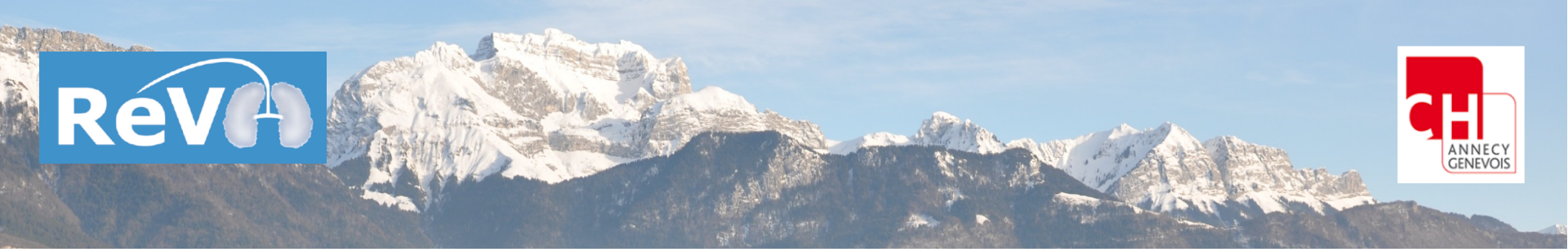


VENTILATION AU COURS DE L'ARRET CARDIAQUE

Pr Jean-Christophe M Richard

Pôle SAMU 74 Urgence et Réanimation Centre Hospitalier Annecy Genevois
INSERM UMR 955 Creteil

CAVIAR
Cardiac Arrest and Ventilation
International Association for Research

CONFLICTS OF INTEREST

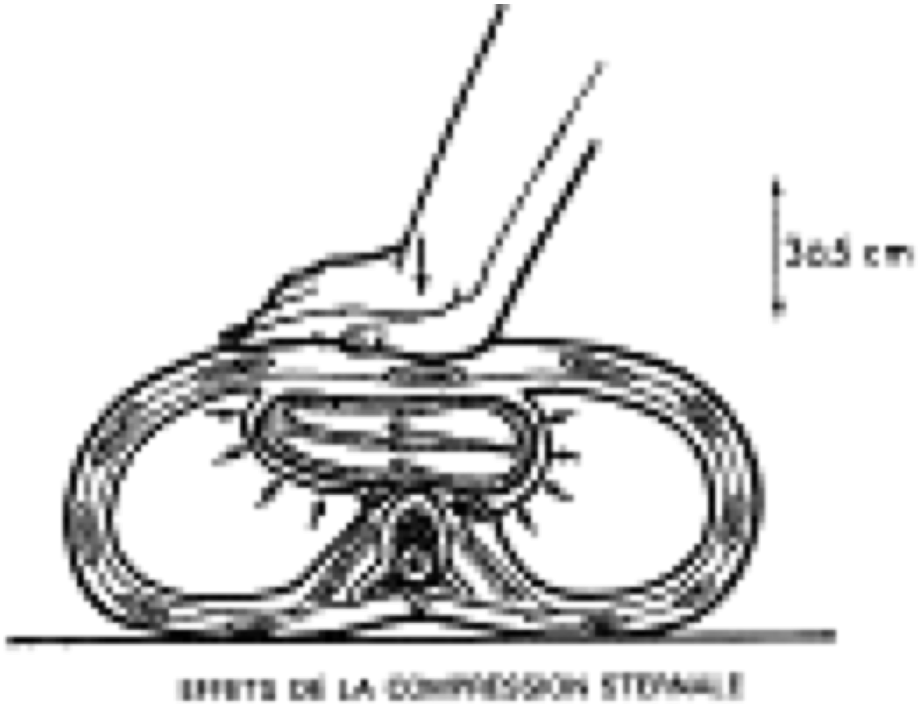
Air Liquide Medical Systems (Med 2 Lab)

Grant from SRLF 2014
Grant from AL 2018

Financial support for research (Genève /Annecy/Angers)

- VYGON (personal fee for lectures)
- SHILLER
- COVIDIEN (PAV+ patent) (personal fee for lectures)
- GE (FRC patent)

Classical interpretation of CPR physiology



EFFETS DE LA COMPRESSION STERNALE

Circulation ***Ventilation***

QUESTION 1 Quelles sont les propositions vraies ?

1. C’est la théorie dite de la pompe cardiaque qui explique la ventilation
2. Les Vt générés par les CT sont suffisants au début de la RCP
3. L’effet des CT sur la circulation ne fonctionnerait pas « sans » CRF
4. L’interruption des CT est délétère même si elle est très brève
5. Les CT sont moins efficaces si le thorax est insufflé au dessus de la CRF

QUESTION 1 Quelles sont les propositions vraies ?

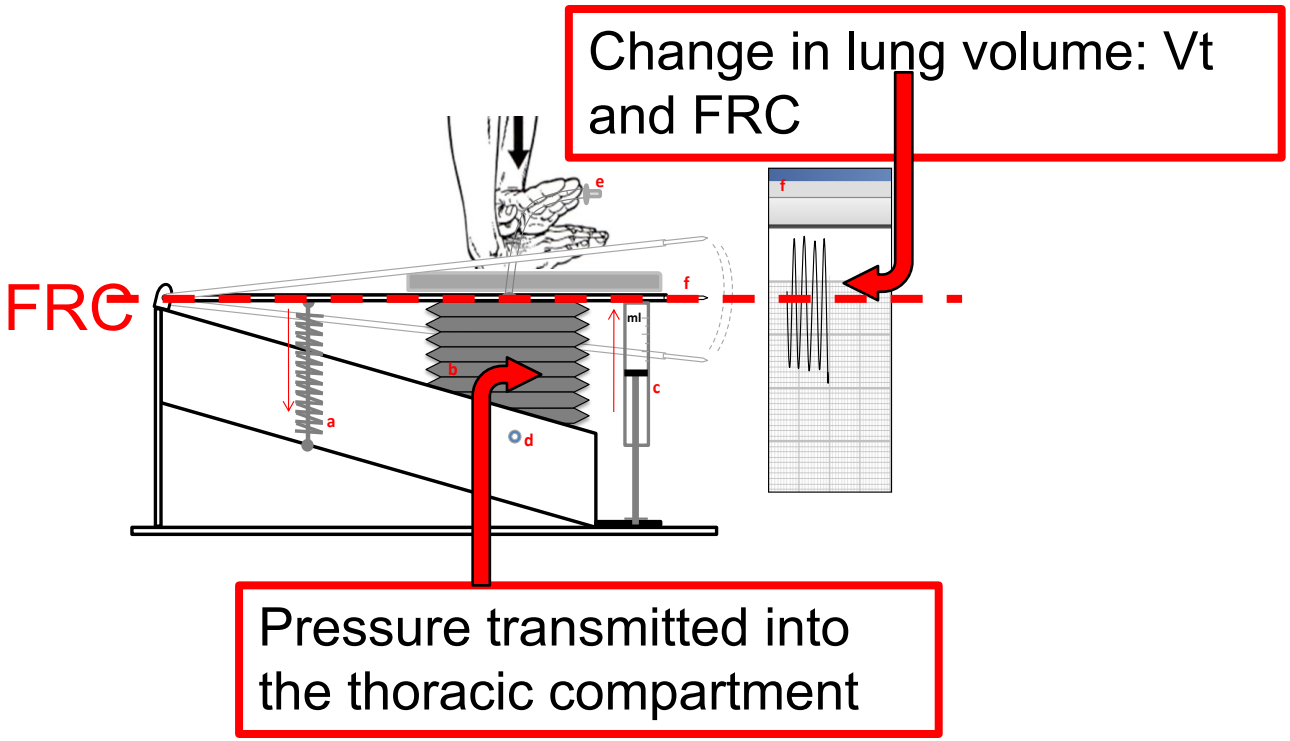
1. C'est la théorie dite de la pompe cardiaque qui explique la ventilation
2. Les Vt générés par les CT sont suffisants au début de la RCP
3. L'effet des CT sur la circulation ne fonctionnerait pas « sans » CRF
4. L'interruption des CT est délétère même si elle est très brève
5. Les CT sont efficaces même quand le thorax est insufflé au dessus de la CRF

J Appl Physiol 120: 000–000, 2016.
First published November 19, 2015; doi:10.1152/japplphysiol.00632.2015.

Impact of ventilation strategies during chest compression. An experimental study with clinical observations

Ricardo L. Cordioli[1,2,3], Aissam Lyazidi[1,4,5] Nathalie Rey[6], Jean-Max Granier[1],

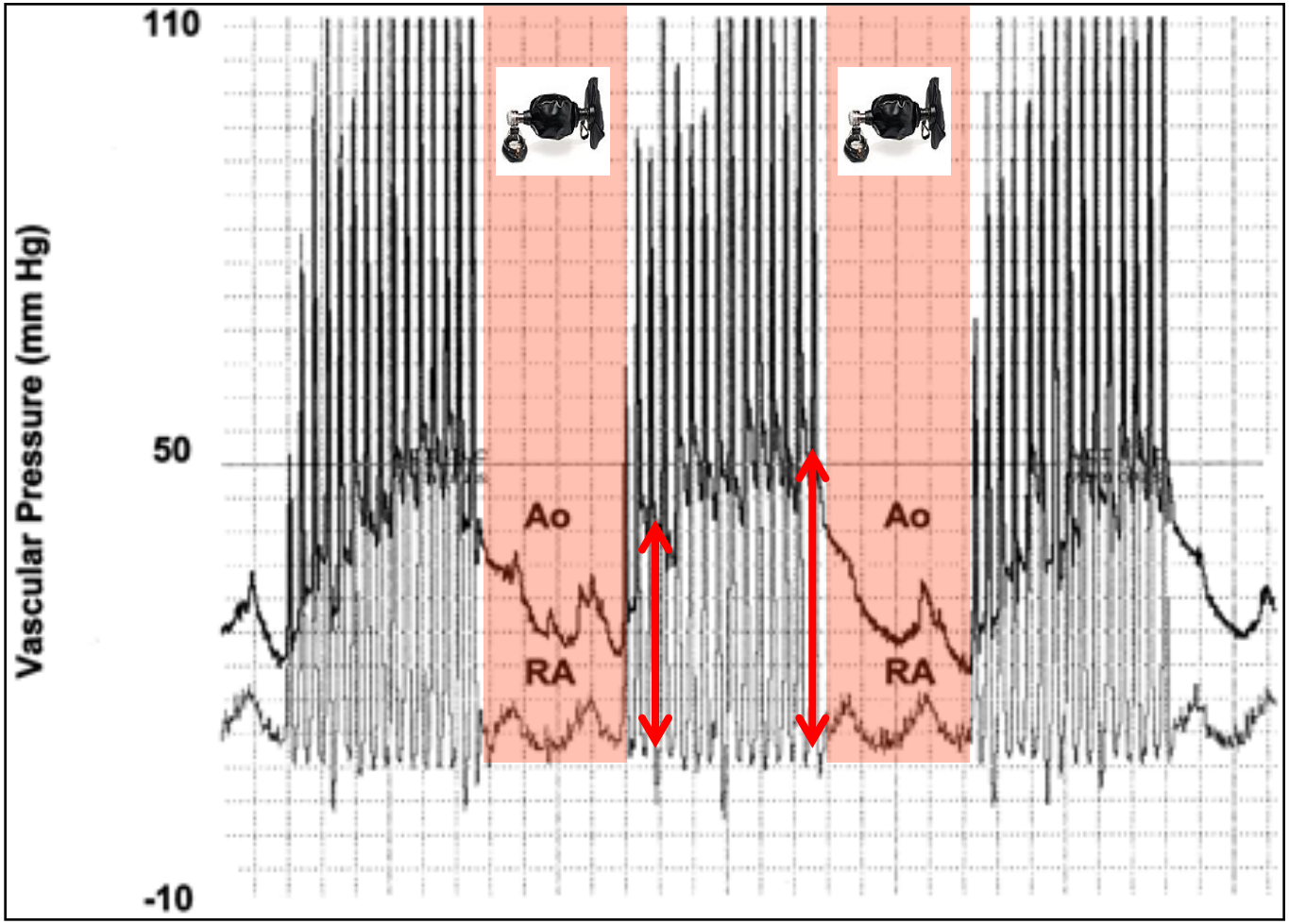
Dominique Savary[7], Laurent Brochard [8,9,10], Jean-Christophe M Richard[7,10]



