BASIC and ADVANCED PAEDIATRIC CARDIOPULMONARY RESUSCITATION GUIDELINES 2010

Jim Tibballs
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Resuscitation Officer, RCH
Convenor, Paediatric Sub-Committee,
Australian Resuscitation Council (ARC)

ARC Paediatric Representative
International Liaison Committee on Resuscitation (ILCOR)
• Outline the process undertaken by ILCOR and the ARC to produce guidelines
• Present main aspects of new ARC guidelines
• Discuss the rationale / science underpinning a few changes
Research Science to Reality

EVIDENCE

Guidelines
ARC, ERC, AHA

Evidence
Evaluation
ILCOR

Courses, Manuals
APLS, PALS

JT 2011
Who/What is ILCOR?

- **ILCOR** (International Liaison Committee on Resuscitation)
  - AHA American Heart Association 1990
  - ERC European Resuscitation Council 1990
  - ARC Australian Resuscitation Council 1990
  - HSFC Heart and Stroke Foundation of Canada 1990
  - CLAR Consejo Latin-Americano de Resuscitation 1997
    (IAHF Inter-American heart Foundation, 2003)
  - NZRC New Zealand Resuscitation Council 1998
  - RCA Resuscitation Council of Asia (Japan, Korea, Singapore, Taiwan) 2008

ARC and NZRC have common guidelines
Objectives of ILCOR?

• Forum for discussion and for coordination of all aspects of resuscitation worldwide.

• Foster scientific research in deficiencies and controversy.

• Share and disseminate information on research training and education.

• Produce international consensus statements on evaluation of science, and if possible issue universal treatment recommendations
ILCOR evidence evaluation process

A “worksheet” author …

• Defines a Clinical Question (PICO format)
• Declares any conflict of interest
• Finds the evidence
  • Search Embase, Medline, Cochrane, AHA database, journals
  • Search strategy reproducible
• Evaluates the science
  • Assign level of Evidence (1-5)
  • Assess methodological quality
  • Assess magnitude and outcome of any observed effect
  • Evaluate and summarise the evidence
• Drafts a recommendation
ILCOR 2006-2010
55 paediatric clinical questions posed

Examples

- Family presence during CPR
- MET
- Pulse check
- End-tidal CO2
- Oxygen
- Cuffed vs uncuffed ETT
- Bag-mask ventilation vs tracheal intubation
- Cricoid pressure
- Compression only CPR
- Compression-ventilation ratio
- Automatic external defibrillation
- DC shock dose
- Calcium in cardiac arrest
- Extracorporeal CPR
- Therapeutic hypothermia
- Adrenaline dose

Total worksheets >400: available at http://www.americanheart.org

JT 2011
ILCOR GUIDELINES published Oct-Nov 2010

”Paediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations”.

Resuscitation 2010; 81: e213-e259 (Oct)
Circulation 2010; 122: S466-S515 (Oct)
Highlights of ILCOR guidelines 2010

- Healthcare personnel do not reliably check the pulse
- Give compression-only CPR if unable/unwilling to ventilate
- Depress sternum 1/3 A-P chest diameter
- Dose of DC shock for VF/pulseless VT 2-4J/kg, higher dose acceptable
- Cuffed tracheal tubes age/4 + 3.5 mm
- Discontinue cricoid pressure if impedes ventilation/intubation
- Titrate oxygen to limit risk of hyperoxaemia
- Monitor exhaled CO2 to:
  - Confirm endotracheal intubation
  - Optimize CPR
- Rapid response system may reduce cardiac and respiratory arrest
- Search for “channelopathy” in unexpected cardiac arrest
# WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

**Worksheet author(s)**
- Elise van der Jagt (AHA)
- James Tibballs (AHA)

**Date Submitted for review:** Jan 15, 2010

## Clinical question.
In pediatric patients with in-hospital cardiac or respiratory arrest (P), does use of EWSS/response teams/MET systems (I) compared with no such responses (C), improve outcome (eg, reduce rate of cardiac and respiratory arrests and in-hospital mortality) (O)?

