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

Worksheet author(s)

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Clinical question.

Does the use of end-tidal CO2 monitoring during cardiac arrest guide more appropriate management?

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

This question is answering the prognosis. End-tidal carbon dioxide is a marker for the prognosis of ROSC and survival.

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

Revision of existing worksheet

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).

List of electronic database searched- Cochrane database for systematic reviews and Central Register of Controlled Trials [http://www.cochrane.org/], MEDLINE [http://www.ncbi.nlm.nih.gov/PubMed/

Pubmed:

Following Mesh words were used to search the articles related to the research questions-

End tidal CO2, End tidal Carbon dioxide, CPR, Cardiopulmonary resuscitation, hypercapnia, hypercarbia, hypocapnia, hypocarbia, normocapnia, normocarbia, cardiac arrest, heart arrest.

end-tidal CO2 AND CPR- 64 hits
end-tidal CO2 AND cardiopulmonary resuscitation- 84 hits
end-tidal CO2 AND cardiac arrest: 83 hits
end-tidal carbon dioxide AND CPR: 88 hits
end-tidal carbon dioxide AND cardiopulmonary resuscitation: 131 hits
end-tidalcarbon dioxide AND cardiac arrest: 171 hits
hypocapnia AND cpr: 6 hits
hypocapnia AND cardiopulmonary resuscitation:13 hits
hypocapnia AND cardiac arrest: 22 hits
normocpnia AND cpr: 4 hits
normocpnia AND cardiopulmonary resuscitation: 4 hits
normocpnia AND cardiac arrest: 5 hits
hypercapnia AND cpr: 14 hits
hypercapnia AND cardiopulmonary resuscitation: 31 hits
hypercapnia AND cardiac arrest: 86 hits
hypocarbia AND cpr: 8 hits
hypocarbia AND cardiopulmonary resuscitation: 15 hits
hypocarbia AND cardiac arrest: 29 hits
normocarbia AND cpr: 0 hits
normocarbia AND cardiopulmonary resuscitation: 2 hits
normocarbia AND cardiac arrest:
hypercarbia AND cpr: 21 hits
hypercarbia AND cardiopulmonary resuscitation: 44 hits
hypercarbia AND cardiac arrest: 108 hits

Cochrane Library (including Registry of controlled Trials):

endtidal CO2: 35 hits
end-tidal CO2: 257 hits
endtidal carbon dioxide: 20 hits
end-tidal carbon dioxide: 270 hits

Cochrane Review:
Ventilation: 298 hits
CPR: 3 hits
CO2: 14 hits

Embase: No search performed.

• State inclusion and exclusion criteria

Inclusion criteria- Studies, which measured, end tidal CO2 after cardiac arrest on commencement of CPR also included studies looking at ROSC, neurological outcome, and survival of the event, long-term survival after cardiac arrest.

Exclusion criteria- Abstract only studies

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

In total 38 articles were selected for detailed review. Out of the 38 only 12 were relevant to question. Out of these 12 articles, 6 articles were relevant in terms of neurological outcome and long-term survival.

Summary of evidence

Evidence Supporting Clinical Question

Good		**Grmec 2003[C]** **Grmec 2001[A]** **Ahrens 2001[C]** **Sanders 1989[A,B]** **Levine 1997[C,D]** **Wayne 1995[A]**	**Aspilin 1995[A]**		
Fair					**Sehra 2003[E]** **Nakatani 1999[E]** **Mauer 1998[B]** **Bhende 1995[B]** **White 1994[E]**
Poor					
	P1	**P2**	**P3**	**P4**	**P5**
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

Good		**Wayne 1995[D]**			
Fair					
Poor					
	P1	**P2**	**P3**	**P4**	**P5**
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 Opposing Clinical Question

Good					
Fair					
Poor					
	P1	**P2**	**P3**	**P4**	**P5**
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

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

End-tidal carbon dioxide is a marker for the prognosis of ROSC and survival. Higher levels correlate with a better chance for ROSC and survival. The Results of the animal and the patient data are consistently positive. After successful intubation, start of controlled ventilation and effective CPR, patients with achieving a maximum value of end-tidal carbon dioxide of less than 10 mmHg have a poor prognosis. Normally those Patients will not survive.
There are 6 good LOE-P2 studies (Grmec 2003, 89, , Grmec 2001,263, Ahrens 2001, 391, Sanders 1989,1347, Wayne 1995,762, and Levine 1997,301) and 1 good LOE-P3 study (Aspilin 1995, 756), which indicates that higher the maximal endtidal CO2 levels, can predict return of spontaneous circulation.
In regards to neurological outcome 3- LOE P2 studies (Ahrens 2001, 391, Grmec 2003,89, Grmec 2001,263) showed that the patients who had high end tidal CO2 survived the cardiac arrest and had better neurological outcome as compared to the ones who had low end tidal CO2 and died. The initial low end tidal CO2 were associated with high mortality and also poor neurological outcome. The 5 fair LOE5 studies also support this finding but don't comment about the neurological outcome. The studies which indicate end tidal CO2 as positive predictor of the outcome the timings of measuring end tidal CO2 were either immediately after arrest or after intubation and subsequent readings were taking after return of spontaneous circulation or 10 &20 minutes.

Clinical studies have shown that patients who were successfully resuscitated from cardiac arrest had significantly higher end-tidal CO2 levels than patients who could not be resuscitated. The use of end-tidal CO2 (capnometry) is very well supported in the literature. The older literature and the studies over the past few years are consistent, which shows that higher end-tidal CO2 levels during CPR are correlated with ROSC and possibly with good neurological outcome.