aps American Physiological Society
Journal of Applied Physiology

Adverse Hemodynamic Effects of Interrupting Chest Compressions for Rescue Breathing During CPR for Ventricular Fibrillation Cardiac Arrest

Berg et al. Circulation. 2001;104:2465



« Interrupting chest compressions for rescue breathing can adversely affect hemodynamics during CPR for VF »

Ventilation and Circulation with Closed-Chest Cardiac Massage in Man

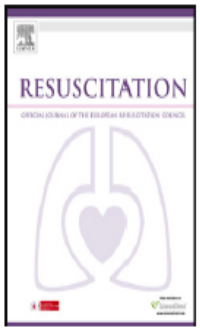
Peter Safar, M.D., Torrey C. Brown, Warren J. Holtey, M.D., and Robert J. Wilder, M.D., Baltimore

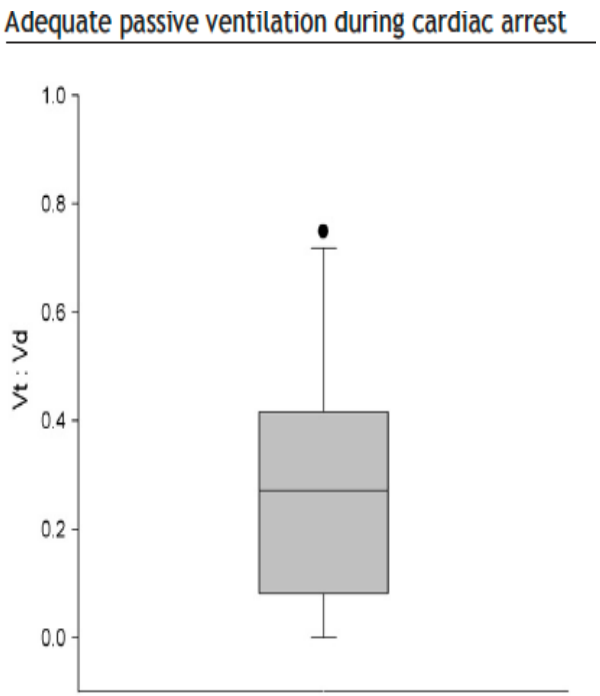
- ETI + curarised subjects → Manual CC generates 156mL of V_T (0 to 390mL)
- ETI + cardiac arrest subjects →Manual CC generates no V_T

J.A.M.A., May 20, 1961

Does compression-only cardiopulmonary resuscitation generate adequate passive ventilation during cardiac arrest?☆

Charles D. Deakin[a,*], John F. O'Neill[b], Ted Tabor[c]



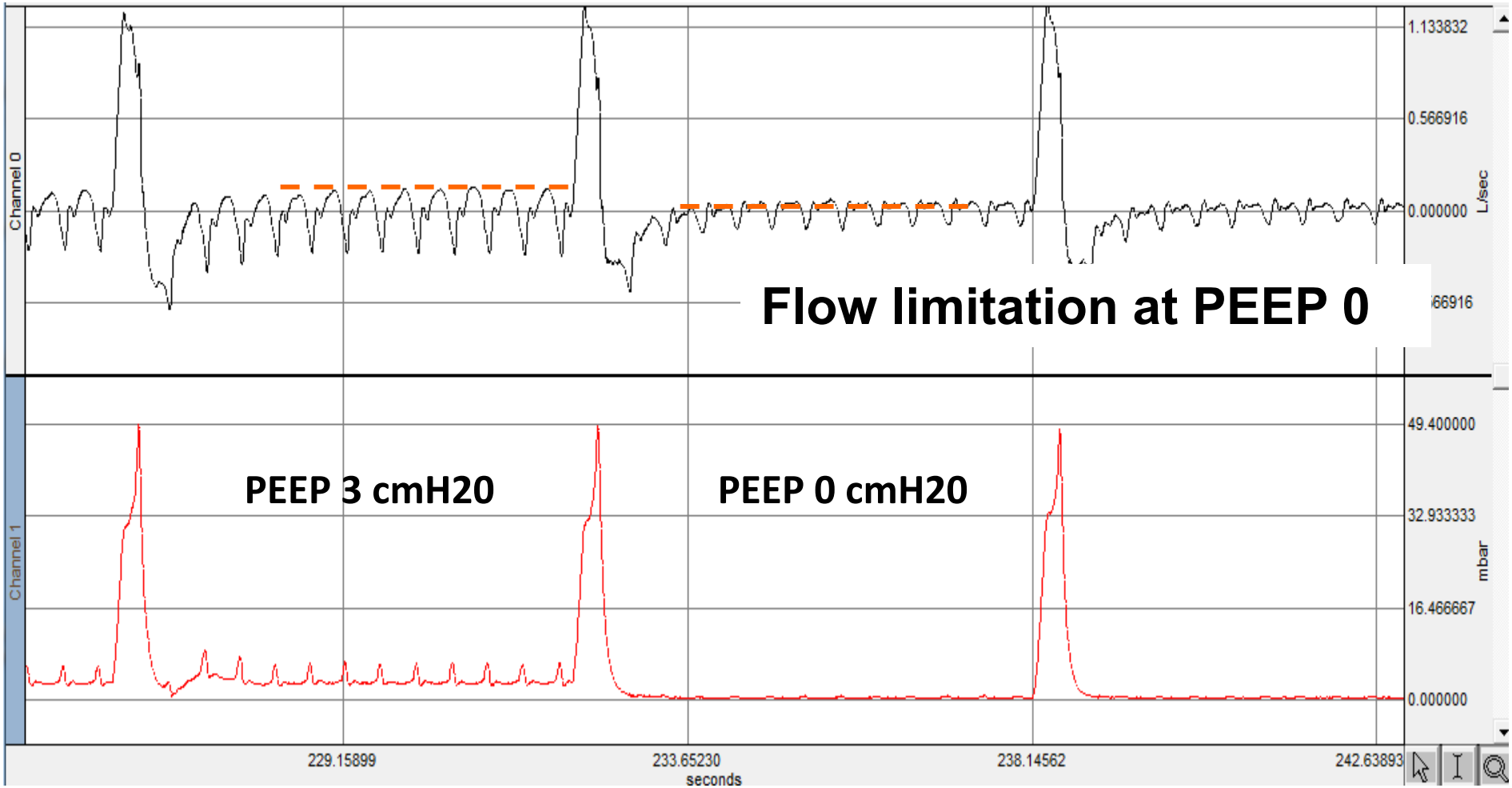


The median Vt per compression : 41.5 ml (33.0-62.1 ml) which was considerably less than measured dead space

Reduction in lung volume below FRC induced by Chest compressions

Cordioli et al. J Appl

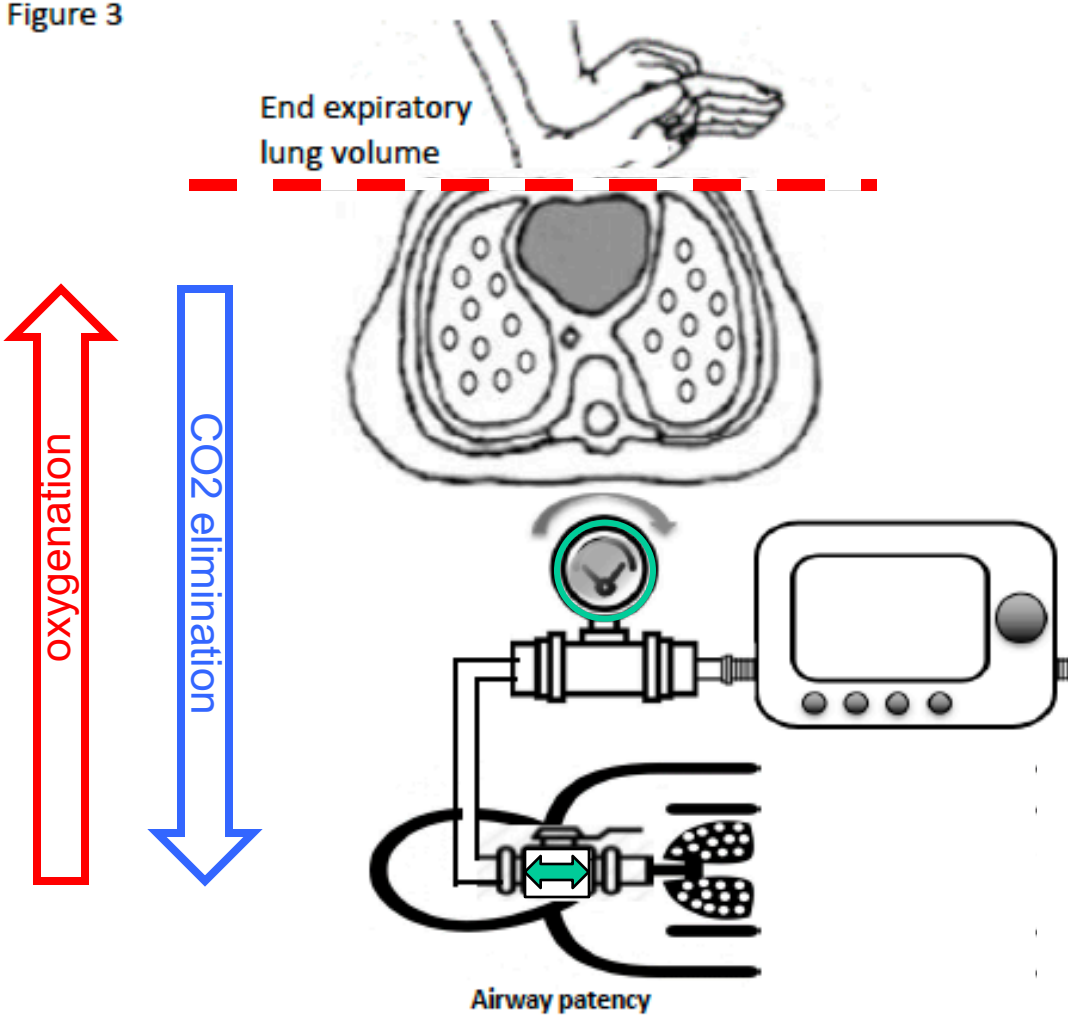
Thoracic airways closure limiting inspiratory flow during Chest compressions



