**Clinical question.**

**Peds 005B.R3:**
In pediatric patients with cardiac arrest (prehospital [OHCA] or in-hospital [IHCA]) (P), does the use of end-tidal CO₂ (I), compared with clinical assessment (C), improve accuracy of diagnosis of a perfusing rhythm (O)?

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

State if this is a proposed new topic or revision of existing worksheet: New specifically for pediatrics

**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).**

**Medline search using PUBMED using the following searches, limited to English language and Children:**
131 references were retrieved. The term capnography was used as an alternative term for end-tidal carbon dioxide in all searches with additional selection of titles.

Cardiac arrest and end-tidal carbon dioxide: 

Cardiopulmonary arrest and end-tidal carbon dioxide: 

Resuscitation and end-tidal carbon dioxide: 

**Cochrane Database:**
Among 331 Clinical Trials, 14 Reviews, and 3 Technology assessment studies, only three studies were retrieved involving the assessment of end-tidal CO₂ using the following terms, either individually or combined: resuscitation, cardiac arrest, cardiopulmonary arrest, cardiopulmonary resuscitation, end-tidal carbon dioxide. Two of the studies were already retrieved in Medline using Pubmed.

**EMBASE using the following search terms limited to English language and Children:**
Among 179 retrieved articles, no additional references over the Medline search using Pubmed was retrieved.

cardiopulmonary AND 'resuscitation'/exp AND 'co2'/exp AND ((newborn)/lim OR [infant]/lim OR [preschool]/lim OR [school]/lim OR [child]/lim OR [adolescent]/lim) AND [humans]/lim AND [english]/lim 8 View | Edit
cardiopulmonary AND arrest AND 'co2'/exp AND ((newborn)/lim OR [infant]/lim OR [preschool]/lim OR [school]/lim OR [child]/lim OR [adolescent]/lim) AND [humans]/lim AND [english]/lim 12 View | Edit
cardiopulmonary AND 'resuscitation'/exp AND 'co2'/exp 129 View | Edit
resuscitation'/exp AND 'carbon'/exp AND 'dioxide'/exp AND ((newborn)/lim OR [infant]/lim OR [preschool]/lim OR [school]/lim OR [child]/lim OR [adolescent]/lim) AND [humans]/lim AND [english]/lim 0 View | Edit
cardiopulmonary AND arrest AND 'carbon'/syn AND 'dioxide'/syn AND [english]/lim AND ([newborn]/lim OR [infant]/lim OR [preschool]/lim OR [school]/lim OR [child]/lim OR [adolescent]/lim) AND [humans]/lim AND [abstracts]/lim

**AHA EndNote Library CPR Training Master January 2008 using the following search terms limited to English language and Children:**
Children OR pediatric AND end-tidal OR capnography.
Among 1389 references, 87 references were selected; however, all relevant citations had already been retrieved with the searches performed in the electronic databases (Medline using PUBMED, EMBASE, Cochrane Library).

### State inclusion and exclusion criteria

#### Inclusion criteria:
- **Population/sample of subjects:** Human subjects; children; age: < 18 years old.
- **Disease or condition:** cardiopulmonary arrest or cardiac arrest; either in or out of hospital.
- **Intervention:** end-tidal carbon dioxide (capnography) measurement or monitoring or evaluation during resuscitation measures for the diagnosis of the following outcome.
- **Outcome:** perfusing rhythm defined as either return of spontaneous circulation (ROSC), alive (survival), or other synonym used for perfusing rhythm.
- **Study design:** original evaluation or study; published in its entirety in English.

#### Exclusion criteria:
- **Population/sample of subjects:** not children, adults only, not human, mannequin, animal.
- **Disease or condition:** not cardiopulmonary arrest such as e.g., transportation of critically ill patients, respiratory arrest only, tracheal intubation and induction of anesthesia only.
- **Intervention:** any other intervention that is not end-tidal carbon dioxide measurement or any end-tidal carbon dioxide evaluation used for other indications or diagnostic purposes such as e.g., tracheal tube patency, tracheal tube placement or displacement.
- **Outcome:** tracheal tube placement; mechanical ventilation parameters (e.g., presence of hyperventilation).
- **Study design:** review, editorial, not peer review publication, published in abstract form only, or unpublished work.

