or revision of existing worksheet: New topic |

**Conflict of interest specific to this question**

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? no

**Search strategy (including electronic databases searched).**

MeSH terms including:   "Cardiac arrest" or “Heart arrest” AND ("infant" birth – 23 months) AND ("defibrillators" OR "electric shock/countershock" OR "automated external defibrillation") AND ("outcome" OR "ROSC" OR "survival")

If EMBASE and/or SCOPUS access is obtained, they will be also included.

- Cinahl
- Medline
- Cochrane Database
- Endnote Database
- Endbase

Additional search for:
- Newborn, Infant, Child, Pediatric, Defibrillation, Electric shock, Countershock, Defibrillation, Automated External Defibrillation, Resuscitation, Ventricular fibrillation or tachycardia.

**State inclusion and exclusion criteria**

- **Inclusion Criteria:**
  - Infant: 1 month - 23months
  - Heart Arrest/ Cardiac arrest
  - In hospital or out of hospital
  - Defibrillation or resuscitation

- **Exclusion Criteria:**
  - All discussion articles
  - All qualitative research

**Number of articles/sources meeting criteria for further review:**

- 24 relating to the evidence of the question
- 6 relating to supporting criteria for body of paper
### Summary of evidence

#### Evidence Supporting Clinical Question

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<td>Level of evidence</td>
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- **A** = Return of spontaneous circulation
- **B** = Survival of event
- **C** = Survival to hospital discharge
- **D** = Intact neurological survival
- **E** = Other endpoint

*Italics = Animal studies*
Evidence Neutral to Clinical question

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Level of evidence

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

Evidence Opposing Clinical Question

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Level of evidence

A = Return of spontaneous circulation  C = Survival to hospital discharge  E = Other endpoint
B = Survival of event  D = Intact neurological survival  Italics = Animal studies
In infants (<1 year, not including newly born) in cardiac arrest (pre-hospital (OCHA), in-hospital (IHCA) (p), does the use of AED’ (I) compared with standard management (which does not include the use of AEDs) (C), improve outcomes (e.g. termination of rhythm, ROSC, survival) (O)?

Early defibrillation has been shown to be the most effective treatment for adult out-of-hospital cardiac arrest with the underlying rhythm of ventricular fibrillation (VF). With chances of survival decreasing by 10% for every minute of arrest with no interventions, the use of the automated external defibrillator (AED) has been advocated for improved outcomes for adult cardiac arrest (Valenzuela, 1997, 3308; Watts, 1995, 635).

AED’s were not initially tested in the pediatric population, as it was assumed the child in cardiac arrest did not experience ventricular fibrillation (VF) (Hickey, 1995, 475). Rather, the predominant rhythm in the pediatric population was asystole, and the focus was on early airway and ventilatory assistance.

Ventricular fibrillation (VF) is not the most common rhythm in infants and children, but has been reported up to 21% in the age group one month to one year in the hospital setting (Samson, 2006, 2328). Twenty-five (25%) of children who exhibited cardiac arrest in the pre-hospital or hospital settings, and who required defibrillation were infants (Rodriguez-Nunez, 2006, 113).

The chance of survival after ventricular fibrillation (VF) is greater than for any other non-perfusing rhythm. Timely treatment of ventricular fibrillation (VF) becomes a priority in pediatric cardiac arrest and resuscitation (Mogayzel, 1995, 484; Lopez-Herce, 2005, 807). In a retrospective study, Smith (2006, 525) reported lower ventricular fibrillation rates in the 1-7 year old age group than in the 8-18 year old age group. Survival rates were approximately 31% for those with ventricular fibrillation (VF) compared to 10.7% for all other rhythms. This provides further support for ventricular fibrillation (VF) being a rhythm that has a better outcome.

Accuracy of rhythm detection is an overall safety goal for the automated external defibrillator (AED). Studies of AED rhythm detection in children have reported good accuracy. Comparing rhythms from an AED and those from a standard EKG device, almost 700 rhythms were analyzed. The AED was found to have 100% specificity for nonshockable rhythms and 96% specificity for identifying ventricular fibrillation (VF) (Atkins, 1998, 168). This identified the AED was safe and effective for children.