Cordioli et al. J Appl

Impact of thoracic airway closure on gas exchanges

Figure 3



Cordioli et al. Curent Op Crit Care (submitted)

Clinical paper

A new physiological model for studying the effect of chest compression and ventilation during cardiopulmonary resuscitation: The Thiel cadaver☆

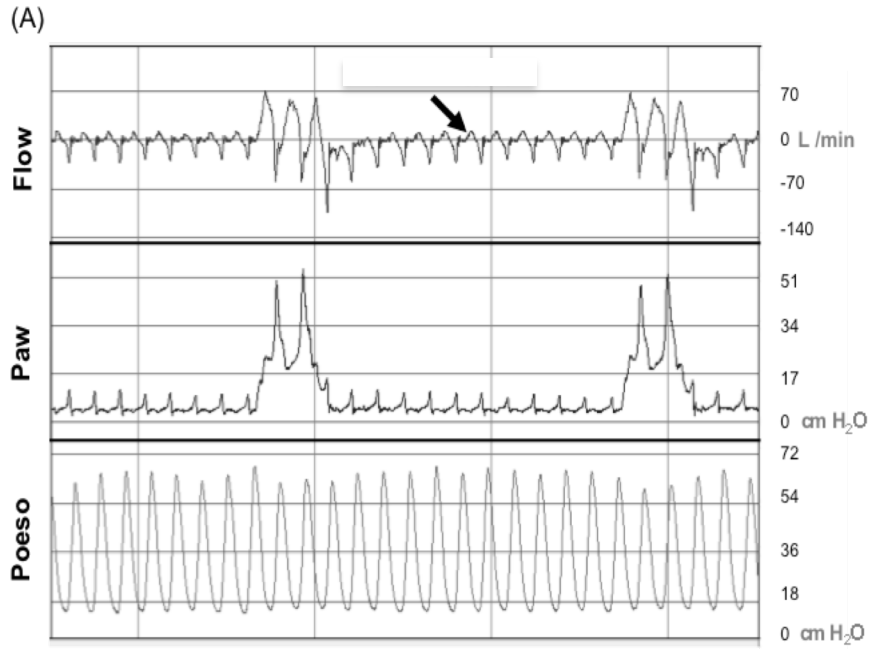
Emmanuel Charbonney[a,b,c,*], Stéphane Delisle[d], Dominique Savary[e], Gilles Bronchti[c], Marceau Rigollot[f], Adrien Drouet[e], Bilal Badat[f], Paul Ouellet[g], Patrice Gosselin[h], Alain Mercat[i], Laurent Brochard[j,k], Jean-Christophe M. Richard[e,l], on behalf of the CAVIAR[1]

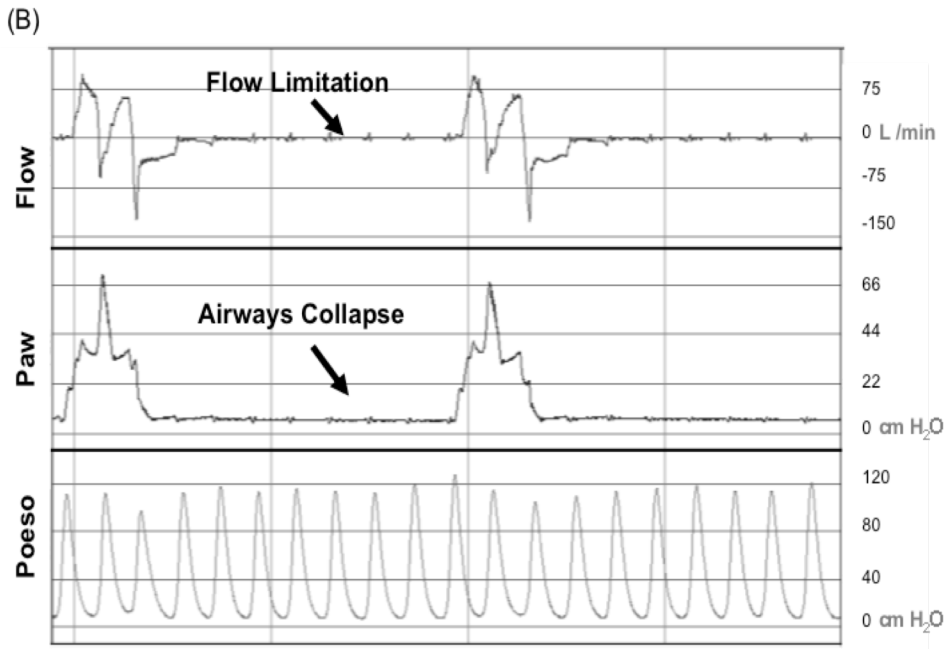
Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL





For similar chest compressions, thoracic airways closure limits both Paw transmission and ventilation….

As results, thoracic airways closure may affect capnogram and therefore be informative regarding ventilation ….

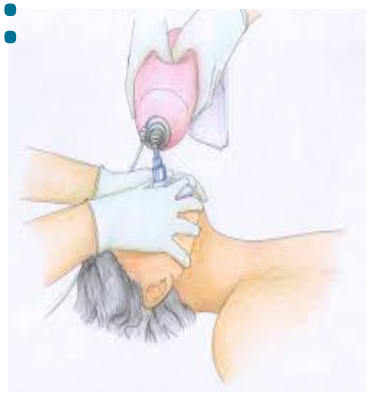
QUESTION 2 Quelles sont les propositions vraies ?

1. La stratégie 30:2 est toujours recommandée avant l'intubation
2. Il est recommandé de ne pas interrompre les CT lors de l'intubation
3. Après l'intubation il est recommandé d'alterner les CT et 10 insufflations par min
4. Les CT pendant l'insufflation augmentent le risque d'inhalation gastrique
5. Les CT pendant l'insufflation gastrique empêchent une ventilation efficace

QUESTION 2 Quelles sont les propositions vraies ?

1. La stratégie 30:2 est toujours recommandée avant l'intubation
2. Il est recommandé de ne pas interrompre les CT lors de l'intubation
3. Après l'intubation il est recommandé d'alterner les CT et 10 insufflation par min
4. Les CT pendant l'insufflation augmentent le risque d'inhalation gastrique
5. Les CT pendant l'insufflation gastrique empêchent une ventilation efficace

Risks associated with 30:2 bag mask CPR: Gastric Inflation



RESUSCITATION 146 (2020) 111 –117

Available online at www.sciencedirect.com

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL

ELSEVIER

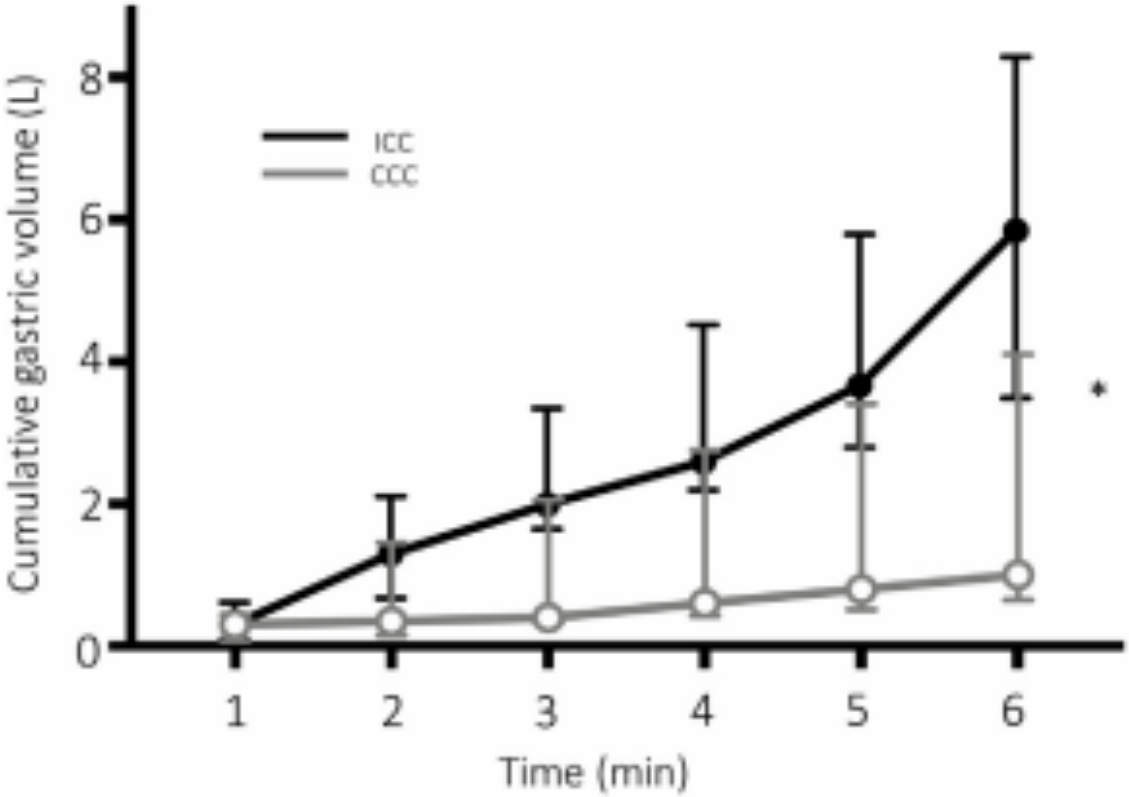
Experimental paper

Gastric insufflation during cardiopulmonary resuscitation: A study in human cadavers

