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

**Worksheet author(s)**

Gabrielle Nuthall

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#### Clinical question

For (adult) pediatric patients (in any setting (P)), is there a clinical decision rule (I) that enables reliable prediction of ROSC (or futile resuscitation efforts)?  (PROGNOSIS) NOTE: adult originally in question but only pediatric papers considered in final worksheet.

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

Prognosis

#### Conflict of Interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to his worksheet? No, I am a Pediatric Intensivist practicing as an attending in a tertiary level Children's Hospital. I am on the New Zealand Resuscitation Council and I am chair of the Starship Children's Hospital Resuscitation Committee. I have no conflicts of interest and receive no funding other than my public hospital salary.

#### Search Strategy (including electronic databases searched)

- Search “Heart Arrest” or “Cardiac Arrest” or “Cardiopulmonary resuscitation” and “Predictors” or “Prognosis” or “Outcome” (All MeSH headings)

  - AHA Endnote master library
    - 607 abstracts narrowed to 33 articles obtained to be read (after exclusion of duplicates)
  - PUBMED
    - 513 abstracts narrowed to 48 articles obtained to be read (after exclusion of duplicates)
  - Cochrane Library (search cardiopulmonary resuscitation, heart arrest, cardiac arrest and prognosis in 1) title, abstract or key words and 2) all text)
    - 905 abstracts narrowed to 0 applicable after review
  - EMBASE
    - 4042 abstracts narrowed to 54 after duplicates removed and abstracts reviewed
  - Hand search of ILCOR worksheets from 2005 on related topics W138B and W12B
    - 37 articles obtained
    - 20 articles obtained to be read
  - 192 articles

#### Inclusion and Exclusion criteria

- **Limits:** Human
- **Exclusion criteria:** Prematurity and Non-English

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

- After email discussions with Jasmeet Soar
  - Initial review limited to worksheet question as related to pediatric patients, in any situation
  - Rapid deployment of ECMO in paediatric excluded as there is another worksheet on this
  - 45 articles
### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Evidence of Clinical Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Nadkarni 2006 C, Meaney 2006 C, Atkins 2009 C</td>
</tr>
<tr>
<td>Poor</td>
<td>Eisenburger 2008 A,C,D</td>
</tr>
</tbody>
</table>

**Prognostic Level of Evidence**

- **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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<tr>
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<th>Evidence of Clinical Question</th>
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<tbody>
<tr>
<td>Good</td>
<td>Samson 2006 C, Donoghue 2005 C,D</td>
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</tbody>
</table>

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### Evidence Opposing Clinical Question

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<tbody>
<tr>
<td><strong>Fair</strong></td>
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<td></td>
</tr>
<tr>
<td>Young 2004 C,D</td>
<td>Zaritsky 1987 C</td>
<td>O'Rourke 1986 B,C,D</td>
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<tr>
<td>Reis 2002 B,D,E</td>
<td>Hickey 1995 A,C,D</td>
<td>Li 1999 C</td>
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<td></td>
<td>Suominen 2002 E</td>
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<td></td>
<td>Fisher 1999 C,D</td>
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<td>Hazinski 1994 B,D</td>
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<td></td>
<td>Crewdson 2007 C</td>
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<tr>
<td><strong>Poor</strong></td>
<td>Suominen 1998 A,D</td>
<td>Gillis 1986 B</td>
<td></td>
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<tr>
<td>Perron 2001 B,C</td>
<td>Innes 1993 B,D,E</td>
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<tr>
<td>Lopez-Herce 2004 A</td>
<td>Young 1999 E</td>
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</tbody>
</table>

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REVIEWER’S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

The majority of studies are retrospective and/or too heterogeneous to provide evidence to make any clinical decision rules (CDR’s) to reliably predict either ROSC or futile resuscitation efforts. Outcomes over time, especially recently, have improved (survival from in hospital cardiac arrest excluding respiratory or hypotensive / bradycardic arrests, Nadkarni 2006 27% and Tibballs 2006 26%, with ~ ¾ having a good neurological outcome (and Tibballs 73% ROSC and 36% survival when include bradycardic/hypotensive arrests requiring CPR)), making papers from the 80’s and 90’s less useful (Zaritsky 1987 9.4% survival to discharge, Gillis 1986 9% survival to discharge and Suominen 2000 17.8% 1 yr survival), which makes reliable CDR’s relevant to present clinical practice difficult. Out of hospital cardiac arrest (OOHCA) has always had a worse outcome than in hospital arrests (Donoghue 2006 12% survived to discharge with 4 % neurologically intact, there is also an increase in survival of OOHCA with Hollenberg (all ages) 2008 showing 15.3% admission to hospital in 1992 increasing to 21.7% in 2005, corresponding to a 1 month survival of 4.8 and 7.3%), and studies are even harder to extract useful information from, due to heterogeneity, especially with respect to decisions made in the field about ongoing resuscitation efforts and cause of arrest (with some ~40% in most studies being due to SIDS). Not all papers even report ROSC, and the real question is increasingly survival to hospital discharge and quality of survival.

Additional note: Since writing and presenting the worksheet the first publication from the prospective population cohort study on OHCA from the Resuscitation Outcomes Consortium has been published (Atkins 2009). This paper, like the similar ones on in hospital cardiac arrest, again supports the premise that outcomes over time from out of hospital cardiac arrest have improved.

It is also difficult to grade papers into those supporting or opposing the clinical question, as many evaluate factors that both support and oppose the question of reliable prediction of ROSC or of futility.

However, there are trends that help guide clinicians make decision as to when to continue or terminate resuscitation efforts. Other factors, such as the availability of rapid deployment ECMO, and of cardiopulmonary bypass for rewarming after submersion, must also factor in any decisions made by clinicians.