### Number of articles/sources meeting criteria for further review: 132 titles.

Among 132 titles and abstracts retrieved in the databases above with the search terms, 110 references were excluded based on the review of the abstracts using the inclusion and exclusion criteria above; specifically the articles were excluded either because of the wrong population by wrong topic, wrong sample of subjects (e.g., animals), wrong disease or condition (e.g., respiratory failure, severe traumatic brain injury, cardiopulmonary bypass study in congenital heart disease), wrong language, wrong intervention, wrong outcome.

Final review of the evidence includes 22 articles included in ETCO$_2$ Summary Table. Some references ultimately include studies without humans or children, but with relevant intervention and outcome, and more likely generalizable to children (reported as Level 5 and Level 5 animal studies).

Among the 22 studies, 20 were classified as supporting the clinical question; 2 were classified as neutral and none as opposing.
## Evidence Supporting Clinical Question

### Summary of evidence

<table>
<thead>
<tr>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Berg, 1994, 35) A</td>
<td>(Gudipati, 1988, 234) A</td>
<td>(Sehra, 2003, 515) A</td>
</tr>
<tr>
<td>(Berg, 1996, 245) A</td>
<td>(Lepilin, 1987, 958) A</td>
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<tr>
<td>(Grmec, 2007, 404) A, B</td>
<td>(Trevino, 1985, 910) A</td>
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<tr>
<td>(Wayne, 1995, 762) A, B</td>
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</tbody>
</table>

### Level of evidence for Assessing Diagnosis

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  
*Italicics = Animal studies*
Evidence Neutral to Clinical question

<table>
<thead>
<tr>
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<tr>
<td>Fair</td>
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<td>Poor</td>
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</table>

1 2 3 4 5

Level of evidence for Assessing Diagnosis

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

<table>
<thead>
<tr>
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<td></td>
</tr>
<tr>
<td>Poor</td>
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</tr>
</tbody>
</table>

1 2 3 4 5

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 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)?

The data generated in studies involving pediatric human subjects with a cardiac arrest, undergoing cardiopulmonary resuscitation (CPR) measures, evaluating (and/or including) the use of end-tidal carbon dioxide (CO$_2$) monitoring (or detection) to make or improve the accuracy of the diagnosis of a perfusing rhythm, is very limited. Ideally, such studies would involve evaluating the diagnostic characteristics of end-tidal CO$_2$ measurement compared to clinical assessment, in order to discern between a perfusing and a non-perfusing rhythm; these studies would evaluate the validity of the measurement of end-tidal CO$_2$ report the sensitivity and specificity of end-tidal CO$_2$ measurement, and the positive and negative predictive values of end-tidal CO$_2$ to discern between a perfusing and a non-perfusing rhythm. Additionally, since device characteristics or measurement conditions could modify the diagnostic capacity of end-tidal CO$_2$, measurement characteristics may also be evaluated and reported.

Given that the majority of studies were not specifically designed to evaluate the accuracy of diagnosis of a perfusing rhythm as the primary outcome, studies that report the relationship between end-tidal CO$_2$ and any alternative endpoint for a perfusing rhythm, were screened. Also, studies reporting some (or any) evaluation of the relationship between end-tidal CO$_2$ and death (survival), regardless of whether the studies reported a diagnostic or prognostic evaluation, were screened. The review was undertaken to focus on summarizing the evidence for the use of end-tidal CO$_2$ in the pediatric population with cardiac arrest, in order to evaluate if its use should be recommended (or not) specifically to improve the accuracy of diagnosis of a perfusing rhythm.

The age related differences between children and adults may be important when evaluating the effectiveness of interventions on definitive resuscitation outcomes such as success rates of return of spontaneous circulation (ROSC), neurological function, or survival. Important differences exist between children and adults in terms of biological characteristics (e.g., cell signaling pathways) modified by developmental age, or in terms of biomechanic characteristics modified by size and anatomy. Nonetheless, it is unclear that these differences are sufficiently relevant when evaluating the “accuracy of diagnosis of a perfusing rhythm” with end-tidal CO$_2$, to render inferences from adult studies, invalid to inform pediatric guidelines. The relationship between the use of end-tidal CO$_2$ during CPR and ROSC has been shown in animal and adults, and previously summarized in the 2005 guidelines. Given the limited amount of studies performed in human pediatric patients addressing the specific question, an evaluation of studies involving relevant pediatric models in animals and specifically relevant studies involving humans i.e., adults, were examined for further review. The term relevant refers to the specific topic of this worksheet. Studies are discussed below in increasing order of LOI D (1 to 5).