Dominique Savary[a,], Ian R. Drennan[b], Bilal Badat[c], Domenico L. Grieco[d], Thomas Piraino[e,f], Arnaud Lesimple[g], Emmanuel Charbonney[h,i], Caroline Fritz[j,k], Stephane Delisle[l], Paul Ouellet[m], Alain Mercat[n], Gilles Bronchti[o], Laurent Brochard[p,q], Jean-Christophe Richard[r], on behalf of the CAVIAR group[1]*

CAVIAR
Cardiac Arrest and Ventilation
International Association for Research

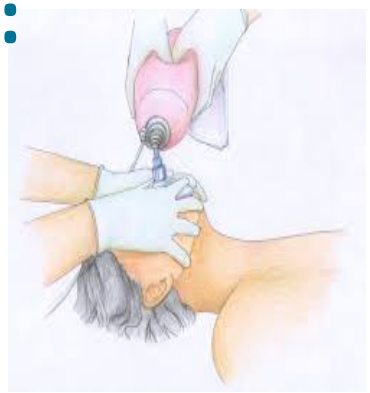
Risks associated with 30:2 bag mask CPR: Gastric Inflation



Accumulated gastric volume inflated after each minute of chest compressions regarding 2 different strategies of bag mask ventilation

(5 thiel cadavers - median with interquartile range)

Risks associated with 30:2 bag mask CPR: Gastric Inflation



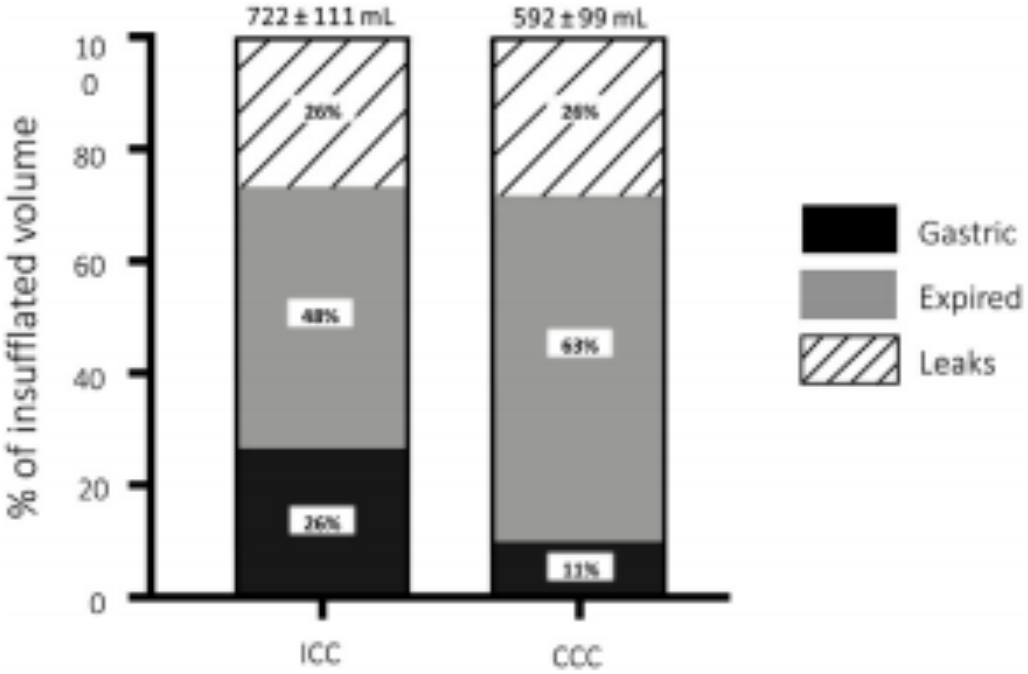
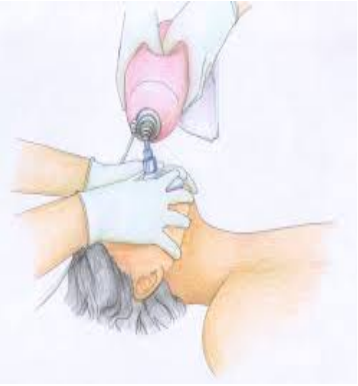


Fig. 3 – Repartition of inspired volume delivered by one bag mask insufflation.

CAVIAR
Cardiac Arrest and Ventilation
International Association for Research

Risks associated with 30:2 bag mask CPR: Gastric Inflation



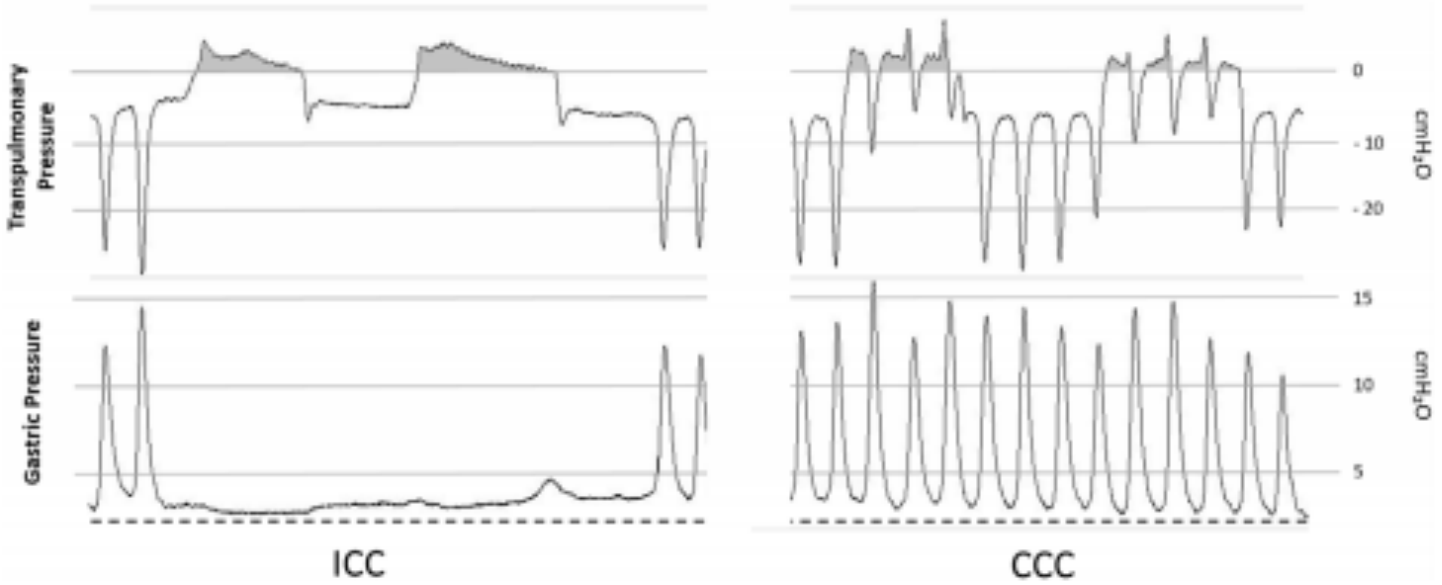
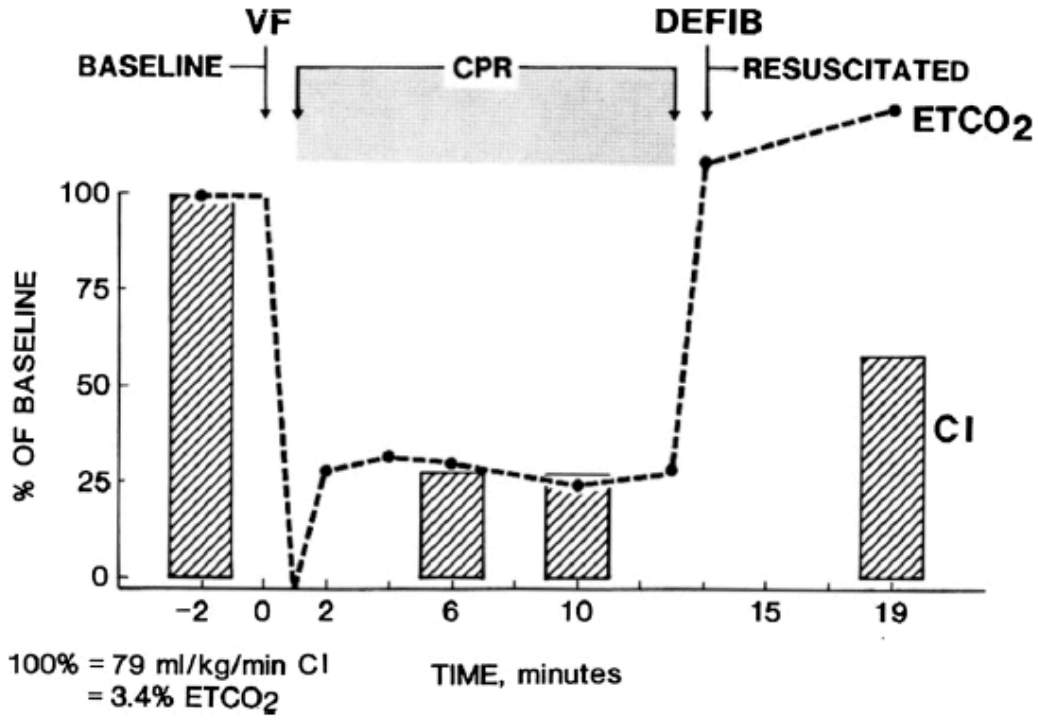


Fig. 4 – Pressure tracings during bag mask insufflations.



Gudipati et al. Circulation 1988; 77:234-9.

QUESTION 3 Quelles sont les propositions vraies ?

Il est recommandé d'utiliser le signal d'EtCO2 pendant la RCP pour:

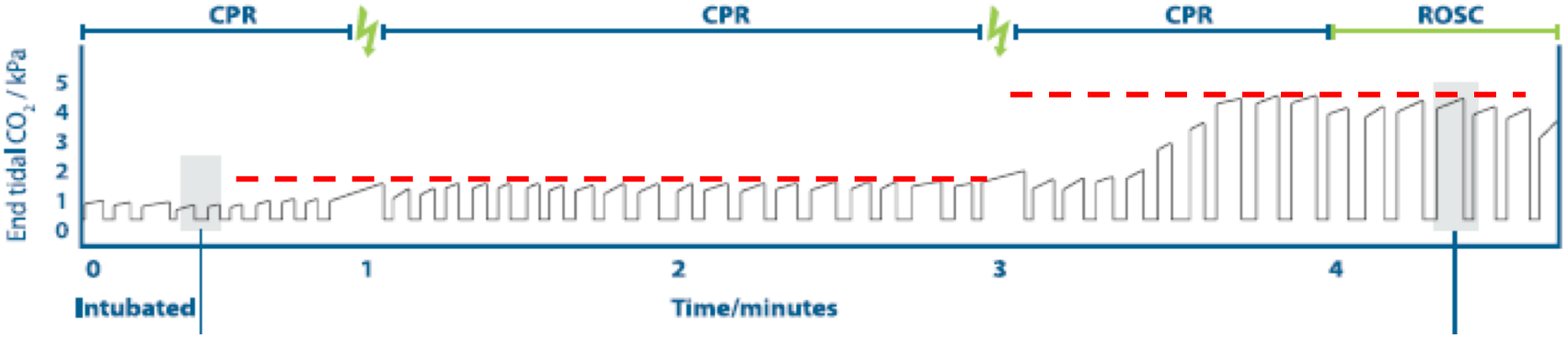
1. Vérifier le bon placement de la sonde d'intubation
2. Pour monitorer la FR au BAVU
3. Pour détecter le ROSC
4. Pour décider de la poursuite de la RCP
5. Pour adapter la ventilation

QUESTION 3 Quelles sont les propositions vraies ?