The specific areas that can aid clinicians in clinical decision making are as follows:

**Length of CPR:**

<table>
<thead>
<tr>
<th>Study</th>
<th>CPR Time</th>
<th>Description</th>
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<tbody>
<tr>
<td>Gillis (1986)</td>
<td>CPR &gt; 15 mins</td>
<td>futile</td>
</tr>
<tr>
<td>Zaritsky (1987)</td>
<td>CPR &gt; 10 mins</td>
<td></td>
</tr>
<tr>
<td>Innes (1993)</td>
<td>CPR &gt; 30 mins</td>
<td>futile</td>
</tr>
<tr>
<td>Slonim (1997)</td>
<td>CPR &gt; 15 mins</td>
<td>survival 5.5% vs 18.6%</td>
</tr>
<tr>
<td>Young (1999)</td>
<td>CPR &gt; 30 mins</td>
<td></td>
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<tr>
<td>Parra (2000)</td>
<td>CPR &gt; 20 mins</td>
<td>52% ROSC and 31% survival to Dx (PICU)</td>
</tr>
<tr>
<td>Reis (2002)</td>
<td>CPR &gt; 30 mins</td>
<td>futile</td>
</tr>
<tr>
<td>Suominen (2002)</td>
<td>CPR &gt; 25 mins</td>
<td></td>
</tr>
<tr>
<td>Rodriguez-Nunez (2006)</td>
<td>CPR 30-60 mins</td>
<td>11.5% ROSC and 3.8% survival to Dx</td>
</tr>
<tr>
<td>Samson (2006)</td>
<td>CPR &gt; 60 mins</td>
<td>37.5% ROSC 0% survival to Dx (PICU)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58% of survivors &lt; 15 mins CPR cf 32% non-survivors</td>
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</table>


Nadkarni (2006) median duration CPR in survivors 15 mins ([IQR 7-36]
median duration of CPR in non-survivors 29 mins (IQR 15-49)

OOHCA
Schindler (1996) CPR > 20 mins in ED futile
Suominen (1997) CPR < 15 mins good outcomes
Young (2004) CPR > 31 mins in ED futile

While there has been an upward trend over the last 20 years as to the appropriate length of
CPR, CPR over 30 minutes for in hospital CPR (outside specialist areas of rapid deployment
ECMO and rewarming for submersion) is still likely in the majority of cases to have a bad
outcome, but there are also many cases reported of good outcomes after 30 minutes CPR.
Therefore, on its own CPR > 30 minutes should not be used to terminate CPR efforts for in-
hospital cardiac arrests but should be taken into account as an important factor.

No ROSC at scene for OOHCA or CPR on arrival in ED:
O'Rourke (1986) CPR on arrival futile
Ronco (1995) CPR on arrival very poor outcome
Hickey (1995) CPR on arrival futile
Sirbaugh (1999) no ROSC at scene futile
Eisenburger (2008) Adult patients transported with CPR in progress ROSC in 31% with
19% favourable long term outcome (6 month survival with CPS 1 or
2), so if get ROSC once in ED 1/5 good outcome

Previously CPR on arrival in ED from OOHCA has had extremely poor outcomes, this recent
paper (adult and retrospective) shows improving survival rates in this group also making it
difficult to make a CDR on this factor alone, with again other factors needing to be taken into
account.

Number of doses of epinephrine:
Gillis (1986) > 1 dose futile
Zaritsky (1987) > 2 doses no survival
Young (1999) > 2 doses futile
Guay (2004) worse outcome with increased epinephrine (no cut off)
Rodriguez-Nunez (2006) ≥ 3 doses epi 48.5 ROSC 9.7% to discharge
Samson (2006) increased doses epinephrine increased chance of secondary
VF and decreased doses better survival
Eisenburger (2008) Adult study survivors mean of 4mg vs non-survivors 7mg

OOHCA
Schindler (1996) > 2 doses futile
Young (2004) > 3 doses futile

Difficult to get a number of does to make a CDR, but clear that increased number of doses
associated with an increasingly poor outcome, but in the Rodriguez-Nunez 2006 paper, those
with > 3 doses still had a ROSC of 48.5% and 9.7% to discharge.
Witnessed CA:

- Eisenberg (1993) witnessed CA 15% survival to Dx vs 3% unwitnessed
- Mogayzel (1995) witnessed higher % of VF and improved survival
- Kuisma (1995) improved survival
- Young (2004) OOHCA witnessed survival to Dx 16% cf 8.6% unwitnessed
- Donoghue (2005) witnessed and bystander CPR grouped together, improved survival
- Eisenburger (2008) improved survival with witnessed (Adult)
- Vayrynen (2008) unwitnessed asystolic arrest (not drowning or hypothermic) no survivors
- Atkins (2009) OOHCA witnessed CA odds ratio of 6.81 statistically associated with survival

There is no doubt that witnessed events have better survival rates, for adults, children and CA from submersion. In terms of witnessed events and bystander CPR in children there is a lack of information. If an event is witnessed it should be considered in the decision making process as to how long to continue resuscitative efforts.

First and subsequent rhythm:

- Mogazel (1995) OOHCA initial shockable rhythm 17% Dx with good neurological outcome vs asystole/PEA 2% (SIDS excluded)
- Tibballs (2006) initial shockable rhythm 40% survival to hospital Dx
- Samson (2006) initial shockable rhythm 35% survival to hospital Dx
- Rodriguez-Nuez (2006) initial shockable rhythm 84.2% ROSC, sustained ROSC 68.4% survival to hospital Dx 21%
- Eisenburger (2008) initial shockable rhythm improved outcome (adults)
- Vayrynen (2008) unwitnessed asystolic arrest (not drowning or hypothermic) no survivors

Well accepted that initial shockable rhythm increases chances of survival. In last few years the new information in this area is that those that then go on to develop a secondary shockable rhythm do worse.