Among 132 studies selected, 22 studies (See End-Tidal CO$_2$ Summary Table) were included for further review to answer this question; only two studies involved pediatric patients. In a prospective cohort study of children receiving CPR for in hospital cardiac arrest (IHCA) reported by Bhende and colleagues LOI D2 (Bhende, 1995, 395), the investigators examined the use of categorical (three levels) measurement of end-tidal CO$_2$. Intratracheal placement of the advanced airway and return of spontaneous circulation (ROSC) and survival were associated with the presence of a positive detection, and of a higher level of end-tidalCO$_2$, respectively. In this study, the use of end-tidal CO$_2$ allowed for the detection of esophageal placement of the tracheal tube and a higher level of end-tidalCO$_2$ at the end of the resuscitation interval was associated with a favorable outcome. A study undertaken over a 24 month period in the intensive care setting reported by Berg and colleagues (Berg, 1994, 35) LOI D5, evaluated in children with IHCA, the effect of audio-prompted rate guidance (100 or 140 per min) during chest compressions on the performance of CPR. Quantitative end-tidal
CO₂ was used as an indicator of adequacy of resuscitation. In this study, audio- prompted rate guidance during CPR resulted in higher end-tidal CO₂, suggesting improved CPR performance. Although the study did not compare whether the diagnosis of a perfusing rhythm was more accurate with end-tidal CO₂ measurement compared to clinical assessment, its results suggest that end-tidal CO₂ measurement may be used as an indicator (endpoint) of adequacy of resuscitation.

Among relevant studies in pediatric animal models (LOI D5), Berg and colleagues (Berg, 1996, 245) evaluated the differences between the characteristics of asphyxial and ventricular fibrillation (VF) piglet models of cardiac arrest. They report the association between levels of end-tidal CO₂ and achieving successful ROSC (LOI D5). Their results support earlier studies performed in adult animal models (Gudipati, 1988, 234; Trevino, 1985, 910; Weil, 1985, 907) that suggested that the use of end-tidal CO₂ during resuscitation may be useful by showing the relationship between end-tidal CO₂ and ROSC.

Among studies performed in adults, several prospective cohorts studies have been performed, across different communities, for out of hospital cardiac arrest (OHCA) or for IHCA; collectively these investigators report the association between higher end-tidal CO₂ and ROSC. Among such studies by (Asplin, 1995, 756; Cantineau, 1996, 791; Deakin, 2004, 65; Garnett, 1987, 512; Grmec, 2001, 263; Grmec, 2007, 404; Kolar, 2008, R115; Varon, 1999, 289; Wayne, 1995, 762), investigators report an association between the level of end-tidal CO₂ and achieving successful ROSC (LOI D5), while some also propose that there may be a minimal threshold (or cut-off values) associated with the probability of achieving ROSC. We summarize the diagnostic characteristics of end-tidal CO₂ measurement in four prospective cohort studies of OHCA in adults in Table 2 below; the studies were chosen based on the capacity to extract comparable or endpoints. In four studies performed in adults with OHCA [LOI D5] (Asplin, 1995, 756; Cantineau, 1996, 791; Deakin, 2004, 65; Garnett, 1987, 512; Grmec, 2001, 263; Grmec, 2007, 404; Kolar, 2008, R115; Nakatani, 1999, 203; Varon, 1999, 289; Wayne, 1995, 762), with a prevalence of ROSC ranging from 27% to 67%, they report positive predictive values of initial and maximal end-tidal CO₂ for ROSC above 55% and up to 100%.