In the younger age group, 1 day to 12 years, rhythms were recorded in a variety of settings, testing the automated external defibrillator (AED) for specificity and sensitivity. Nineteen (19) infants exhibited more than forty (40) shockable rhythms, as well as another 59 infants exhibiting more than 200 non-shockable rhythms. The AED was 100% specific for non-shockable rhythms, supporting the accuracy of rhythm detection in all age groups (Cecchin, 2001, 2483).

An observational study evaluating the use of attenuated pediatric electrode pads for adult automated external defibrillators was conducted to determine if the reduced energy level could be used on pediatric patients. Eight children aged 4.5 months to 10 years were in ventricular fibrillation (VF) and shocks by the AED were advised resulting in termination of ventricular fibrillation (VF). Non-shockable rhythms were reported in 16 cases, and no shock advised was accurately reported (Atkins, 2005, 31). The data supports the use of AED’s for young children, as well as adults.

As AED’s are refined and the specificity and sensitivity are accurate for pediatric rhythms, new rhythm detection criteria is being defined. A pediatric based AED can detect shockable rhythms correctly, making it
safe and effective for children. Pediatric modifications need to be confirmed they are accurately identifying pediatric rhythms (Atkins, 2008, 168).

**AED energy** is currently accepted as 2 J/kg initially followed by 4 J/kg in manual defibrillation. In the mid 1970’s a retrospective chart review of 27 children with weights as low as 2 kg and 3 days of age were examined for defibrillation energy doses. More than 70 attempts were made to defibrillate. More than 90% of the shocks between 2 and 10 J/kg were effective, and 2 shocks below the 2 J/kg was ineffective. This study confirmed the guidelines for effective defibrillation, and it was noted the damage threshold was much higher (Gutgesell, 1976, 898).

Babbs (1980, 734) studied more than 100 dogs to determine effective, damaging and lethal doses of defibrillation based on monophasic technology. Five times more energy was required for histologic damage than required for effective defibrillation. The authors concluded effectiveness of defibrillation should be the criteria for dose rather than fear of damage.

Newborn pigs weighing less than 5 kg were studied for defibrillation safety. The authors determined it took a substantial amount of energy to damage the heart of a newborn pig when compared with the results of the dogs, suggesting newborn hearts may be more resistant to damage from defibrillation than the adult heart (Gaba, 1982, 281; Killingsworth, 2002, 177; Berg, 2002, ; Berg, 2004, 352, Berg, 2005, 786, Berg, 2008, 429). Animal data indicates a wide variance in effective doses and damaging doses, particularly in the newborn population.

**High Dose Energy** has been described in the literature in three cases, two which were less than a year in age. Describing a case report of AED use on a patient 3 years old, the AED correctly detected ventricular fibrillation (VF), recommended a shock, and the child was converted using 9 J/kg. No cardiac damage was noted from the defibrillation (Gurnett, 2000, 1051).

An 11 week old previously healthy infant arrested and required CPR to be administered by parents as well as pre-hospital personnel. Two shocks were provided in the field, with two more shocks being administered in the hospital setting prior to conversion from sinus tachycardia to sinus rhythm. Wolf-Parkinson-White Syndrome was identified, with subsequent ablation and discharge to home. Six weeks post op the infant arrested, and was resuscitated with an AED and 50 J shock, approximately 8 J/kg, converting to sinus bradycardia. Approximately 7 minutes after the event, the infant was alert and crying. No neurological or cardiac damage was noted (Bar-Cohen, 2005, 135).

An infant with known Long- QT syndrome was discharged from the hospital with family education on the use of an AED. At 8 months of age the infant arrested in her home, was defibrillated three (3) times prior to converting to a junctional rhythm, followed by sinus tachycardia. The dose administered amount to 6 J/kg, and no neurological deficit was noted (Divekar, 2006, 526)

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**Acknowledgements:**
Citation List


LOE 5 – prospective study which included 700 rhythms and 99% accuracy for pediatric based AED rhythm analysis.


