Symbiosis

www.symbiosisonline.org
www.symbiosisonlinepublishing.com

Case Report | Journal of Emergency, Critical Care and Diagnostic Management | Open Access

$EtCO_2$ in VA ECMO Management: Recognition of Increased Cardiac Output During ECMO and IABP Support

Cusmà Piccione R[1], Spaini G[2], Cazzani C[3] and Alberio G[4]

[1]MSN, RN at Cardiac Surgery Intensive Care Unit, Department of Cardiological Anesthesia, ASST Sette Laghi – University of Insubria – Varese. Professor at Master I level in Operating Room Nurse – Department of Medicine and Surgery – University of Insubria, Italy

[2]RN at Department Abdominal Surgery, Sarcomas and rare cancers, European Institute of Oncology, Milan, Italy

[3]RN at Cardiac Surgery Intensive Care Unit, Department of Cardiological Anesthesia, ASST Sette Laghi – University of Insubria – Varese, Italy

[4]MSN, RN, Nurse Coordinator at Cardiac Surgery Intensive Care Unit, Department of Cardiological Anesthesia, ASST Sette Laghi – University of Insubria – Varese, Italy

Received: August 30, 2018; Accepted: Novermber 25, 2018; Published: January 07, 2019

***Corresponding author:** *Cusmà Piccione R, Cardiac Surgery Intensive Care Unit, Department of Cardiological Anesthesia, ASST Sette Laghi – University of Insubria – Varese. Professor at Master I level in Operating Room Nurse – Department of Medicine and Surgery – University of Insubria, Italy, Email: riccardo.cusmapiccione@gmail.com*

Abstract

Introduction: A 60 yo male was under ECMO and Intra Aortic Baloon Pump (IABP) support due to cardiogenic shock. When IAPB was suspended for few seconds, myocardial contractility decreased with an $EtCO_2$ around 14 mmHg and an arterial blood flat line. Despite the IAPB suspension, an ABP tracing was observed and $EtCO_2$ increased to 25 mmHg.

ECMO is a lifesaving treatment in some specific cases of cardiac arrest [8] and $EtCO_2$ represents a non-invasive measurement of the quality in cardiopulmonary resuscitation, which also gives a good probability of ROSC with levels above 10-15mmHg [20].

Materials and methods: A case report and literature review were applied to study a correlation between $EtCO_2$ and cardiac output during ECMO support and identify the $EtCO_2$ measurement like a non-invasive parameter about recovery of cardiac contractility during ECMO and IABP support.

Results: Different studies confirm $EtCO_2$, cardiac arrest and ROSC correlation: in a meta-analysis and systematic review emerged that $EtCO_2$ values are lower in ROSC obtained by a superficial CPR with differences between 10 to 20 mmHg. [13] Another survey deals an $EtCO_2$ higher in people with ROSC than others without a pulse restored (34.5 ± 4.5 vs 23.1 ± 12.9 mmHg, p < .001) [23]. However, there are less references about ECMO and $EtCO_2$.

Discussion: A literature review and case report, about $EtCO_2$ and cardiac output during ECMO – IABP support, revealed that $EtCO_2$ can be a non-invasive indicator of heart contractility in patients with low ejection fraction and non-pulmonary circulation, and It shows a contractility increasing with a consequent recovery of pulmonary circulation, without suspending the IABP activity, during ECMO VA support.

Keywords: ECMO: extracorporeal membrane oxygenation; VA ECMO: veno-arterial membrane oxygenation; CPA: cardiopulmonary arrest; $EtCO_2$: endtidal CO_2; ROSC: return of spontaneous circulation; CO: cardiac output

Introduction

From European Guidelines of Resuscitation (2015), the out-of-hospital cardiac arrest (OHCA) has an incidence of 38 per 100 000 people: cardiac aetiology is around 40% in a population under 75 years old, whereas traumatic or non-cardiac aetiologies concerned, principally, patient under 35 years old [10]. According to ELSO and AHA Guidelines, ECMO should be considered the lifesaving treatment in some specific cases of patient who had an excellent CPR [8] or in adults with cardiogenic shock and low cardiac output, in persisting shock despite volume, drugs administration and intraortic balloon pump (IABP), in septic shock, or in many cardiac diagnosys (i.e. acute myocardial infarction, myocarditis, post cardiotomy shock) [9].

For an efficient resuscitation it's foundamental an adequate blood flow and an optimal perfusion, relied to capnography parameter [22,11]. Related to $EtCO_2$ concept, CO_2 is a result of relation between volume ventilation and pulmonary perfusion (V/Q), directly linked to blood flow [15]. It depends on many factors like issues about ventilation system, placement of endotracheal tube, body temperature, hypoventilation or hyperventilation, blood perfusion and so forth [27].

$EtCO_2$ swings are rapid indicator of systemic changes about CO_2, like in cardiac arrest [4], where the $EtCO_2$ trace crashes to zero [20]; during a cardiopulmonary arrest (CPA), it can recognize a ROSC, managing the resuscitation efforts. Therefore, an $EtCO_2$ increasing is an index of myocardial contractility restoring and a successful reanimation [20].