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

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

## Conflict of interest specific to this question
James Tibballs is co-publisher of 2 studies which showed reductions in preventable cardiac arrest and death in a pediatric hospital.

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

See above.

## Search strategy (including electronic databases searched).

Electronic data base searches: with the following databases and terms:

**Medline (1950 to Jan 2010):**
- “medical emergency team” 135 articles
- “rapid response team” 76 articles
- “critical care outreach” 63 articles

**Embase (1980 to Jan 2010):**
- “paediatric AND medical AND emergency AND team” 82 articles
- “rapid AND response AND team” 356 articles
- “critical AND care AND outreach” 370 articles

**Cochrane database: (Jan 2010)**
- “medical emergency team” 2 articles
- “rapid response team” 7 articles
- “critical care outreach” 1 article

Search of journal articles: 1 article

7 articles concerned pediatric patients

### State inclusion and exclusion criteria

Articles were included if they if they included paediatric patients and the use of early warning /rapid response/medical emergency team systems and they analysed incidence of cardiac arrest and/or respiratory arrest and/or mortality

Articles were excluded if: they did not provide outcomes or if outcomes were provided without a control; they were case reports; they were based solely on admission to intensive care or area of high dependence were excluded.

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

7 were exclusively pediatric.
### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
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<th>Chan et al., 2010, E,F,G</th>
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<td>Brilli (2007) E,F</td>
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**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Decreased rate of respiratory arrest  
F = Decreased rate of cardiac arrest  
G = Decreased rate of hospital-wide mortality
### Evidence Neutral to Clinical question

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<tr>
<td>Hunt (2008) F</td>
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<td>Brilli 2007, F</td>
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<td>Zenker (2007) B,F</td>
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### Evidence Opposing Clinical Question

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**Evidence Opposing Clinical Question**

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**Results:** Rate of Cardiopulmonary Arrest (↓ 38%)

**Results:**

**Hospital Mortality Rate** (↓21%)
Worksheet Consensus on Science and Treatment recommendation

**Conclusion**

**CONSENSUS ON SCIENCE:**

One LOE 3 metanalysis (Chan 2010, Good quality) and six pediatric cohort studies (LOE 3) (Good quality: Sharek 2007, p2267; Tibballs 2009, p306; Hunt 2008, p117. Fair quality: Brilli 2007, p306; Tibballs 2005, p1148. Poor quality: Mistry 2006, p241.) provide statistically significant evidence for prevention of respiratory or cardiac arrest and better survival from respiratory or cardiac arrest on in-patient wards and reduction in hospital-wide mortality by implementation of medical emergency or rapid response teams.

**TREATMENT RECOMMENDATION:** Paediatric rapid response or medical emergency team systems are recommended to reduce the risk of respiratory and/or cardiac arrest in hospitalised children outside the intensive care environment.

**ILCOR Guideline Treatment recommendation**

Paediatric RRT or MET systems *may be beneficial* to reduce the risk of respiratory/or cardiac arrest in hospitalised paediatric patients outside an intensively monitored environment.
Australian Resuscitation Council

- Doctors
  - Australian and New Zealand College of Anaesthetists
  - Australian and New Zealand Intensive Care Society
  - Royal Australasian College of Surgeons
  - Royal Australian College of General Practitioners
  - Australasian College for Emergency Medicine
  - Royal Australian College of Physicians, Paediatrics
  - Cardiac Society of Australia and New Zealand

- Ambulance Officers
  - Convention of Ambulance Authorities
  - Australian College of Ambulance Professionals

- Nurses
  - Australian College of Critical Care Nurses
  - College of Emergency Nursing Australasia
  - Royal College of Nursing, Australia

- Defence personnel
  - Australian Defence Force

- First-aid providers
  - Royal Life Saving Society of Australia
  - Australian Red Cross
  - Surf Living Saving Australia
  - St John Ambulance Australia
  - National Heart Foundation