LOE 4 – Prospective study, no controls. Children receiving attenuated doses of 50 joules in biphasic manner terminated ventricular fibrillation in 4 or less shocks.


LOE 3 – Retrospective cohort study. AED’s detected all non-shockable rhythms, recognized with 88% accuracy ventricular fibrillation.


LOE 5 – Prospective study of collection of EKG’s using records to determine accuracy and sensitivity of an AED. Determined to be >99% in both cases.


LOE 5 – Animal study. Determining a therapeutic dosage for defibrillation, with 1.5j/kg the median and 30j/kg median toxic dose.


LOE 4 – Case report – Successful AED use in 5 month old


LOE 5 – Evidence Review- Supports use of AED in children


LOE 5 – Animal study using attenuated biphasic doses on piglets vs weight based monophasic dosing. Attenuated biphasic dosing of AED for ventricular fibrillation is effective.

LOE 5 – Animal Study comparing adult and pediatric biphasic waveform AED escalating dosing with ventricular fibrillation. Fewer elevations of troponin levels and LV ejection fractions in pediatric dosing.


LOE 5 – Retrospective Study with 2j/kg terminating VF in ½, no perfusing rhythms and no survivors.


LOE 5 – Animal study randomized using defibrillation of attenuated adult dosing and standard dosing. Survival similar in both groups with differences in myocardial function at four hours and need for increasing the number of shocks.


LOE 4 – Prospective study using EKG's which had been digitalized and tested for accuracy with a specific AED. Excellent specificity 100% and good sensitivity 96%.


LOE 4- Case report of successful AED use in infant by a parent.


LOE 5 – Animal study of piglets to determine consequences of countershock by use of technetium-99m. Relatively large doses of energy may be applied without permanent damage.


LOE 5 – Case study of successful AED home use with 9j/kg

LOE 5 – Analysis of data in pre-hospital setting determined children resuscitated in the field had better chance of survival with no neurologic damage than those who were resuscitated in the emergency department.


LOE 5 – Animal study using biphasic shocks. Determined defibrillation threshold and to estimate myocardial function after shock delivery. Provides a potentially wide range of safe defibrillation dosing


LOE 5 – Case study of successful AED use in a child.


LOE 5 – Case study of infant survival after fall and cardiac arrest with delayed defibrillation.


LOE 5 – Prospective study reviewing children in arrest. Patients younger than 1 year were less likely to survive than those >1year. Pre-hospital resuscitation was more likely to end in survival than in the hospital setting. Patients presenting with VF had higher survival rate than those with non-shockable rhythms.


LOE 5 – Retrospective cohort study determining 19% of cardiac arrest was initial rhythm of VF. Earlier recognition and treatment of VF may result in improved pediatric cardiac arrest survival rates.


LOE 5 – Prospective observational study comparing in house cardiac arrest between children and adults. Determined initial shockable rhythm was 14% vs 23% in adults.

LOE – 5 Analysis of data of defibrillation both in and out of hospital pediatric arrests. Shockable rhythms were noted as initial rhythm in 43% of cases. 2j/kg terminated VF in 18% of cases and 40% needed more than 3 shocks.


LOE 5 – Retrospective Analysis of data for children ,18 years with VF receiving defibrillation. Average number of shocks was 3. Survival related to duration of CPR.


LOE 5 – Prospective analysis of data of in hospital patients comparing initial shockable rhythm to one occurring later. Better survival with initial shockable rhythms.


LOE 5 – Retrospective cohort study over 27 years. VF presented in 7.6% of the cases of children 1-7 years and 27% in kids 8-18 years.


LOE 5 – Animal study looking at the effects of 50 j/kg in prolonged VF. All animals successfully resuscitated.


LOE 5 – Prospective study looking at pediatric cardiac arrest. Shockable rhythm initially in 10 patients and secondary VF occurred in 15 patients.


LOE 5 – Retrospective study of cardiac arrest determining pre-hospital interventions for out of hospital cardiac arrest are influenced by collapse to CPR and defibrillation.


LOE 5 – Meta analysis of defibrillation in the pre-hospital setting noting an increase in survival due to early defibrillation.