- Tibballs (2006) secondary VF have worse outcomes and are associated with an increased dose of epinephrine
- Samson (2006) secondary VF/VT 11% survival (vs primary 35%)
- Rodriguez-Nuez (2006) secondary VF/VT ROSC 48% (vs primary 84.2) and none Dx alive from hospital

Those with an initially shockable rhythm do better, but are also resuscitated more quickly and with fewer doses of epinephrine, so this is unlikely to impact upon decisions to terminate resuscitation efforts. The relatively poor outcome of secondarily shockable rhythms should be considered as part of decisions to stop resuscitation, but outcome is not poor enough to not resuscitate or to stop resuscitation efforts.

Drowning/Submersion:

In OOHCA submersion do better than the group as a whole. Donoghue (2006) 22.7% survival to discharge compared to overall OOHCA 12.1% survival to discharge.
Quan (1992)  < 5 mins submersion do well  
ALS > 25 mins (non icy water) poor outcome

Waugh (1994)  ALS > 25 mins after rewarming no survivors

Suominen (2002)  ALS > 25 mins (water > 5 degrees) or submersion > 25 mins no survivors

Eich (2007)  rewarmed with bypass and had some good survivors with long ALS times (>110 mins)

Without bypass or ECMO (neither evaluated here) ALS > 25 mins for non icy water has a very poor outcome and termination of resuscitation should be considered. Longer submersion times are associated with poorer outcome, but often are predicted times only.

**Trauma:**
There are adult recommendations on withholding and terminating resuscitation in traumatic cardiac arrest, but these do not include children because of the lack of data on the subject. Survival from pediatric traumatic cardiac arrest varies from 0% to 23.5% (included in-hospital cardiac arrest from trauma), with a large degree of heterogeneity in data collection.

Haizinski (1994) no functional survivors if pulseless/BP <50 on arrival in ED (blunt trauma only)

Suominen (1998)  no survivors if transported with CPR
no survivors of blunt trauma and CPR pre-hospital
Li (1999)  pulseless on arrival 1.5% survival 
Penetrating injury 4.4 x less likely to survive
Fisher (1999)  6% survived 24 hrs and 1.5% survived to Dx (vegetative)
Perron (2001)  CPR in- hospital very poor outcome (chance of death 5.9 times more likely)
CPR and penetrating trauma 2% survival to Dx
Lin (2007)  35.5% sustained ROSC (any CPR) 1.8% survival to Dx 
ROSC more likely with VT/PEA cf asystole
Survival unlikely with >25 mins in hospital ALS
Crewson (2007)  Penetrating trauma no survivors 
Blunt trauma 8.75% survival

ROSC and especially survival to hospital discharge is poor after traumatic cardiac arrest, however there is still too little information (few prospective papers and lack of uniform data collection) to be able to make definitive rules on withholding and withdrawing resuscitative efforts.

This is highlighted by the recent Crewdson paper (2007) from the London Helicopter Emergency Medical Service, where a 10 yr retrospective trauma database review of paediatric patients of < 15 yrs had a 23.8% discharge rate from the ED, (of patients who required high dose adrenaline, cardiac massage and/or defibrillation at the scene) and 8.75% survival to hospital discharge. While these numbers are encouraging, they do not say how many patients were receiving CPR on arrival in ED, or what the survival or ROSC of this group was. Although they had physicians (capable of doing a thorocotomy at the scene) attend the scene and a rapid transport time back to the hospital, the mean time for the team to get to the scene was still 26.4 minutes and local EMS services attended first.

Despite the improving survival over the years it is clear that those with hypovolaemic cardiac
arrests from penetrating trauma and in most centres, those with ongoing CPR on arrival in hospital have only a very small chance of survival and that this should be taken into account when making termination of resuscitation decisions. Length of CPR and the initial rhythm also have an impact on survival and should be taken into account.

**Age:**

There are some recent studies that suggest that children have better outcomes than adults and that infants do better than older children. There is not enough information to consider a CDR in this area.

Nadkarni (2006) found the survival to discharge for children was 27% (65% good outcome) vs 18% for adults (73% good outcome), even after correcting for confounding factors. This was because children did better from PEA/asystole than adults, with similar outcome from primary shockable rhythms.

Meaney (2006) survival to hospital Dx

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Survival Rate</th>
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<tbody>
<tr>
<td>0-1 month</td>
<td>27%</td>
</tr>
<tr>
<td>1 month-1 yr</td>
<td>36%</td>
</tr>
<tr>
<td>1 yr-8 yrs</td>
<td>19%</td>
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<tr>
<td>8 yrs-21 yrs</td>
<td>16%</td>
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The same findings are not found with OOHCA, largely due to SIDS (Engdahl 2003).

**Out of hospital cardiac arrest:** - additional note written since writing and presentation of worksheet in New Orleans on the publication by Atkins (2009) from the Resuscitation Outcomes Consortium Epistry – Cardiac Arrest on outcomes from out of hospital cardiac arrest in children. This is the first prospective information we have on pediatric out of hospital cardiac arrest, it was collected over a geographically diverse area and over a short time (16 months) and included a large number of patients – 624 under 20 years. The paper excluded trauma and burns, and definitions of age and cardiac arrest were made a priori and are rigorous. The primary outcome measure was survival to hospital discharge. Children less than 1 yr were analysed separately which means SIDS doesn't affect the outcomes for the other groups. These factors are unique in publications on OHCA and make the information presented very useful.