- State Branches of ARC

AIMS: encourage CPR in community
promote research, teaching, uniformity, standards of CPR
co-ordinate with other resuscitation authorities

Formed 1976

Guidelines

www.resus.org.au

JT 2011
Principles of Guideline Formulation

Survival = Science x Education x Implementation
ARC Paediatric Guidelines 2010

Essential recommendations/changes

• Apply to all infants except at birth and within few hours, and to children
• Start CPR when “unresponsive and not breathing normally”

• Don’t spend >10 seconds palpating pulse

• If cannot insert peripheral IV, get intraosseous access
• Initially give 100% O₂, then reduce to PaO₂ 80-100 mmHg
• Compress lower sternum 1/3 A-P chest diameter
• Give 15 compressions, 2 breaths (may give 2 breaths first)

• Give continuous uninterrupted compressions 100/minute, pause for ventilations unless intubated

• Restrict ventilation when intubated to about 10 ventilations/minute.

• Detect expired CO₂ after intubation to:
  • Confirm tracheal intubation
  • Monitor effectiveness of CPR

• If unwilling/cannot ventilate, give continuous compressions
• Bag-mask ventilation is OK, tracheal intubation better

• Defibrillate with single shock 4J/kg, then immediate 2 minutes CPR

• Don’t interrupt compressions unnecessarily
• Treat asystole/bradycardia with adrenaline, not atropine
Basic Life Support

Dangers?

Responsive?

Send for help

Open Airway

Normal Breathing?

Start CPR
30 compressions : 2 breaths
if unwilling/unable to perform rescue breaths continue chest compressions

Attach Defibrillator (AED)
as soon as available and follow its prompts

Continue CPR until responsiveness or normal breathing return
Advanced Life Support for Infants and Children

**During CPR**
- Airway adjuncts (LMA / ETT)
- Oxygen
- Waveform capnography
- IV / IO access
- Plan actions before interrupting compressions
  - (e.g. charge manual defibrillator to 4 J/kg)
- Drugs
  - **Shockable**
    - Adrenaline 10 mcg/kg after 2nd shock
    - (then every 2nd loop)
  - **Non Shockable**
    - Amiodarone 5mg/kg after 3rd shock
    - Adrenaline 10 mcg/kg immediately
      - (then every 2nd loop)

**Consider and Correct**
- Hypoxia
- Hypovolaemia
- Hyper / hypokalaemia / metabolic disorders
- Hypothermia / hyperthermia
- Tension pneumothorax
- Tamponade
- Toxins
- Thrombosis (pulmonary / coronary)

**Post Resuscitation Care**
- Re-evaluate ABCDE
- 12 lead ECG
- Treat precipitating causes
- Re-evaluate oxygenation and ventilation
- Temperature control (cool)

**Start CPR**
- 15 compressions : 2 breaths
- Minimise Interruptions

**Attach Defibrillator / Monitor**

**Shockable**
- Shock (4 J/kg)
- CPR for 2 minutes

**Non Shockable**
- Adrenaline 10 mcg/kg
  - (immediately then every 2nd cycle)
- CPR for 2 minutes

**Assess Rhythm**
- Return of Spontaneous Circulation ?

**Post Resuscitation Care**

**15 compressions : 2 breaths**
- Minimise Interruptions

**Attach Defibrillator / Monitor**

**CPR for 2 minutes**

**Assess Rhythm**
- Return of Spontaneous Circulation ?

**Post Resuscitation Care**

**December 2010**

**JT 2011**
Diagnosing cardiac arrest by pulse palpation

- Doctors and nurses reliability 78%
- Sensitivity 86% (fail to diagnose 14%)
- Specificity 64% (diagnose arrest incorrectly 36%)
- Need 15 seconds to confirm presence when truly present
- Need 30 seconds to confirm absence when truly absent
Compression-ventilation ratio
Compression-ventilation ratios

- Different C:V ratios investigated in animal models, mannequins and computer simulations (100:2; 50:2; 50:5; 15:2; 30:2; 5:1)

- 30:2 shorter time to return of spontaneous circulation and better oxygen delivery (animal models)

- Mathematical modelling favours 30:2 (oxygen transport)

- Insufficient (NONE!) human evidence at present
Effects of low compression-ventilation ratios, eg, 5:1

1. Too much "hands off" during CPR (adult studies only)
2. Interrupts external cardiac compression causing BP to fall to zero
3. Too much ventilation in proportion to a limited cardiac output.
4. Impedes venous return and hence cardiac output.
5. Causes hypocarbia and cerebral vasoconstriction.
In 176 arrests ...