Il est recommandé d'utiliser le signal d'EtCO2 pendant la RCP pour:

1. Vérifier le bon placement de la sonde d'intubation
2. Pour monitorer la FR au BAVU
3. Pour détecter le ROSC
4. Pour décider de la poursuite de la RCP
5. Pour adapter la ventilation

ERC Guidelines 2015 on $EtCO_2$ monitoring



1. To check proper placement of tracheal tube
2. To monitor respiratory rate to avoid hyperventilation
3. To assess quality of chest compressions
4. To detect ROSC without interrupting chest compressions

"Our Lack of confidence in the accuracy of $EtCO_2$ measurement during CPR, and the need of advance airway to measure EtCO2 reliably, limits our confidence in its use for prognostication" ….

Available online at www.sciencedirect.com

Resuscitation

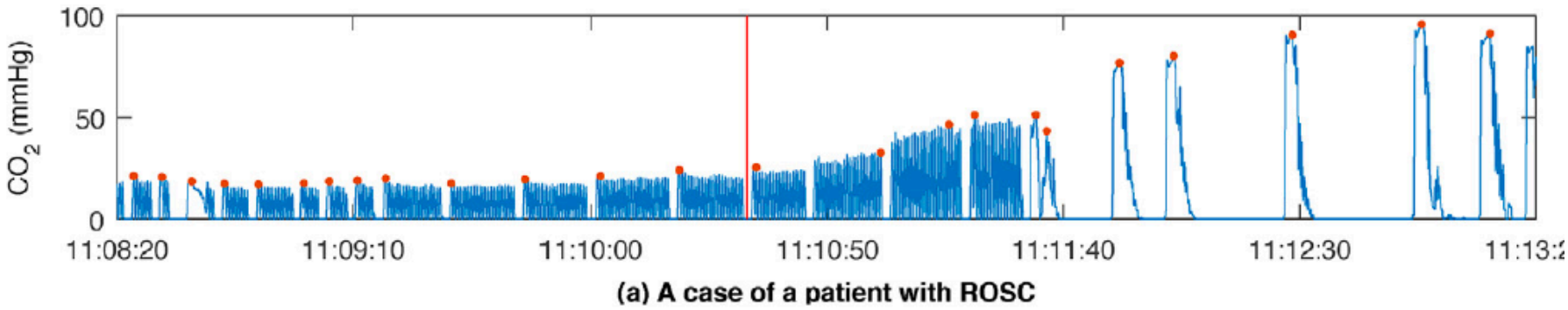
journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL

Clinical paper

Capnography: A support tool for the detection of return of spontaneous circulation in out-of-hospital cardiac arrest

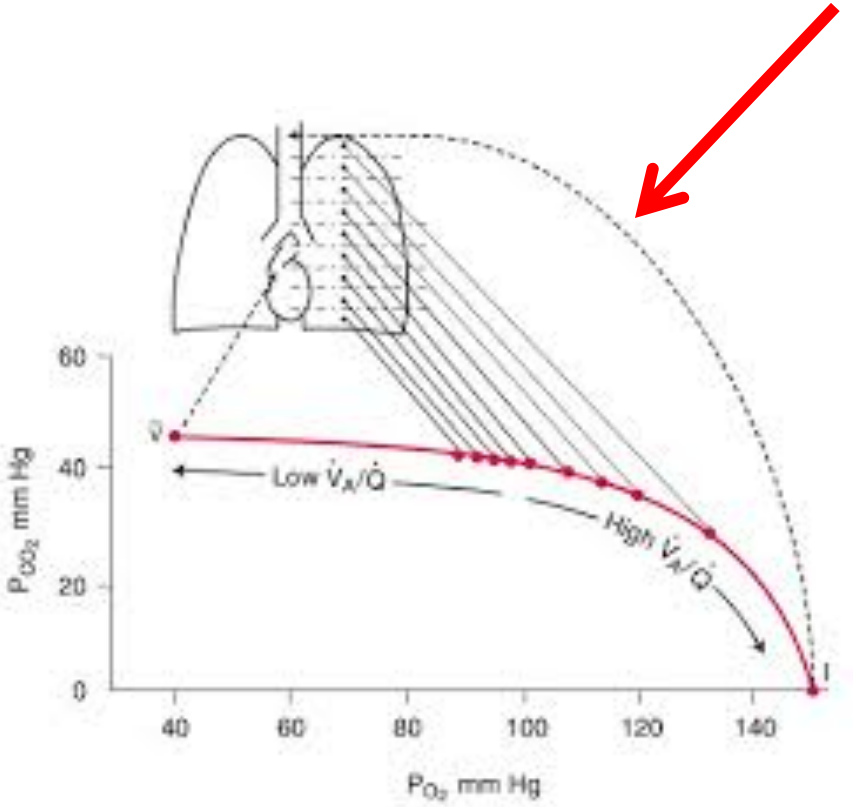
Andoni Elola[a,], Elisabete Aramendi[a], Unai Irusta[a], Erik Alonso[a], Yuanzheng Lu[b], Mary P. Chang[c], Pamela Owens[c], Ahamed H. Idris[c]*



(a) A case of a patient with ROSC

Elola et al. Resuscitation 2019

CO2 depends on ventilation and circulation
Both depend on chest compression



Accidental observation: Periodic variation of $EtCO_2$ during CPR

P_{aw}

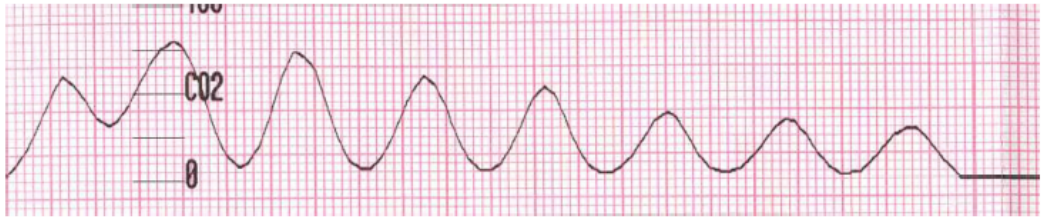
CO_2

Capnogram (EtCO2 waveform) during CPR varies periodically with chest compressions and ventilation….

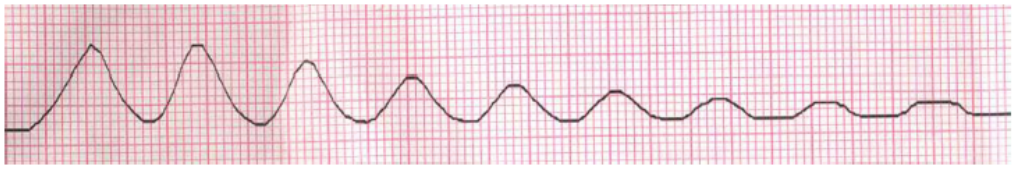
Capnograms obtained during chest compressions in OHCA