Like the trends in outcomes from in hospital cardiac arrest, this paper shows that outcomes from OHCA have also improved and therefore that the “old termination of resuscitation” rules no longer hold.

Survival to hospital discharge over all was 6.4% (compared to adults in the registry 4.5%), with infants 3.4%, children 8.5% and adolescents 8.2%. Outcomes for those who received EMS treatment (ie: excluding those with obvious signs of death where treatment was deemed futile) were 7.8% overall, infants 3.5%, children 10.4% and adolescents 12.6%.

It is difficult to compare this paper to other studies as it is the first prospective data we have for OHCA, but compared to historical data collection (Donoghue 2006 where when a rigorous definition of cardiac arrest applied to this group of retrospective patients only 1.1% survival to hospital discharge) with it's inherent flaws, suggest that outcomes from OHCA are better than previously expected and that children and adolescents are twice as likely to survive to hospital discharge from OHCA than infants or adults. This supports the conclusion from the New
Orleans meeting that previously predictive rules need to retested in OHCA as well as for in hospital cardiac arrest. (for further information on this excellent paper see notes made in the Citation List).

**Recent landmark adult papers that highlight difficulty in making clinical decision rules for this worksheet question:**

Sasson (2008): A retrospective analysis using prospectively collected data to analyse termination of resuscitation (TOR) rules in 5505 patients who met the inclusion criteria from 2005-2008 in adult Out Of Hospital Cardiac Arrest (OOHCA). There were rules for Basic Life Support with a specificity of 0.987 and positive predictive value of 0.998 (event not witnessed by EMS personnel, no AED used or manual shock applied in out of hospital setting, no ROSC in out of hospital setting) and for the Advanced Life support a specificity of 1.0 and a positive predictive value of 1.0 (rules as for BLS plus arrest not witnessed by bystander and no bystander administered CPR). The paper is a rigorous assessment of the prognostic factors in adult OOHCA but needs prospective evaluation.

Morrison (2006, 2007) has also looked at this area, both with a retrospective analysis to derive TOR rules and with prospective evaluation for both BLS and ALS. The TOR rules are similar to above and had a positive predictive value of 99.5% and specificity of 90.2%(see citation list for details). As stated by the authors, TOR rules need prospective evaluation and should be for guidance not obligatory.

With ongoing improvement of all aspects of the chain of survival, outcomes over time will hopefully continue to improve, resulting in a need for ongoing re-evaluation of such TOR rules, but information in these TOR rules does provide guidance for clinicians and has implications for resource allocation. There are no pediatric papers exploring this area.

Nichol (2008): Adult and pediatric prospective study on OOHCA looking at outcome of discharge alive from hospital. This study showed a huge variation in outcome between centres, with a difference of 3% to 16.3% survival for all episodes, and a variation of 7.7% to 39.9% for VF arrests. Information such as this shows us that making termination rules that are appropriate to all centres, let alone all countries is a very difficult thing to do.

Eisenburger (2008): A retrospective study over 15 yrs (1991-2006) looking at patients transported with ongoing CPR, the majority OOHCA but some from in-hospital cardiac arrest. The outcomes are much better than previously documented with 31% achieving ROSC and 19% favourable long term outcome (no data given on how many survive with a non favourable outcome). Some useful information missing from this paper (survival with an unfavourable outcome, no information as to why physicians choose to stop resuscitation or continue it pre-hospital), however it shows that ongoing CPR on admission can no longer be regarded as futile. A prospective database that includes appropriate information on this topic is the only way further questions about these patients can be reliably answered.

**Conclusion**

For pediatric patients in any setting, there are no clinical decision rules that enable reliable prediction of ROSC or futile resuscitation efforts. The prognostic information that needs to be taken into account by medical personnel making decisions are: length of CPR, CPR on admission in hospital, number of doses of epinephrine, first and subsequent rhythm, submersion history, trauma history and age.

**Acknowledgements:**
Citation List

Note: All levels of evidence given below are prognostic levels of evidence.


- First prospective data collection on out of hospital cardiac arrest in children.
- Collected over a geographically diverse area over a short period of time (16 months) with 624 patients < 20 yrs old (25 405 adult patients > 20 years).
- Trauma and burns excluded, submersion and suffocation patients included.
- Definitions such as age and definition of cardiac arrest all both rigorous and defined a priori and the primary outcome was survival to hospital discharge (no quality of survival information).
- 44% (277) were infants (<1 year), 25% (154) were children (1-11 years) and 31% (193) were adolescents (12-19 years).
- 19% received no treatment by EMS services as it was deemed to be futile ("presumably because resuscitation was considered futile eg, dependent lividity, rigor mortis").
- Over all incidence of pediatric OHCA was 8.04 per 100 000 pediatric person years, compared to 126.52 per 100 000 for adults Incidence of OHCA in infants 10x that of children or adolescents, presumably due to SIDS).
- Bystander witnessed CA occurred in 19%, but only ~1/3 received bystander CPR. Bystander use on an AED rare – 3 total uses out of 624 patients.
- 2/3 of events had no obvious cause and were presumed to be of cardiac origin.
- Rhythm: VT/pulseless VF occurred in 7%. In 4.5% of infants and children and in 15% of adolescents. Asystole/PEA in 82% and undetermined in 11% and missing in 7%.
- Over all survival to hospital discharge was 6.45 compared to 4.5% in adults, with infants 3.4%, children 8.5% and adolescents 8.2%. If those patients who received no treatment from EMS personnel were excluded survival to hospital discharge overall was 7.8% with infants 3.5%, children 10.4% and adolescents 12.6%.
- Children and adolescents twice as likely to survive as infants and adults.
- Those with VT/VF as initial rhythm more likely to survive, 20% vs 5%.
- Over all survival rates heavily influenced by the poor infant survival rate from SIDS, which have often been difficult to separate out in other retrospective papers.
- Number to treat to save a life is 13, which compares favourably to other aggressive interventions, similar to adults, but with far great potential in terms of potential life years saved.
- 19% no resuscitation attempted compared to adults where 40% no resuscitation attempted. Possibility that with pediatric patients there is a lower thresh hold to do CPR and transport to hospital even though it is obvious it is futile, if this is so it would under estimate survival figures.
- Majority of OHCA arrest occurs in non public locations, primarily peoples homes, this has implications for CPR education.
- LOE P1/ Good Supporting