External Cardiac Compression ...

• not given during 48% of arrest time

• too shallow 62% of time
Quality of Cardiopulmonary Resuscitation During In-Hospital Cardiac Arrest

Context The survival benefit of well-performed cardiopulmonary resuscitation (CPR) is well-documented, but little objective data exist regarding actual CPR quality during cardiac arrest. Recent studies have challenged the notion that CPR is uniformly performed according to established international guidelines.

Objectives To measure multiple parameters of in-hospital CPR quality and to determine compliance with published American Heart Association and international guidelines.

Design and Setting A prospective observational study of 67 patients who experienced in-hospital cardiac arrest at the University of Chicago Hospitals, Chicago, Ill, between December 11, 2002, and April 5, 2004. Using a monitor/defibrillator with novel additional sensing capabilities, the parameters of CPR quality including chest

In 67 arrests …

• For 24% of arrest time, no External Cardiac Compression

• For 59% of arrests, ventilation rate >20/min
Hyperventilation-Induced Hypotension During Cardiopulmonary Resuscitation

Tom P. Aufderheide, MD; Gardar Sigurdsson, MD; Ronald G. Pirrallo, MD, MHSA; Demetris Yannopoulos, MD; Scott McKnite, BA; Chris von Briesen, BA, EMT; Christopher W. Sparks, EMT; Craig J. Conrad, RN; Terry A. Provo, BA, EMT-P; Keith G. Lurie, MD


Results not due to hypocarbia
... so how much ventilation is needed (for V/Q matching)?

- If 100% blood flow
  - Then 100% ventilation = 100-120mL/min/kg

- If 30% blood flow
  - Then 30% ventilation = 30-36mL/min/kg

= 6/min x 5-6 mL/kg

“Adequate chest rise” in adult is 5-6 mL/kg
Why 15:2, not 30:2 ratio for infants and children?
Why 15:2 not 30:2 for paediatrics?

• No human evidence

• Consensus with adult scientists NOT achieved. (Paediatricians not persuaded by animal cardiac arrest studies, mannekin studies and computer simulations)

• Rationale conjecture:
  • Paediatric ventilation requirement greater than adult
  • Hypoxic arrest, not sudden arrhythmia arrest, more common in paediatric practice
  • In out-of-hospital paediatric cardiac arrest (Kitamura et al., Lancet 2010; 375: 1347)
    • Survival from asphyxial cause better (7.2%) with standard CPR (7.2%) vs compression-only CPR (1.6%) vs no CPR (1.5%)
    • Survival from cardiac cause same with standard CPR (9.9%) vs compression-only CPR (8.9%) vs no CPR (4.1%)

• 15:2 previously used for children (one-person rescue)
Importance of NOT interrupting external cardiac compression
Effects of compression depth and pre-shock pauses predict defibrillation failure during cardiac arrest

Dana P. Edelson, Benjamin S. Abella, Jo Kramer-Johansen, Lars Wik, Helge Myklebust, Anne M. Barry, Raina M. Merchant, Terry L. Vanden Hoek, Petter A. Steen, Lance B. Becker

- Observational study of 60 adult in-hospital and out-of-hospital arrests
- ROSC from defibrillation is associated with shorter delay between interruption of external cardiac compression and DC shock. Odds ratio 1.86 (1.10-3.15) for every 5 second decrease in delay
- ROSC from defibrillation is associated with depth of external cardiac compression. Odds ratio 1.99 (1.08-3.66) for each 5mm increase in depth