CO_2

Patient 21-34941



Patient 31-61974



Patient 24-57924

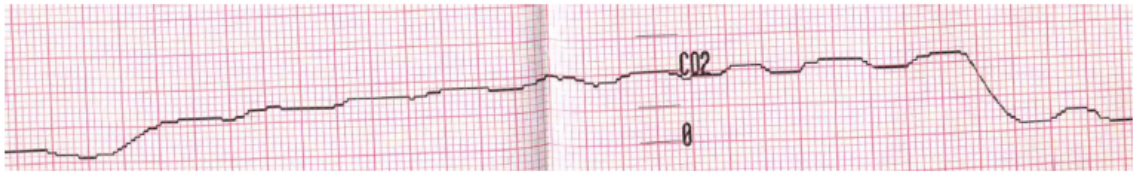
Patient 25-60807

CAVIAR
Cardiac Arrest and Ventilation
International Association for Research

Capnograms obtained during chest compressions in OHCA

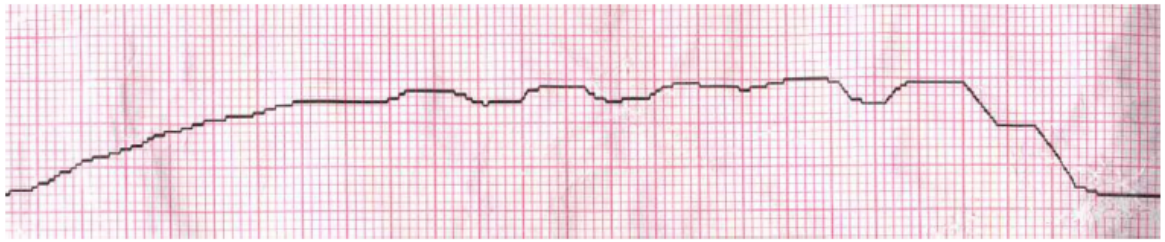
CO_2

Patient 8-41345



Patient 18-15222

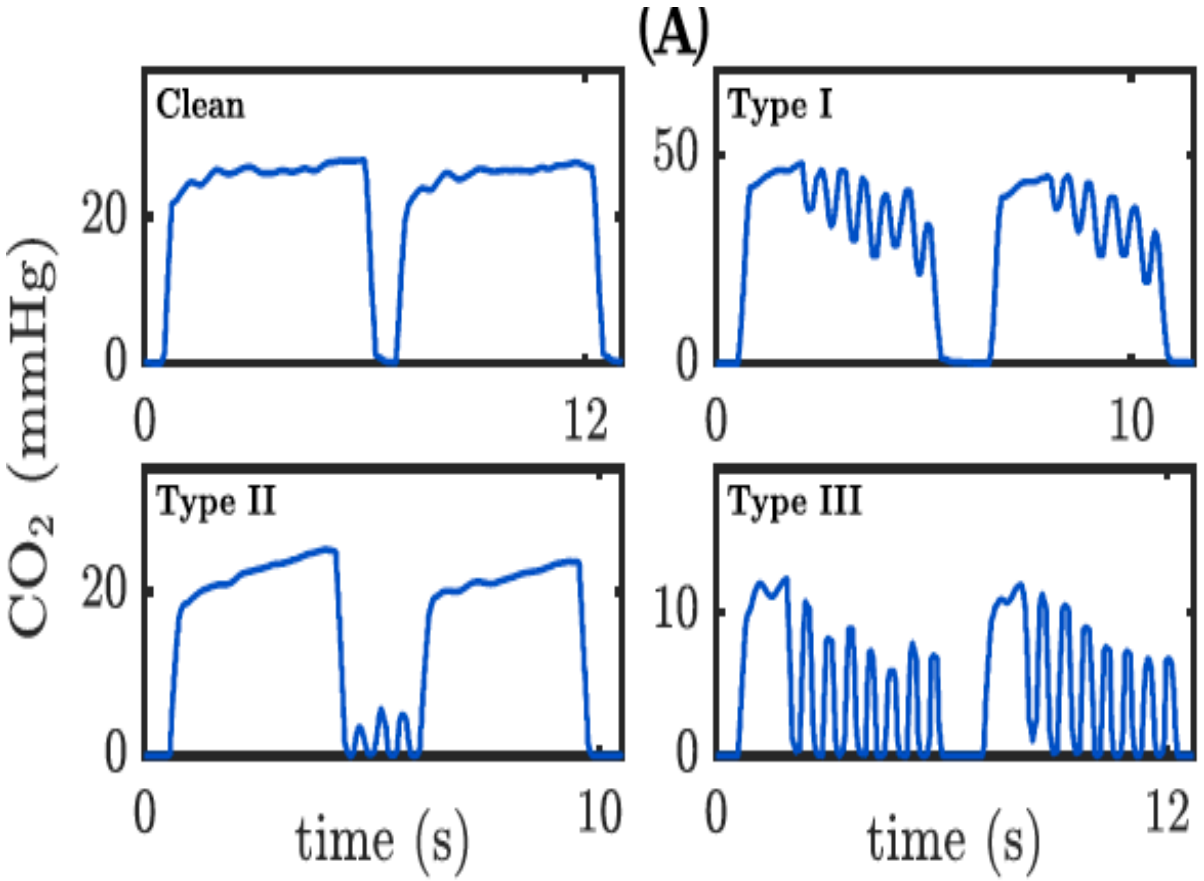
Patient 11-



CH ANNECY GENEVOIS

CAVIAR
Cardiac Arrest and Ventilation
International Association for Research

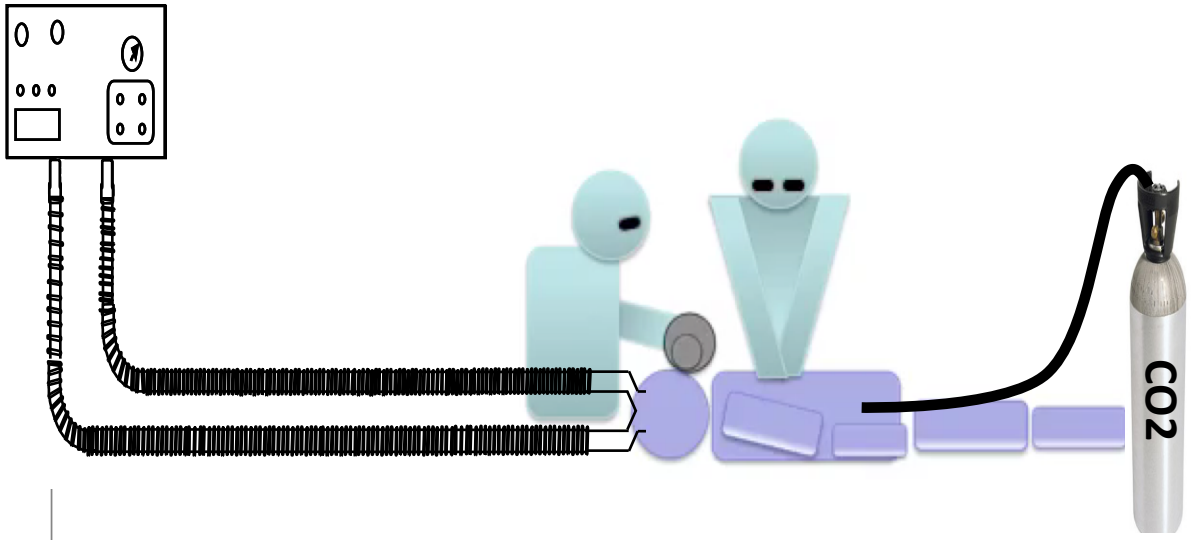
Influence of chest compression artefact on capnogram-based ventilation detection during out-of-hospital cardiopulmonary resuscitation.

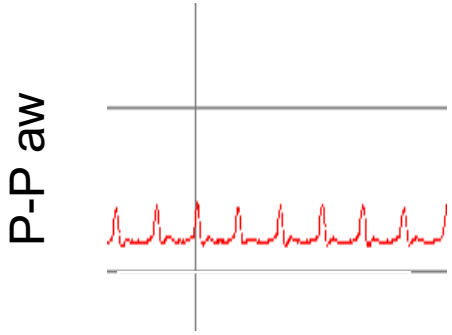


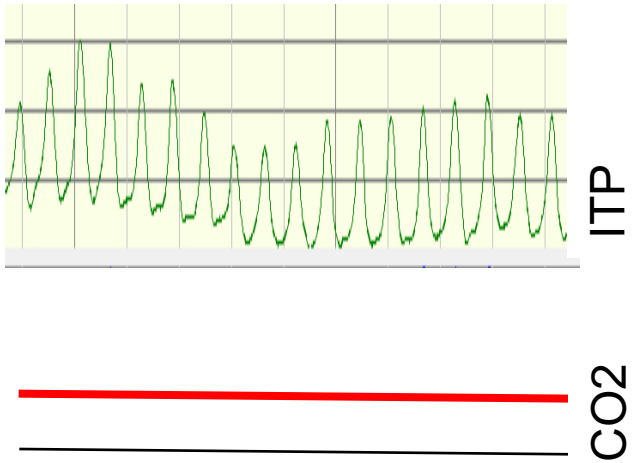
Leturiondo M et al. Resuscitation 2018

Thiel cadaver model with CO2 (CAVIAR lab)

ENGAGE IGNITE IMPACT
Resuscitation in Motion
RiM 2016
May 2-3
Toronto, ON
www.resusinmotion.ca





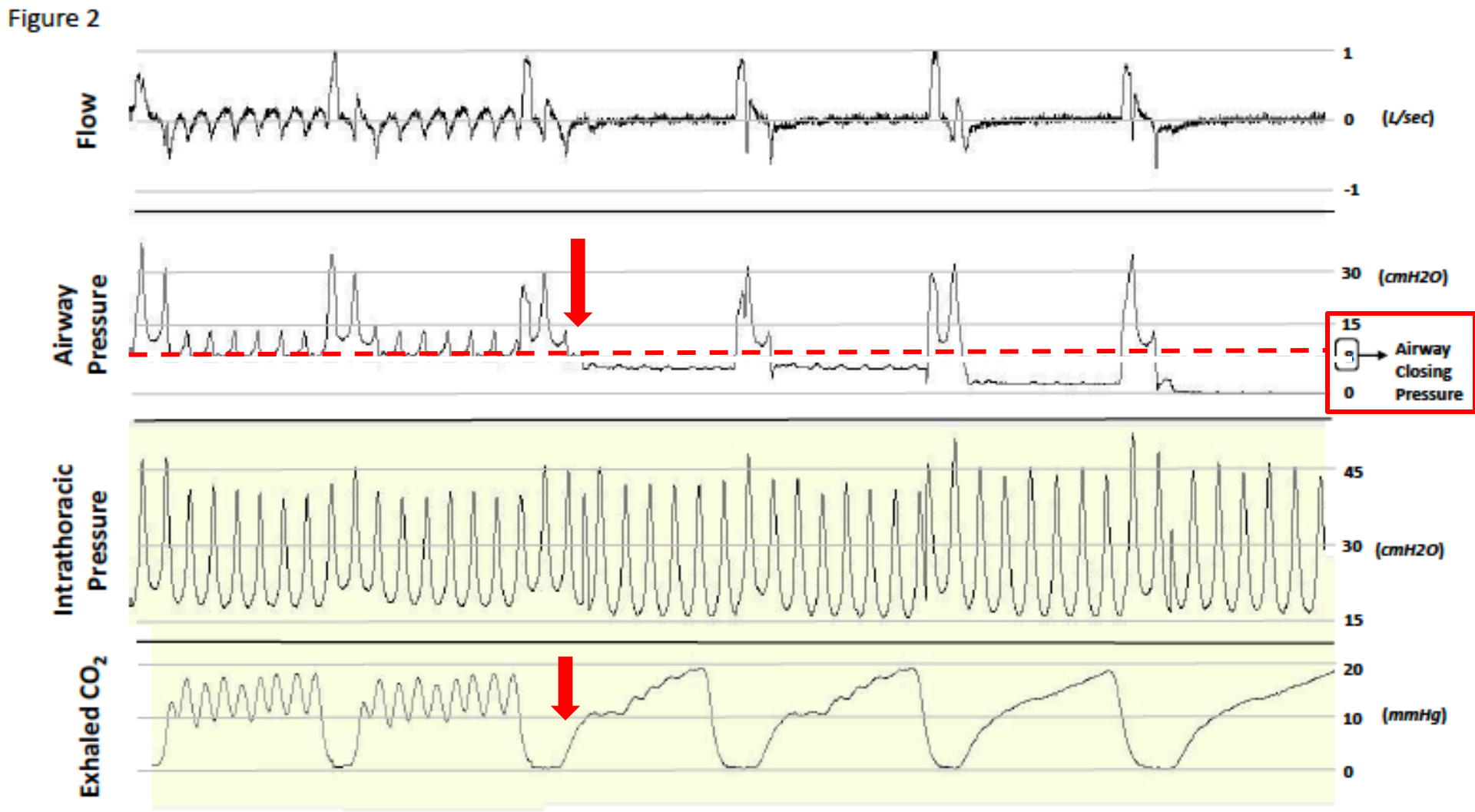


Airways opening measurements

Intra thoracic measurements

CAVIAR
Cardiac Arrest and Ventilation
International Association for Research

Thiel cadaver model with CO2 (CAVIAR lab)