- 10 yr retrospective review 1994-2004, age < 16 yrs and CPR in pre-hospital setting in trauma patients, physician staffed EMS service
- CPR= Adrenaline, cardiac compressions and/or defibrillation at scene or on route to hospital
- Outcome measure was survival to hospital discharge
- 19/80 (23.75%) survived to discharge from the ED, and 7 (8.74%) to hospital discharge. There were no survivors of penetrating trauma (4/16 has thoracotomy at scene)
- LOE P3 / Fair  Opposing


- Robust meta-analysis, but adds little to over all knowledge due to heterogeneity of studies and lack information on important questions. Tells us outcome from OOHCA is bad, but doesn't aid in clinical decision rules
- Submersion injury as a group have overall better outcomes, trauma do badly, witnessed cardiac arrest associated with improved survival
- LOE P2 / Good  Neutral


- Small retrospective study 1087-2005 , Utstein data collection
- All receiving ALS on arrival to hospital and all put on CPB 5/12 survived (2 normal 3 vegetative) 7/12 died
- The 2 normal survivors had immersion times of 20 and 30 mins and both had first recorded rhythm of idioventricular bradycardia not asystole
- Survivors had lower initial K+ ( 3.6) than non-survivors (6.6)
- Study too small to make CDR’s , highlights difficulties of knowing exact submersion times, times to BLS and length of CPR, but shows good survival possible with longer submersion times and raised possibility of initial K+ being useful prognostically
- Like other studies witnessed events do better
- LOE P 4 / Fair  Neutral (possibility of initial K+ being useful and of survival with longer CPR and immersion times when warmed with bypass)


- Retrospective case review of OOHCA patients <18 over 6 ½ yrs (started in 1983)
- Definition “no pulse or BP” and trauma excluded
• 33 had witnessed CA with 5 surviving to discharge (15%) cf 86 un-witnessed and 3 (3%) survival to Dx
• Drowning did best
• LOE P3 / Poor Neutral towards supporting (Witnessed arrest and near drowning did best)


- Retrospective cohort study over 15 yrs of patients transported with CPR, majority OOHCA but some in-hospital
- No information as to why physicians choose to Tx patients while still doing CPR (as provision to stop at scene)
- 31% ROSC and 19% favourable long term outcome, but don't say how many survive with non-favourable outcome
- Some different findings to other papers, eg low percentage of patients with an initially shockable rhythm
- LOE P5 / Fair Supporting (Doesn't give absolute predictors of ROSC, but suggests all should have a very good attempt at achieving ROSC). As this is a pediatric worksheet all adult papers have been graded as LOE 5


- Prospective observational study over 20 yrs (1980-2000), retrospectively evaluated, but limited data collected and not using Utstein.
- 94 patients with poor outcome but unable to assess any clinical decision rules from data given eg 65% of patients had ongoing CPR on arrival in ED, but survival of this subgroup not given.
- LOE P1 / Poor Neutral (difficult to grade as although prospective data collection, collected over 20 yrs, limited data collected and then retrospectively analysed)


- Retrospective review from 1984-1996 of all pediatric patients with a mechanism of blunt trauma who required CPR in the pre-hospital setting (no age range given)
- 94% died within 24 hrs, 98.5% did not survive to hospital discharge and the one survivor was in a persistent vegetative state
- LOE P3 / Fair Opposing


- Retrospective case series in hospital 42 pts (33 cardiac arrest 9 resp arrest)
- No patients survived after having CPR > 15 mins and only 2 survived after more than one dose of epi and both died before 6 months
- LOE P4 / Poor Opposing (length of CPR and number of doses of epi)


- Retrospective chart review of in hospital arrests 1983-87, using Utstein guidelines (published 14 yrs later).
- Bradycardia and “respiratory compromise” included and age < 21yrs
- LOE P4 / Poor Neutral (Can not predict > 30 minutes CPR as futile)


- Retrospective study from 1984-1991, < 16 yrs, blunt trauma presenting to ED, with cardiovascular collapse (pulseless arrest or severe hypotension(< systolic of 50)), 30/38 pulseless arrest
- No functional survival to discharge (1/38 (3%) survived with severe neurological impairment)
- Now an “old” study
- LOE P3 / Fair Opposing (blunt trauma pediatric victims who present to ED pulseless of with systolic BP < 50 futile to resuscitate)


- Retrospective chart review from hospital records not EMS records, not Utstein
- 33 (35%) patients no perfusing rhythm on arrival in ED, 1 (3%) survived with severe neurological sequelae (ventilator dependant, vegetative)
- No patient given > 1 dose of epi in the ED survived
- Trend to improved survival with bystander CPR
- LOE P3 / Fair Opposing (CPR on arrival in ED and > 1 dose of epi in ED)


- Retrospective analysis of prospectively collected data for the Swedish Cardiac Arrest Registry from 1992-2005 (almost 40 000 patients)
- All ages, median age ~ 70 and no age breakdown or specific pediatric information given
- Increase in survival of admission to hospital alive from 15.3% in 1992 to 21.7 in 2005 with one month survival increasing from 4.8 to 7.3%. Most of increase in survival in
those with shockable rhythms, but overall % of patients in a shockable rhythm decreased.