Resuscitation 2006; 71: 137-145

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Adverse effect of pre-shock pause

- Shock Success
  - ≤10.0: 94% (n=17)
  - 10.1–20.0: 72% (n=16)
  - 20.1–30.0: 60% (n=10)
  - >30.0: 38% (n=8)

p=0.002
Adverse effect of shallow compressions

The graph shows the percentage of shock success at different compression depths. The x-axis represents compression depth (mm) with categories: <26, 26-38, 39-50, and >50. The y-axis represents shock success percentage, ranging from 0% to 100%. The data points are as follows:

- <26 mm: 50% success, n=10
- 26-38 mm: 60% success, n=15
- 39-50 mm: 88% success, n=17
- >50 mm: 100% success, n=5

The p-value is 0.008, indicating statistical significance.
Effects of Interrupting Precordial Compressions on the Calculated Probability of Defibrillation Success During Out-of-Hospital Cardiac Arrest

Trygve Eftestøl, PhD; Kjetil Sunde, MD, PhD; Petter Andreas Steen, MD, PhD

$P_{ROSC}$, %

$n=156$

Duration of hands-off, seconds/minute


JT 2011
Why such adverse effects of “hands off”?
"Coronary Perfusion Pressure" During CPR
Fig. 10. Frozen pictures from the video uptake after induction of ventricular fibrillation.
Interruptions to compressions are bad …

- Are common …
- Reduce survival …
- Reduce probability of successful defibrillation

… should be minimised
External cardiac compression

PUSH HARD!

PUSH FAST!

DON’T INTERRUPT!
Advanced Life Support for Infants and Children

Start CPR
15 compressions : 2 breaths
Minimise Interruptions

Attach
Defibrillator / Monitor

Shockable
Assess Rhythm
Shock (4 J/kg)
CPR for 2 minutes

Non Shockable
Adrenaline 10 mcg/kg
(immediately then every 2nd cycle)
CPR for 2 minutes

Return of Spontaneous Circulation ?

Post Resuscitation Care

During CPR
Airway adjuncts (LMA / ETT)
Oxygen
Waveform capnography
IV / IO access
Plan actions before interrupting compressions
(e.g. charge manual defibrillator to 4 J/kg)

Drugs
Shockable
* Adrenaline 10 mcg/kg after 2nd shock
  (then every 2nd loop)
* Amiodarone 5mg/kg after 3rd shock
Non Shockable
* Adrenaline 10 mcg/kg immediately
  (then every 2nd loop)

Consider and Correct
Hypoxia
Hypovolaemia
Hyper / hypokalaemia / metabolic disorders
Hypothermia / hyperthermia
Tension pneumothorax
Tamponade
Toxins
Thrombosis (pulmonary / coronary)

Post Resuscitation Care
Re-evaluate ABCDE
12 lead ECG
Treat precipitating causes
Re-evaluate oxygenation and ventilation
Temperature control (cool)

December 2010

JT 2011
What’s the right dose of DC shock?
Evidence with Paediatric Monophasic DC shock

Gutgesell et al., *Pediatrics* 1976; 58: 898

- Observational study:
- 27 children; 71 DC shocks
- All defibrillated:<2J/kg +/- 10J or 4 J/kg
Biphasic DC shock for VF and pulseless VT
Pediatr Crit Care Med 2011; 12: 14-20

![Graph showing the relationship between body weight and Joules for ROSC and non-ROSC outcomes.]

- ROSC 50% if ≤2 J/kg
- ROSC if 3-5 J/kg

N=48
Why one DC shock strategy?