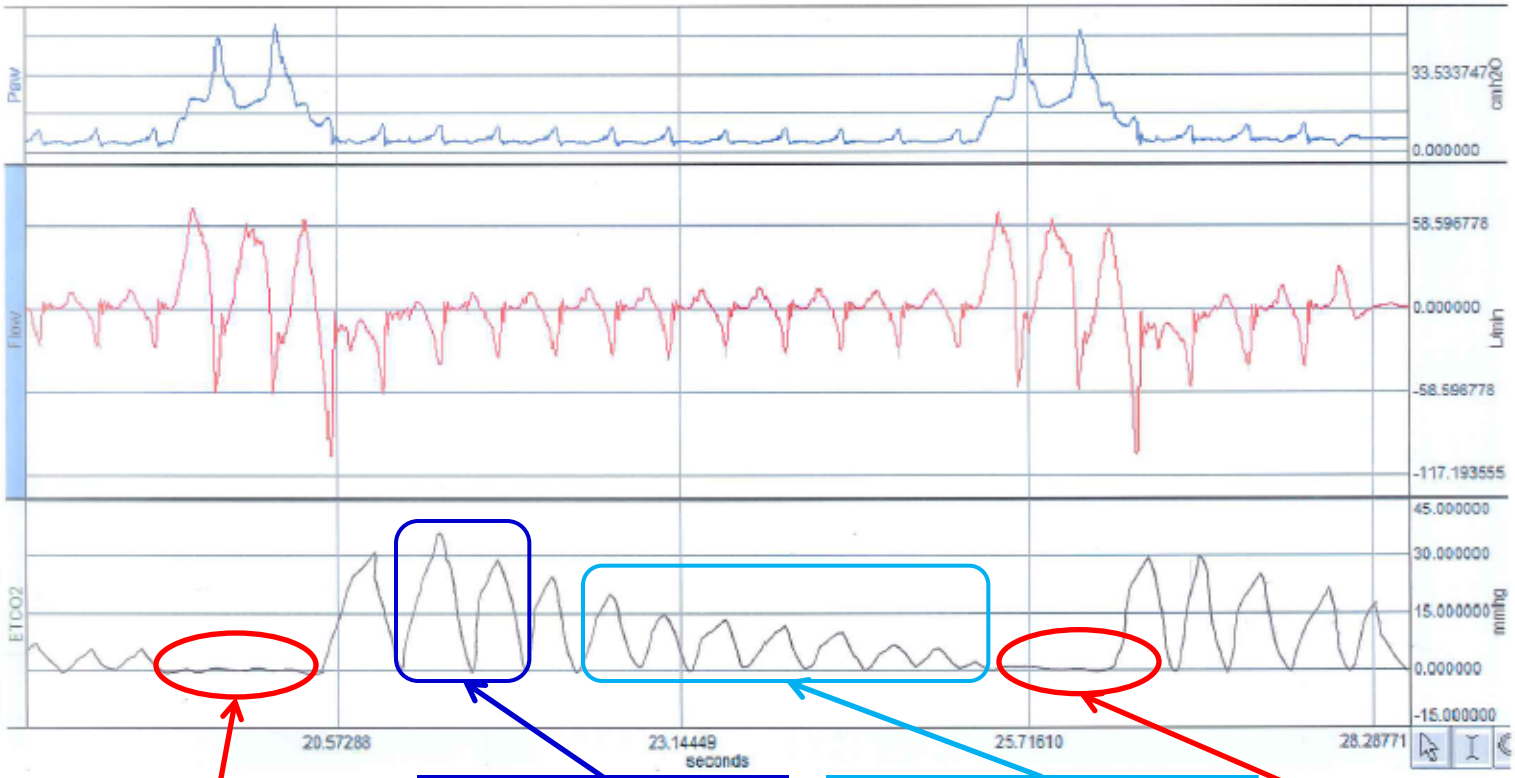


Full Airway patency: **PEEP 10 cmH_2O**

Partial and complete airway closure: **PEEP < $P_{closing}$**

Cordioli et al. Curent Op Crit Care 2019

How to interpret capnogram during chest compressions?



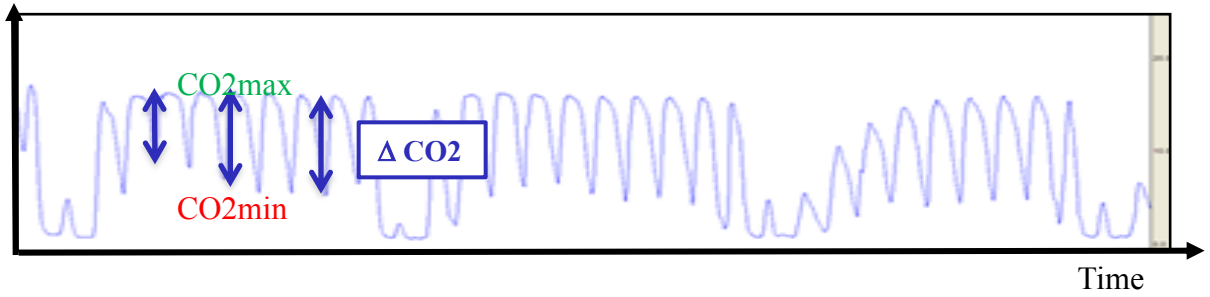
Insufflation from the ventilator

Alveolar CO2

CO2 Wash out by fresh gas

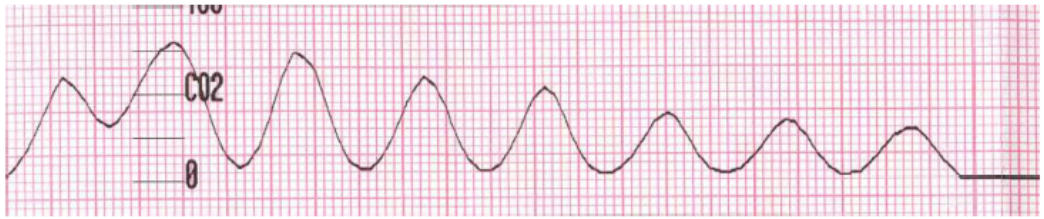
Insufflation from the ventilator

Airway Opening Index : AOI



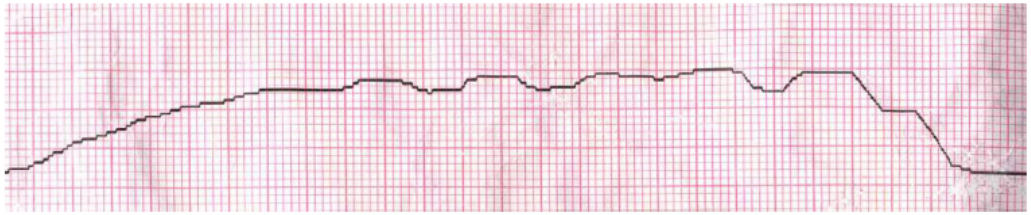
$$AOI = \frac{\Delta CO2}{CO2max} = 75\%$$

Patient 21-34941



AOI = 85%

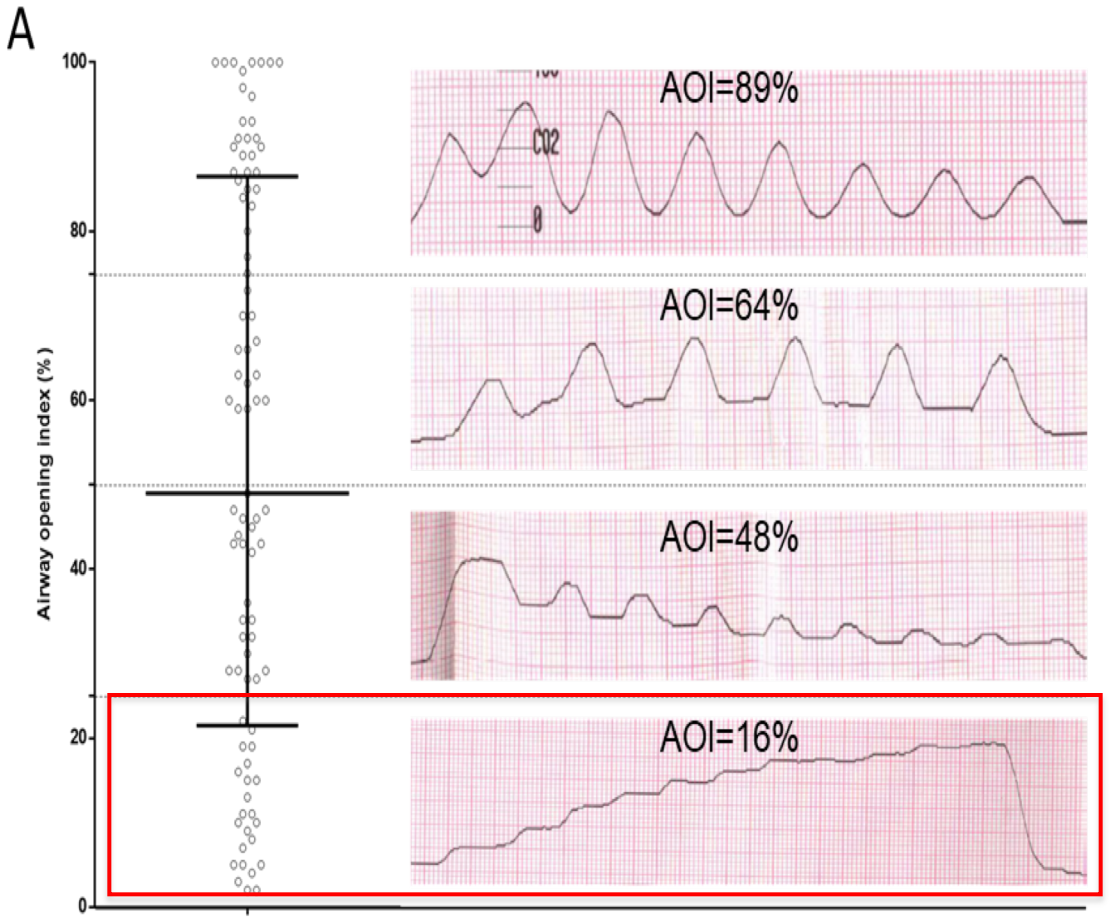
Patient 11-



AOI = 5%

The AOI permits to characterize and quantify oscillations on capnogram that is correlated with alveolar ventilation