- LOE P5 / Fair (see limitations of study section) Neutral. LOE 5 as majority of population adult not pediatric.


- Case series, ICU arrests excluded and included patients arrived in ED with CPR (26 had cardiac arrests 7 of which CA originated outside the hospital)
- LOE P4 / Poor Opposing (CPR > 30 mins futile)


- Retrospective data collection from EMS files, pediatric = <16 yrs, 1985-1994
- Results as above plus survival 25% for attempted resuscitation when CA witnessed
- No information given for number of doses of epi or for survival if CPR at arrival at ED, but physicians attended scene, some patients had no resus efforts with signs of irreversible death and some had resus efforts stopped at scene.
- Outcome improved as above but nothing significant on multivariate analysis
- LOE P3 / Fair / Supporting (Witnessed 25% survival (for “attempted resuscitation”)


- Retrospective review of patients < 15yrs who received CPR at scene or in hospital 1988-1996
- Primary outcome measure is survival to discharge from hospital
- 68% CPR at scene, rest in hospital. Survival rate for CPR at scene 26% in hospital 19%
- Survival rates: 39% with a pulse and respirations, 19% pulse and apnoeic and 1.5% if pulseless and apnoeic at the time of admission
- Systolic BP < 60 on admission associated with 24 fold increase in mortality. Coma, penetrating injury and CPR initiation in hospital all associated with a worse outcome
- Penetrating injury 4.4 x more likely not to survive (percentage or exact numbers not given)
- LOE P4 / Fair Opposing (no pulse or resp at admission 1.5% survival and worst outcome with penetrating trauma)

- Retrospective chart review, < 18 yrs, 2000-2004, sustained ROSC = 20 mins where chest compressions not required, trauma and cardiac arrest
- 20/56 (35.7%) obtained sustained ROSC, only one survived to discharge
- The only factors significantly associated with sustained ROSC was initial rhythm (asystole worse outcome, PEA and VF (and pulseless VT) better), and length of in hospital CPR with a cut off value of 25 mins (90% of patients with sustained ROSC had CPR for >25 mins in hospital and 86% of patients with out sustained ROSC did not achieve ROSC even after 25 mins of in hospital CPR)
- Pre-hospital intubation assoc with worse outcome
- LOE P3 / Poor Neutral (used non-trauma OOHCA as control group but didn't really compare groups and didn't identify and control for confounders)


- 18 month (April 98 - Sept 99) prospective in and out of hospital cardiac arrest in children (up to 17 yrs), multicentre
- Utstein data
- Very heterogeneous group:In and out of hospital included, along with trauma, bradycardia and respiratory arrest
- After multivariate logistic regression analysis only factor predicting initial and final mort was duration CPR > 20 mins
- LOE P1 / Poor Opposing (CPR > 20 mins best indicator for futility)


- Prospective cohort study, also from AHA National registry of CPR (NRCRP) 2 yrs 2000-2002 paediatric but age<21 yrs
- In paediatric ICU patient cohort
- LOE P1 / Good Supporting (younger age higher chance of survival)


- Retrospective cohort out of hospital CA study, SIDS excluded
- VF subgroup more likely to have had a witnessed arrest (52% vs 22% p=.002), 38% discharged alive and 17% with a good outcome.
- VF only variable associated with a good outcome
- No info on epi doses or length of CPR
- LOE P3 / Fair Supporting (VF and witnessed arrest)

- Aiming to derive termination of resuscitations rule (TPR rule) for advanced life support (ALS) paramedics. Secondary aim to look at data with respect to previously published TOR rules for basic life support (BLS) paramedics, as authors felt it would be good to have a single set of TOR rules for both ALS and BLS.
- Secondary data analysis of adult cardiac arrest receiving ALS in another study.
- As per results above, rule worked well, but as stated by the authors should not be applied without prospective evaluation.
- Only adult patients, but useful as no equivalent pediatric data.
- LOE P5 / Good Opposing. All adult papers graded P5 as pediatric worksheet.


- Prospective clinical evaluation of a clinical prediction rule for termination of resuscitation derived from retrospective review of data, which was published in advance of this study.
- Study well planned and well executed.
- Site specific (24 sites) enrolment varied from 21-100% of eligible patients, but demographics of cases enrolled was similar.
- 57.4% of CA’s witnessed, 94.5% no ROSC, 70% no shock delivered, 9.7% witnessed by EMS personnel.
- 3.1% survival to Dx –which is lower than Nichol - 4.6% overall and 3-16.3% between centres.
- Of the 4 survivors (0.5%) 3 had a good outcome, 1 bad.
- Addition of cardiac arrest not witnessed to TOR rules would have resulted in a survival rate of 0% and a positive predictive value and specificity of 100%, but would have resulted in a significant increase in the number of patients transported to hospital.
- As pointed out by the authors, rules such as these always need prospective validation before clinical implementation and should be used for guidance rather than obligatory.
- LOE P5 / Good opposing. All adult papers graded P5 as pediatric worksheet.


- Prospective observational study of in hospital CA comparing children and adults with respect to rhythm and outcomes
- Large and very robust study, very well done
- Children better outcomes than previous studies, despite long resuscitation times, implications that adult studies on termination rules less applicable to paediatrics
• LOE P1 / Good  Supporting (children better outcomes than adults for asystole and PEA)


- Adult and paediatric study (age 0-108) out of hospital cardiac arrests
- Prospective study in 10 centres, huge study- 20520 cardiac arrests outcome= discharge alive
- Huge variability (3%-16.3% all resus attempts and 7.7%-39.9% VF) of survival rates in different centres raises important questions about validity of assessing success or futility clinical decision rules
- LOE P5 / Fair  Neutral. All adult papers graded P5 as pediatric worksheet.