Among randomized studies evaluating two methods of performing CPR, and where end-tidal CO₂ was measured in both groups; the investigators suggest (Dickinson, 1998, 289) in one study, that end-tidal CO₂ it may be an indicator of adequate resuscitation, while in the other study (Mauer, 1998, 67), the investigators suggest that end-tidal CO₂ may be an indicator of the patients’ prognosis (LOI D5).

**Risk and benefits associated with the use of end-tidal CO₂ devices or with the use of thresholds for the diagnosis of a perfusing rhythm:**

The risks associated with the use of end-tidal CO₂ monitoring devices during resuscitation in children are likely to be minimal. Quantitative end-tidal CO₂ monitoring is broadly used in the standard anesthesia setting and minimal risks are reported with its use; we assume that the probability of publication bias is low. Although the setting of standard anesthesia practice involves a more controlled setting than a pediatric resuscitation for OHCA or IHCA, the wide and sustained utilization of capnography, combined with the field’s collective experience, suggest that the devices themselves are probably not associated with a direct increase in risk for children undergoing resuscitation. The easiness and simplicity of the use of the devices is also inferred from studies performed in adults with OHCA mentioned above, where adherence to protocol was not often discussed, and in other studies such as the one performed by Nakatani and colleagues (Nakatani, 1999, 203) who successfully used qualitative end-tidal CO₂ with laryngeal mask airway or face mask airways in the pre-hospital setting.

The risks and benefits associated with the use of specific end-tidal CO₂ thresholds during resuscitation in children, to improve the accuracy of the diagnosis of a perfusing rhythm, remain unclear; specific values (minimal or maximal) have not been sufficiently evaluated and reported in pediatric patients with cardiac arrests to prescribe strict thresholds. In circumstances where the only changing variable is the presence or
absence of a perfusing rhythm associated with VF (e.g., in adults undergoing cardiac electrophysiology testing (Sehra, 2003, 515) LOI D5), some have illustrated that the rapid change in end-tidal CO₂, may be a simple sensitive, likely specific, method to detect the presence or absence of a perfusing rhythm. However, end-tidal CO₂ absolute values are modified by more than just the presence of a perfusing rhythm. End-tidal CO₂ values are modified by several other parameters and conditions that may be modified during a cardiac arrest or modified in a child before the event: cardiac output and pulmonary blood flow to systemic blood flow ratio, ventilation, tracheal tube patency or placement, CO₂ production and metabolism. Using end-tidal CO₂ thresholds associated with increased likelihood of achieving ROSC, proposed from evidence generated in adult studies may be reasonable for general guidance in children; however, special considerations and should be taken before applying thresholds broadly to children undergoing CPR with conditions or diseases or receiving medications that may modify absolute values of end-tidal CO₂. Such circumstances may occur in young children with complex congenital heart disease with single ventricle physiology or significant right to left shunts, in children undergoing CPR in hypothermic conditions such as after immersions in cold water or drowning, or in children receiving boluses of sodium bicarbonate. Moreover, given that absolute end-tidal CO₂ values may be modified by other factors than by the presence of a perfusing rhythm (e.g., endotracheal tube with a large leak) or that the absence of end-tidal CO₂ may be due to technical conditions (e.g., obstructed endotracheal tube), the decision to discontinue resuscitation measures should not be made based on end-tidal CO₂ values.

Acknowledgements: NA
## Table 1: End-Tidal CO₂ Summary of 22 Selected References with LOI for Assessing Diagnosis