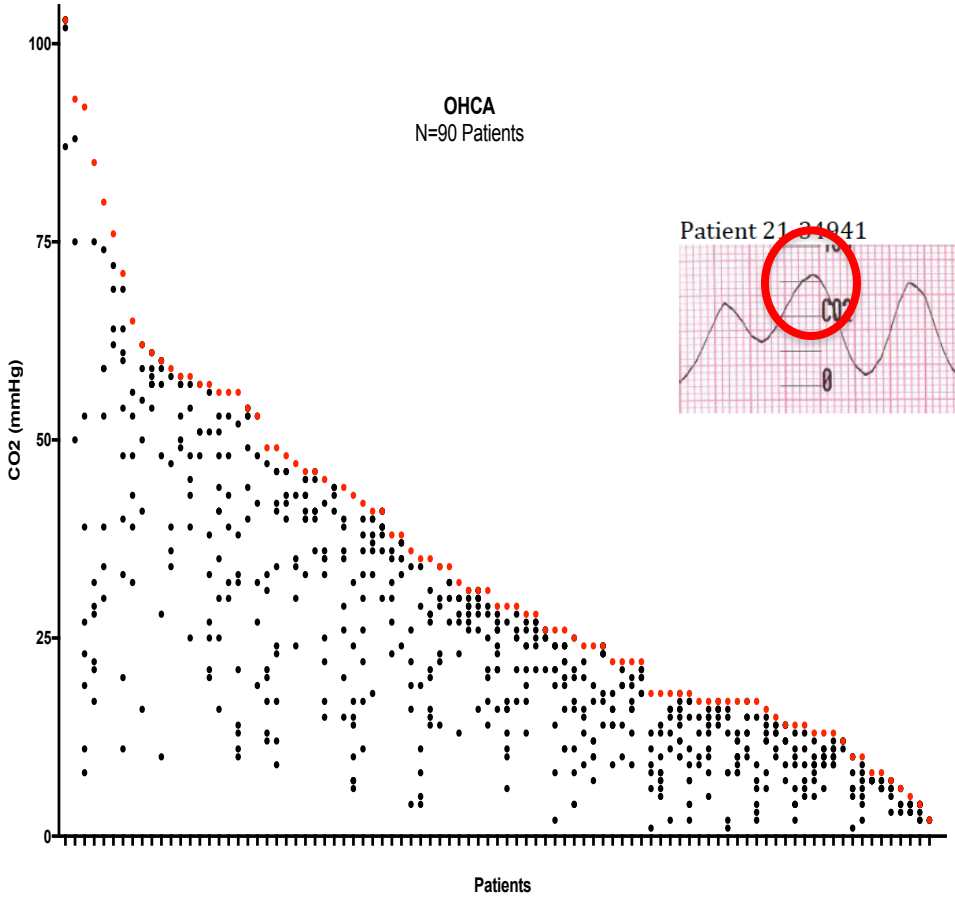
CLINICAL OBSERVATIONAL STUDY : 100 OHCA patients:



D Luca Grieco et al. AJRCCM

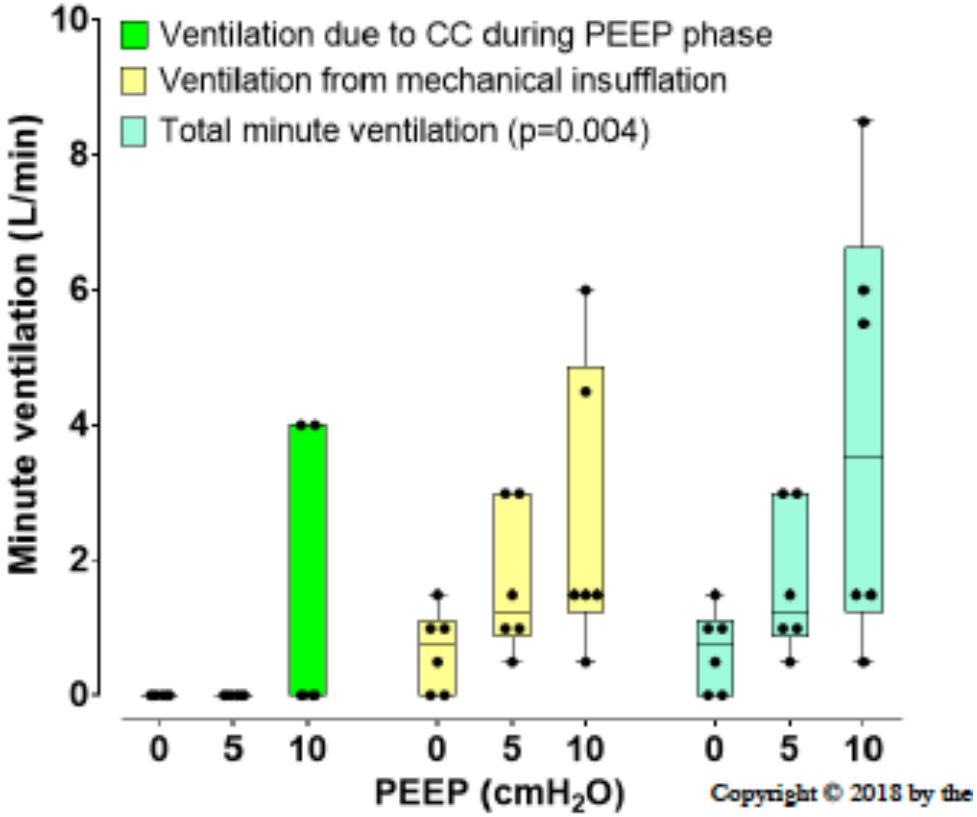
Maximal EtCO2 value is the best surrogate of alveolar CO2

CLINICAL OBSERVATIONAL STUDY : 100 OHCA patients:



D Luca Grieco et al. AJRCCM 2019

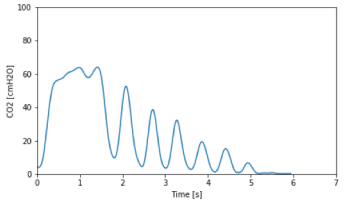
Thiel cadaver model with CO2 (CAVIAR lab)

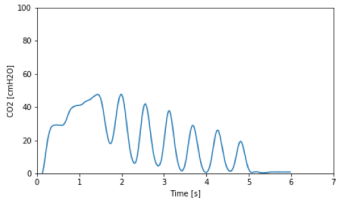


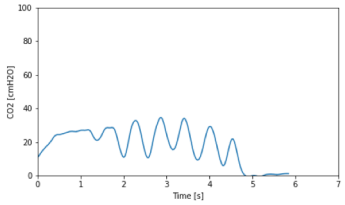
D Luca Grieco et al. AJRCCM 2019

Capnogram: series of 108 patients with out hospital cardiac arrest

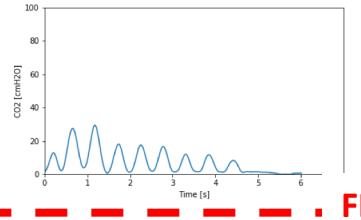
Automatic analysis obtained by mathematic model

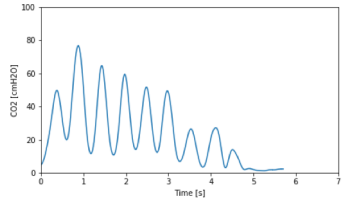


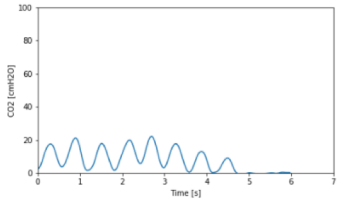




30-40%
Potential Hyper inflation

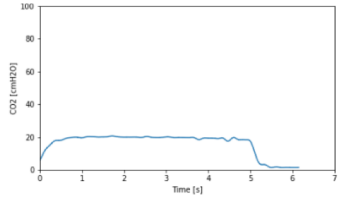


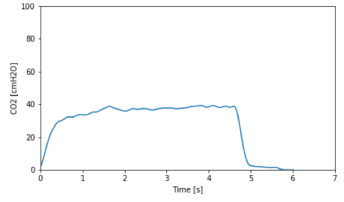


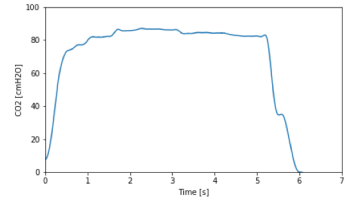


30-40%
complete thoracic airway patency

FRC FRC FRC



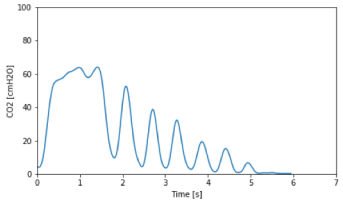


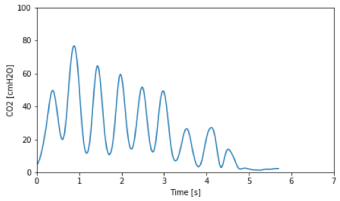


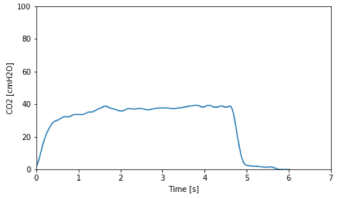
20-30%
complete thoracic airway closure

Capnogram: series of 108 patients with out hospital cardiac arrest

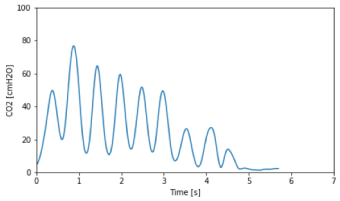
Potential impact on ventilation strategy







Potential Hyper inflation
Reduce ventilation



FRC

FRC

complete thoracic airway closure
Increase PEEP

Annecy CPR Round Table :

Two phase time sensitive model to OHCA

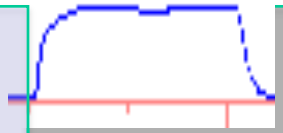
The 1st Round Table on CPR

Annecy's invitational

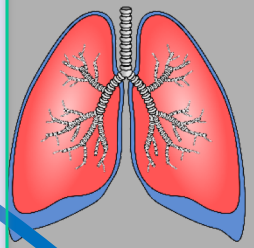
Laurie MORRISON
MD, FRCPC, MSc

Scientific Committee

Toronto, CANADA
St Michael's Hospital



$ETCO_2$ guided therapy

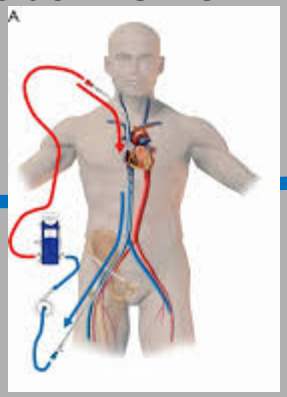


Airway Closure? guided therapy

High Quality CPR
Early Defibrillation
Cardiac Pump

Goal Directed Optimization
Cardiac and Thoracic Pump

Consider ECMO



Brain perfusion guided therapy

SURVIVAL

4 **7** 10

TIME

- Ventilation during CPR should be revisited to be adapted to this specific context
- Continuous CT and Bag Mask ventilation is probably compatible and efficient
- Thoracic airways closure may impair oxygenation and CO2 elimination during CPR.
- Only maximal value of exhaled CO2 during CPR reflect alveolar CO2
- Capnogram oscillations reflect thoracic airways patency and ventilation quality during CPR
- EtCO2 monitoring during CPR is highly recommended but not adapted to CPR