- Retrospective case series, too old to be very useful. Terrible outcomes
- LOE P 4 / Fair  Opposing (all receiving CPR on arrival)


- Retrospective case review (95-97) in a cardiac PICU (up to 21 yrs)
- Non- Utstein data collection eg different CPR definition of CPR > 2 mins
- Standard dose epi for 3 doses then 10 x dose given
- Half the patients had CPR < 20 mins 73% ROSC and 52% survival to Dx and half had CPR > 20 mins 52% ROSC and 31% survival to dx
- LOE P3 / Fair Neutral


- Multi-centre database analysis, age < 19, 1988-1995, who had pre-hospital CPR
- 32% of blunt trauma survived to discharge, 2% of penetrating trauma survived to discharge (Don't give statistics for those arriving in ED with CPR)
- Additional CPR in-hospital significantly decreased chance of survival as did pre-hospital intubation
- LOE P 1 / Fair-Poor  Opposing (multi-centre database so prospective data collection, but no initial rhythm, no number receiving CPR on arrival, identification of some confounders, but not controlled for)

- Retrospective cohort study in patients under 20 yrs 1985-1989, following on from a first retrospective study from 1974-1983. The first study found 2 risk factors for death or severe neuro impairment 1) submersion > 9 mins and ALS > 25mins. This study tests these hypotheses and also includes data from the first study (there for the first paper has not been included in the worksheet).
- Included all cases of submersion, including brady < 40 and those with output on arrival of EMS
- Those with submersion < 5 mins usually do well and those with > 10 mins 90% do badly
- ALS > 25 mins with no ROSC, all do badly
- Small study CPR attempted in total of 29 patients
- They state problem is that only the extremes predict outcome and that the remaining large number of patients have some likelihood (18-45%) of doing well
- LOE P 3 / Fair  Supporting (submersion < 5 mins) Opposing (ALS > 25 mins)


- Prospective data collection in tertiary paediatric hospital (no acute cardiac or trauma care) CPR using Utstein guidelines, over 12 months (N = 129)
- 16% survival at dx (cf Nadkarni 2006 27%) with inclusion of bradycardia CPR and only 1 case VF no VT
- In those that survived majority good outcome
- CPR > 30 minutes (44 patients) 3 (7%) survival to hospital Dx and 2(5%) 1 yr survival, both with severe neurological impairment "Wisdom of CPR > 30 mins questioned"
- Looked at survival and doses of epi, but with multivariate analysis number of doses not independent variable
- LOE P1/ Fair  Opposing (Long CPR time predicting poor outcome (lack of acute trauma and cardiac patients not controlled for))


- Secondary analysis of prospectively collected data in 15 PICU’s in Spain (same data set as other publication above 98-99). Utstein data collection
- 3 or more doses of Adrenaline 61.5% initial mortality and 90.3 % mortality at hospital discharge (stat sig)
- 30-60 min CPR 88.5% initial mortality and 96.2% mortality at discharge and > 60 min CPR 62.5 % initial mortality and 100% mortality at discharge
- LOE P1 / Fair  Opposing ( CPR > 30-60 mins and > 3 doses of epi)

- Secondary analysis of data collected prospectively (for Lopez-Herce) in and out of hospital cardiac arrest 1998-1999 (Utstein data collection), paediatric up to 18 yrs.
- Of those with primary shockable rhythms (19) ROSC in 84.2% sustained ROSC in 68.4% discharged alive in 21% and alive at 1 yr in 15.8%, compared to secondary shockable rhythms (25) ROSC in 48% sustained ROSC in 24% and no patients discharged alive or alive at 1 yr.
- LOE P1/ Fair Opposing (secondary shockable rhythms poor outcome)


- Retrospective case series from children < 15 yrs presenting to a children's ED (1988-1993)
- Only 1/60 survival with good neurology (total 6/60 survival, case with good survival successfully defibrillated before arrival in ED), rest vegetative, but 60/63 were receiving CPR on arrival
- Unusual in that follow up done by examination by a neurologist(not by phone or retrospective note review)
- Trauma cases included
- LOE P 3 / Fair Opposing (CPR on arrival in ED)


- Prospective observational in hospital cardiac arrest data collection. Robust with clearly defined comparison groups
- Same data as Nadkarni JAMA 2006 but 3 months longer data collection and different information presented.
- VF/VT higher incidence than previously described and poorer outcome of subsequent VF/VT noted
- Increasing number of interventions (epi, other drugs, length of CPR) lower survival.
- LOE P1/ Good Neutral to supporting (35% with initial rhythm of VT/pulseless VT survived to Dx)


- Adult paper (< 16 excluded), Trauma also excluded, out of hospital cardiac arrests
- Retrospective analysis of prospectively collected data, to analyse a clinical decision rule
- Identified with high specificity and sensitivity Termination of resuscitation rules
• Needs prospective evaluation, problem is clinical rules for terminating treatment are self fulfilling
• LOE P5/ Fair (confounding factors not identified and controlled for) Opposing (adult rules for termination). All adult papers graded LOE P5 as pediatric worksheet.