<table>
<thead>
<tr>
<th>Author</th>
<th>LOE D (Subjects)</th>
<th>Relevance of question Yes or No: IHCA or OHCA</th>
<th>Methodology</th>
<th>Outcome</th>
<th>Magnitude</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asplin, 1995, 756</td>
<td>D5 (adults)</td>
<td>Y, OHCA</td>
<td>Fair</td>
<td>A, (B)</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Berg, 1994, 35</td>
<td>D5 (children)</td>
<td>Yes, IHCA n = 6</td>
<td>Good</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Berg, 1996, 245</td>
<td>D5 (piglet)</td>
<td>Yes, (asphyxia vs.VF)</td>
<td>Good</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Bhende, 1995, 395</td>
<td>D2 (children)</td>
<td>Yes, IHCA</td>
<td>Good</td>
<td>A, (B)</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Cantineau, 1996, 791</td>
<td>D5 (older adults)</td>
<td>Yes, OHCA</td>
<td>Good</td>
<td>A</td>
<td>ROC and cutoffs</td>
<td>Supportive</td>
</tr>
<tr>
<td>Deakin, 2004, 65</td>
<td>D5 (adults, trauma)</td>
<td>Yes, excluded</td>
<td>Poor</td>
<td>B</td>
<td>B</td>
<td>Supportive</td>
</tr>
<tr>
<td>Garnett, 1987, 512</td>
<td>D5 (adults)</td>
<td>Yes, OHCA in ER</td>
<td>Fair</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Grmec, 2001, 263</td>
<td>D5 (adults)</td>
<td>Yes, OHCA</td>
<td>Fair</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Grmec, 2007, 404</td>
<td>D5 (adults)</td>
<td>Yes, OHCA</td>
<td>Good</td>
<td>A, B</td>
<td>Supportive</td>
<td></td>
</tr>
<tr>
<td>Gudipati, 1988, 234</td>
<td>D5 (swine)</td>
<td>Yes</td>
<td>Fair</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Kolar, 2008, R115</td>
<td>D5 (adults)</td>
<td>Yes, OHCA</td>
<td>Good</td>
<td>A, B</td>
<td>Specific cut offs</td>
<td>Supportive</td>
</tr>
<tr>
<td>Lepilin, 1987, 958</td>
<td>D5 (adults)</td>
<td>No, IHCA post CPB</td>
<td>Fair</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Malzer, 1996, 243</td>
<td>D5 (adults)</td>
<td>No, OHCA ACD</td>
<td>Good</td>
<td>A</td>
<td>-</td>
<td>neutral</td>
</tr>
<tr>
<td>Nakatani, 1999, 203</td>
<td>D5 (adults)</td>
<td>Yes, OHCA</td>
<td>Good</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Pokorna, 2006, 317</td>
<td>D5 (adults)</td>
<td>No, OHCA</td>
<td>Poor (3 cases)</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Sehra, 2003, 515</td>
<td>D5 (adults)</td>
<td>Yes, IHCA EP study</td>
<td>Poor</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Trevino, 1985, 910</td>
<td>D5 (swine)</td>
<td>Yes</td>
<td>Fair</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
</tr>
<tr>
<td>Varon, 1991, 289</td>
<td>D5 (adults)</td>
<td>Yes, CA and RA</td>
<td>Fair</td>
<td>A</td>
<td>-</td>
<td>Supportive</td>
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<tr>
<td>Wayne, 1995, 762</td>
<td>D5 (adults)</td>
<td>Yes, OHCA</td>
<td>Good</td>
<td>A, B</td>
<td>Specific cut off</td>
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<td>Weil, 1985, 907</td>
<td>D5 (swine)</td>
<td>Yes</td>
<td>Fair</td>
<td>E (cardiac output)</td>
<td>Supportive</td>
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**Question Peds 005B:** In pediatric patients with cardiac arrest (prehospital [OHCA] or in-hospital [IHCA]) (P), does the use of end-tidal CO₂ (I), compared with clinical assessment (C), improve accuracy of diagnosis of a perfusing rhythm (O)?

**Methodology:** Good, Fair, Poor. **Outcomes:** A = Return of spontaneous circulation; B = Survival of event; C = Survival to hospital discharge; D = Intact neurological survival; E = Other endpoint
Table 2: Positive and negative predictive values of end-tidal CO₂ for the diagnosis of ROSC in four selected prospective cohort studies in adults with OHCA (LOI D5)