Why resume ECC immediately after DC shock - why not analyze rhythm straight after DC shock?
First shock efficacy

- Six studies of defibrillation in out-of-hospital cardiac arrest reported **first-shock success** (5 sec) with various waveforms in patients whose initial rhythm was shockable (VF/pulseless VT):

200-J **Monophasic** damped sinusoidal: 77 – 91%
200-J **Monophasic** truncated exponential: 54 - 63%

150-J or 200-J **Biphasic** truncated exponential: 86 - 98%
120-J **Biphasic** rectilinear: 85%

... that is, both monophasic and biphasic waveforms defibrillate BUT ...
481 out-of-hospital VF, treated with AED stacked shocks (series of 3)

- 1st shock success 83.6%
- 2nd shock success 7.5%
- 3rd shock success 4.8%

ROSC is NOT synonymous with successful defibrillation

- 1st shock produced pulse 21.8% patients
Why is monitoring exhaled CO$_2$ important?
1. To detect non-tracheal intubation (standard of care)

2. Assess effectiveness of CPR
Assessing effectiveness of CPR

No ROSC – low end-tidal CO₂
ROSC – normal end-tidal CO₂

Sample clinical question
ILCOR worksheet (Peds 005A)

**Question**: In pediatric patients with cardiac arrest prehospital [OHCA] or in-hospital [IHCA]) (P), does the use of end-tidal CO$_2$ (I), compared with clinical assessment (C), improve accuracy of diagnosis of a perfusing rhythm (O)?

**Evidence evaluation** – 1478 citations found – 47 evaluated

**Recommendation**: continuous capnography … may be beneficial by providing feedback on effectiveness of chest compressions.

Whereas a specific target number cannot be identified, if the PETCO$_2$ is consistently <15 mmHg, it is reasonable to focus efforts on improving the quality of chest compressions and avoiding excessive ventilation.

Although a threshold PETCO2 may predict poor outcome … and might be useful as a guide to terminate CPR, there are insufficient data to establish the threshold and appropriate duration of ALS (in children) …
Guideline Differences Remain!

Remarkable progress in creating common guidelines but some (slight) differences remain

The science is common … therefore…

Why do different resuscitation councils recommend differently?

- No evidence
- Some evidence, could not reach consensus
The real reason?
When to start External Cardiac Compression?

ILCOR (2005)
unresponsive, not breathing, no pulse

2010

AHA
unresponsive
no pulse

ARC & NZRC
unresponsive
not breathing normally
no pulse (10 secs)

ERC
unresponsive
not breathing normally
no signs of life
no pulse (10 secs)
Initial Number of Breaths

ILCOR
2-5 (2005)

2010

AHA
start ECC first

ARC & NZRC
Start ECC first
2 breaths first optional

ERC
5

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Compression – Ventilation Cycles
Basic CPR 30:2 (single rescuer)

- ILCOR silent
- AHA 5 in 2 min*
- ARC & NZRC 5 in 2 min*
- ERC silent

• 75 compressions/minute
• 5 breaths/minute
Compression – Ventilation Cycles
Advanced CPR 15:2 (2 rescuers)

- AHA: 5 in 1 min*
- ARC & NZRC: 5 in 1 min*
- ERC: silent

- 75 compressions/minute
- 10 breaths/minute
Ventilations after intubation

ILCOR
“reduce”

2010

AHA
8-10/min (no circ)
12-20/min (circ)

ARC & NZRC
10/min

ERC
10-12/min
Dose of DC Shock

ILCOR CoSTR
2 - 4 J/kg

AHA
2 - 4 J/kg

ARC & NZRC
4 J/kg

ERC
4 J/kg

2010
Foreign Body

ILCOR (2005)
back blows, chest thrusts, abdo thrust

2010

AHA
back blows, chest thrusts, abdo thrust

ARC & NZRC
back blows, chest thrusts

ERC
back blows, chest thrusts, abdo thrust
ARC Airway obstruction

- Combination of back blows and chest thrusts
- Lateral chest thrusts – removed (no evidence)
- Abdo thrusts (Heimlich manoeuvre) – removed (multiple cases of harm and some claims of success are fraudulent)

- But …
Fortunately for Sparky, Zeke knew the famous "Rex manoeuvre."
ARC – coping with failed IV, IO, ETT access
Superior sagittal (longitudinal) sinus injection