• Retrospective case review, apnoea and/or no pulse 1986-1993 SIDS and trauma included
• Respiratory arrest included
• No patient who had > 2 doses of epi or > 20 mins resuscitation in the ED survived
• Patients who survived beyond ED were more likely to have had a pulse or arrival (p< 0.001) less epi (p< 0.05) and a shorter duration of CPR in ED (p<0.001)
• LOE P3 / Good Opposing (length of CPR (> 20 mins) CRP on arrival in ED and > 2 doses of epi)


• Prospective pediatric OOHCA study < 17 yr over 3 ½ yrs (92-95), only included cardiac arrest (no bradycardia), but 40% of non-trauma cases were SIDS
• No patients who did not obtain ROSC at scene survived (non-trauma: 13% ROSC 3% survival. Trauma: 13% ROSC 1% survival) 6/300 total survivors (2%) 1/6 no neurological deficit
• Only factor associated with ROSC at scene was ET intubation (number of doses of epi and length of CPR not documented.
• LOE P1 / Fair Opposing (no ROSC at scene no survivors)


• Prospective data collection in 32 pediatric ICU's 1989-1992 (heterogeneous group and those arriving with CPR and who did not achieve stable vital signs were excluded)
• < 15min CPR survival 18.6% > 30mins survival 5.6%.
• One CA in PICU and 2 CA in PICU similar survival 14.2 and 13.8% but 3 CA survival 9.5%
• 5.7% of those with arrest pre PICU survived
• LOE P1 / Fair Neutral (length of CPR > 30 mins poor survival, but still 5.6% survived)

- Retrospective EMS review 1985-1994 and 1992-1994 of pediatric arrests (<16), physicians attended the scene. Resuscitation only attempted in 50%
- SIDS included, efforts terminated in no ROSC at scene
- Only CPR lasting < 16 minutes was associated with “good neurological outcome”
- LOE P3 / Fair Supporting (CPR < 16 mins)


- Retrospective study 1985-1997, paed and adult, only includes those with ROSC and admitted to an ICU (but included all who had CPR from EMS or bystander)
- Submersion time usually an estimate, but remains the best predictor, but no clear cut off point, but if the victim has been immersed in warm water (>5 degrees) for > 25 mins there is almost no chance of survival and those that survive are in a vegetative state)
- 6 patients transported with ongoing CPR 3 survived (all 3 re-warmed with bypass)
- LOE P3 / Fair Opposing (CPR > 25 mins (water > 5 degrees) or submersion time > 25 mins, no survivors)


- Retrospective 5 yr case series of in hospital from 1990. 227 cardiac arrests, 118 CPR.
- Only duration external CPR statistically significant for hospital discharge with the mean duration of external CPR in patients alive at 1 yr being 8 mins and no patient surviving after > 25 mins CPR
- LOE P4 / Good Opposing (length of CPR)


- Retrospective study, 10 yrs 1984-1994, age < 16. All those with no vital signs and requiring CPR pre hospital or in hospital were included. Submersion injury was excluded.
- 121 but 80 excluded as no CPR initiated, no reasons given.
- None of the patients transported with ongoing CPR survived no details about length of CPR
- Thorocotomy and open chest CPR in 5, 4 had ROSC but only 1 survived
- Penetrating injury no survivors
- Over all ROSC 14.6% and survival 7.1 (2 good survival and 1 moderate disability)
- LOE P3 / Poor Opposing

• Prospective study (1999-2002), tertiary paed hospital with both cardiac surgery and trauma included. Included bradycardia and hypotensive cardiac arrests requiring chest compressions (66% of cardiac arrests). Utstein template, neurological outcome not recorded.
• If hypotensive / bradycardia removed survival to dx is 26% and 1 yr survival is also 26%
• Above poor outcome with secondary VF or pulseless VT also statistically associate with increased dose of adrenaline
• LOE P1 / Fair Neutral (Opposing for secondary VF and for large doses of epi (as increase chance of secondary VF and Supporting for hypotension and bradycardia (38% 1 yr survival) and VF (40% 1 yr survival)


• Retrospective observational study 1997 to 2005 of asystolic arrests only, say ALL OOHCA's and don't specify ages, so assume children included.
• Survival to hospital 18.1%, discharge from hospital survival 3.3% and 1 month survival 2.3%, with 46% in overall performance category 1-2.
• Bystander-witnessed arrest was associated with improved outcome (bystander CPR was not)
• Only 3 survivors out of 548 un-witnessed arrests (resuscitation attempted in 294), all were hypothermic or victims of near drowning
• LOE P5 / Fair Opposing (un-witnessed asystolic arrest) Neutral (drowning and witnessed cardiac arrest). All ages not specifically pediatric therefore LOE 5


• Older study 1981-84, retrospective but with prospective neurodevelopmental assessment by neurologist
• LOE P3 / Fair Opposing (no child survived > 25 mins CPR after being warmed)


• Secondary analysis of prospectively collected data for a interventional trial, paediatric patients < 12 yrs (1994-1997)(Utstein data collection attempted but not always possible)
• Used PCPC good outcome as 1 and 2 vs Nadkarni JAMA 2006 which used PCPC good as 1,2 and 3
• Don't specifically look at those receiving CPR on arrival in ED as a group.
• LOE P1 / Fair Opposing (CPR > 31 mins or > 3 doses of epi, witnessed CA almost twice the survival to Dx 8.6 vs 16%)

- Review of articles published between 1970-1997 in Pediatric Cardiopulmonary Resuscitation. Unable to perform meta-analysis as data non-uniformly collected. 44 articles, mainly in 80's and early 90's
- Data strongly suggests that the need for > 2 doses epi or for CPR > 30 mins indicators of poor outcome
- LOE P4 / Poor Opposing (CPR > 30 mins and > 2 doses of epi)


- Data collected over a 1 yr period by a researcher doing a chart review, but cases were identified by a daily check of hospital operator log and by talking to the PICU charge nurse
- Now an “old study”
- No CA patient receiving > 2 doses epi survived to Dx (2 survived to 24 hrs, survival to ROSC not documented) and all survivors had < 10 minutes of CPR
- LOE P3 / Fair Opposing (length of CPR and number of doses of epi)