<table>
<thead>
<tr>
<th>Study Time of end-tidal CO₂</th>
<th>Subjects with ROSC Yes/NO (N)</th>
<th>Total Analyzed (N)</th>
<th>Prevalence ROSC (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Cantineau, 1996, 791) Initial end-tidal CO₂</td>
<td>30/66</td>
<td>96</td>
<td>27</td>
<td>87</td>
<td>74</td>
<td>60</td>
<td>92</td>
</tr>
<tr>
<td>(Cantineau, 1996, 791) Maximal end-tidal CO₂</td>
<td>30/66</td>
<td>96</td>
<td>31</td>
<td>100</td>
<td>67</td>
<td>58</td>
<td>100</td>
</tr>
<tr>
<td>(Grmec, 2001, 263) Initial end-tidal CO₂</td>
<td>41/68</td>
<td>139</td>
<td>29</td>
<td>100</td>
<td>74</td>
<td>56</td>
<td>92</td>
</tr>
<tr>
<td>(Grmec, 2001, 263) Minimal end-tidal CO₂</td>
<td>41/68</td>
<td>139</td>
<td>29</td>
<td>60</td>
<td>90</td>
<td>87</td>
<td>92</td>
</tr>
<tr>
<td>(Grmec, 2007, 404) Initial end-tidal CO₂</td>
<td>186/91</td>
<td>277</td>
<td>67</td>
<td>OR 1.61 [1.28-2.64]*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Kolar, 2008, R115) Initial end-tidal CO₂</td>
<td>438/299</td>
<td>737</td>
<td>59</td>
<td>100</td>
<td>50</td>
<td>71</td>
<td>100</td>
</tr>
<tr>
<td>(Kolar, 2008, R115) Mean End-tidal CO₂ at 20min (14.3mmHg)</td>
<td>438/299</td>
<td>737</td>
<td>59</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet Question Peds 005B: In pediatric patients with cardiac arrest (prehospital [OHCA] or in-hospital [IHCA]) (P), does the use of end-tidal CO₂ (I), compared with clinical assessment (C), improve accuracy of diagnosis of a perfusing rhythm (O)? * Odds ratio of achieving ROSC with 95% Confidence Interval.

LOI D5; methodology level: fair; outcome: ROSC, survival; direction: supportive.


LOI D5; IHCA in children; methodology good; outcome: ROSC; supportive. Study not designed to evaluate the diagnostic capacity of ETCO2 but suggestive that it may inform on CPR performance.


LOI D5; asphyxial vs. VF CA in piglets; methodology; good; outcome: ROSC; supportive.


LOI D2; IHCA in children; methodology good; outcome: ROSC and survival; supportive.


LOI D5; OHCA in older adults; methodology good; outcome: ROSC, Sens-Spec 10 torr cutoff.


LOI D5; adults with trauma; methodology: poor; outcome: survival; supportive.


LOI D5; adults OHCA, evaluation of Thumper device; methodology: good; outcome: ROSC; neither supportive or negative (also retrieved in Cochrane Clinical Trials Database).


LOI D5; adults OHCA in ER; methodology: fair; outcome: ROSC; supportive.

LOI D5; adults OHCA; methodology fair; outcome: ROSC; supportive.


LOI D5; adults OHCA; methodology: good; outcomes: ROSC and survival; supportive.


LOI D5; swine CA; methodology: fair; outcome: ROSC; supportive.


LOI D5; adults OHCA; methodology good; outcome ROSC and survival; estimation of cut offs at specific times during resuscitation; supportive.


LOI D5; not specifically relevant IHCA post CPB for specific results but relevant for illustration of diagnostic representation of cardiac output by ETCO2; methodology: fair; outcome ROSC; supportive.


LOI D5; not specifically relevant for review; OHCA and ACD; methodology: good; outcome: ROSC; neutral.


LOI D5; not specifically relevant for pediatric review; OHCA and ACD; methodology: fair; outcome: ROSC; supportive; retrieved in Cochrane Clinical Trials Database.


LOI D5; adults OHCA; methodology: good; outcome: ROSC; supportive;also retrieved in Cochrane Clinical Trials Database.


LOI D5; not immediately relevant for pediatric review; OHCA; methodology: poor (case series 3 cases); outcome: ROSC.

LOI D5; IHCA during EP studies of adults; methodology: poor; outcome: ROSC; supportive.


LOI D5; swine CA; methodology: fair; outcome: ROSC; supportive.


LOI D5; adults with RA and CA; methodology: poor; outcome: ROSC; supportive.


LOI D5; adults OHCA; methodology: good; outcomes: ROSC and survival; specific cut off but unable to re-run their estimates (?) (if specificity 100% and PPV 100%?; supportive.


LOI D5; swine CA; methodology: fair; outcome: cardiac output; supportive.