Acknowledgements:

Citation List

Ahrens 2001 (391-8)	Ahrens T, Schallom L, Bettorf K, Ellner S, Hurt G, O'Mara V, Ludwig J, George W, Marino T, Shannon W. End-tidal carbon dioxide measurements as a prognostic indicator of outcome in cardiac arrest. Am J Crit Care. 2001 Nov;10(6):391-8. LOE P2, Good. End point C. 127 patients; etCO2 every 5 minutes during cpr; all except one patient with an etCO2-levels less than 10 mmHg did not survive; survivors had etCO2-levels greater than 10 mmHg; one patient with an initial etCO2 < 10 mmHg survived
Aspilin 1995 (756-61)	Asplin BR, White RD Prognostic value of end-tidal carbon dioxide pressures during out-of-hospital cardiac arrest. Ann Emerg Med. 1995 Jun;25(6):756-61. LOE P3, Good Endpoint A Observational study on 27 patients; patient having a ROSC had a significant higher 1-minute and maximum etCO2 than those without ROSC.
Bhende 1995 (395-99)	Bhende, M. S. and A. E. Thompson (1995). "Evaluation of an end-tidal CO2 detector during pediatric cardiopulmonary resuscitation." Pediatrics 95(3): 395-399. LOE P5, fair, supportive, End point B. Pediatric human observational case series; prognostic value of capnometry

	supported
Grmec 2003 (89-96)	Grmec S, Kupnik D. Does the Mainz Emergency Evaluation Scoring (MEES) in combination with capnometry (MEESc) help in the prognosis of outcome from cardiopulmonary resuscitation in a prehospital setting? Resuscitation. 2003 Jul;58(1):89-96. LOE P2, Good. End point C. Prospective; 246 patients with out-of-hospital cardiac arrest; only patients with an initial etCO2 > 10 mmHg had a ROSC or survived to ICU-discharge.
Grmec, S. (2001) (263-9)	Grmec, S. and P. Klemen (2001). "Does the end-tidal carbon dioxide (EtCO2) concentration have prognostic value during out-of-hospital cardiac arrest?" Eur J Emerg Med 8(4): 263-9. LOE P2, Good, supportive; human observational study correlating ETCO2 with ROSC. End point A
Levine 1997 (301-6)	Levine RL, Wayne MA, Miller CC. End-tidal carbon dioxide and outcome of out-of-hospital cardiac arrest. N Engl J Med. 1997 Jul 31;337(5):301-6. LOE P2, Good. Endpoint C and D prospective observational study; prehospital cardiac arrest; 150 patients; no difference between survivors and non-survivors looking at initial etCO2-values. Second measurement after 20 min with a significant difference (higher etCO2 in the survivor group). An etCO2 < 10 mmHg after 20 min of CPR was a predictor of death.
Mauer, D. (1998) (67-74)	Mauer, D., T. Schneider, et al. (1998). "Carbon dioxide levels during pre-hospital active compression--decompression versus standard cardiopulmonary resuscitation." Resuscitation 39(1-2): 67-74. LOE P5, fair, supportive; observation of ETCO2 levels from an ACD-CPR study.
Nakatani 1999 (203-6)	Nakatani K, Yukioka H, Fujimori M, Maeda C, Noguchi H, Ishihara S, Yamanaka I, Tase C. Utility of colorimetric end-tidal carbon dioxide detector for monitoring during prehospital cardiopulmonary resuscitation. Am J Emerg Med. 1999 Mar;17(2):203-6. LOE P5, Fair. End point E. 121 patients with pre-hospital CPR; etCO2-measurement using a laryngeal mask; patient with an etCO2 <0,5% had a significant lower ROSC rate than patients with an etCO2 >2%.

Sanders 1989 (1347-1351)	Sanders AB, Kern KB, Otto CW, Milander MM, Ewy GA. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation: a prognostic indicator for survival JAMA. 1989;262:1347-1351 LOE P5, fair evidence, not directly answering the neurological outcome. Endpoint A
Sehra 2003 (515-7)	Sehra R, Underwood K, Checchia P. End tidal CO2 is a quantitative measure of cardiac arrest. Pacing Clin Electrophysiol. 2003 Jan;26(1 Pt 2):515-7. LOE P5, Fair. End point E. 11 patients; prospective; during ICD-implantation
White 1994 (25-30)	White RD, Asplin BR. Out-of-hospital quantitative monitoring of end-tidal carbon dioxide pressure during CPR. Ann Emerg Med. 1994 Jan;23(1):25-30. LOE P5, Fair. Endpoint E. In a pilot study over 4 patients end-tidal CO2 was measured. The authors report that changes of chest compressions resulted in end-tidal CO2 changes

Wayne 1995 (762-7)	Wayne MA, Levine RL, Miller CC. Use of end-tidal carbon dioxide to predict outcome in prehospital cardiac arrest. Ann Emerg Med. 1995 Jun;25(6):762-7. LOE P2, Good. Endpoint A. Prospective observational study; prehospital cardiac arrest; 90 patients; no difference between survivors and non-survivors looking at initial etCO2-values. Second measurement after 20 min with a significant difference (higher etCO2 in the survivor group). An etCO2 < 10 mmHg after 20 min of CPR was a predictor of death.