Considering a pattern of intubated-patient in Intensive Care Unit with same conditions of ventilation system [18] and catecholamine administration [22], capnography is associated to cardiac output [1,5] and pulmonary flow [20].

In literature, there are many references about the $EtCO_2$ role to manage the resuscitation effort, especially in ROSC. $EtCO_2$ levels above 10-15mmHg give a high probability of ROSC, but at the same time low levels are indicator of negative prognosis [20].

$EtCO_2$ has a key role in the chain of survival to advanced circulatory support, especially in extracorproeal life support (ECLS): the French Society of Intensive Care Medicine published a decision algorithm with ECLS inclusion criteria, like the "no-flow" time <5 min and $EtCO_2$ > 10 mmHg [12]. While the early cardiopulmonary resuscitation (CPR) by bystanders has been demonstrated to be fundamental to improve survival and neurological outcome in CPA victims [6]; the $EtCO_2$ plays an important role in ECLS application, because several studies demonstrate that $EtCO_2$ < 10 mmHg (before ECMO implantation) is relied to 100% of mortality rate [2]. Heart activity can be functional or not during ECMO support and this is recognizable by arterial blood pressure waveform. In fact, a numeric value of systolic and diastolic pressure is indicator of heart contractility and cardiac output; however, an absence of this value remarks cardiac inactivity and systemic pressure (represented by mean arterial pressure) is totally supported by VA ECMO.

Sometimes, in addition to ECMO, an implant of IABP support can prevent pulmonary edema due to inadeguate heart venting: in this case the suspenction of IABP activity for few seconds allows to evaluate the presence of flatline [16].

Case report

A 60 yo male was admitted from another hospital for cardiogenic shock due to anterior STEMI. After percutaneous coronary intervention and intraortic balloon pump (IABP) placement, the cardiogenic shock status remained with increasing of serum lactate, anuria, and VA ECMO was inserted. The cardiac output was highly depressed, and the blood flow was totally ensured by ECMO with the mean arterial pressure generated by ECMO output, when the IABP was suspended. During ECMO and IABP supports, $EtCO_2$ had different values corresponding to changes of arterial blood pressure waveform.

Cause of the clinical case report, we can pose the following question: Can $EtCO_2$ monitor functional cardiac recovery in patient supported by ECMO and IABP, without suspension of aortic counterpulsation?

Materials and Methods

We performed a literature review and a rectrospective study on clinical case report.

The principal medical databases consulted were PubMed, Cinahl and Cochrane Library with a search strategy composed by two principal steps: firstly, correlation between $EtCO_2$, CPA and ROSC was searched and, secondly, relation between $EtCO_2$ in VA ECMO was applied.

The inclusion criteria were VA ECMO in adult's population, whereas pediatric ECLS and VV ECMO were excluded. Relevant articles between 2008 and 2018 were considered for the first search strategy.

The principal keywords used in literature review were "$EtCO_2$" OR "end-tidal carbon dioxide" OR "capnography" AND "cardiac arrest" OR "heart arrest" OR "cardiopulmonary arrest" AND "rosc" OR "return of spontaneous circulation" AND "post-arrest" AND "cpr" OR "cardiopulmonary resuscitation" OR "cardiorespiratory resuscitation" OR "chest compressions" OR "cardiac arrest".

A retrospective study was applied on the telemetry, as a continuous multiparameter registration. We focused on temporary stopping of IABP activity and hemodynamic signs, especially the correlation between $EtCO_2$ and arterial blood pressure.

Results

Case report

Observing hemodynamic sign registrations, during IAPB stopping, we have extracted the time we checked the pulsatility presence. In these time-lapse, we notice a correlation with $EtCO_2$ and arterial blood pressure (ABP). When pulse is present, checking the arterial waveform with a systolic pressure around 90 mmHg and dyastolic around 40 mmHg, the $EtCO_2$ increases to 24-26 mmHg, as represented in figure 2; when there is pulseless activity, $EtCO_2$ values are around 13-15 mmHg, as represented in figure 1. During the recovery in ICU, many decreasing-increasing episodes about $EtCO_2$ were identified, respectively, in depression and in recovery of cardiac output; this was confirmed by arterial pressure waveform during interruption of IABP activity.

Literature review

In the first search strategy many articles were consulted, while in the second one five relevant articles were identified. The literature review was extended to the Extracorporeal Life Support Organitation (ELSO), American Heart Association (AHA) and European Resuscitation Council Guidelines (ERC) and to principal books, especially about $EtCO_2$ and ECMO correlation: in these references the keywords "$EtCO_2$", "CO_2" and "capnography" were searched.

Different studies confirm a juction between $EtCO_2$ and ROSC: from different reviews, like Paiva E. and Aminiahidashti H. studies in 2018, it's emerged that $EtCO_2$ is statistically higher in patients survived after CPR. In a meta-analysis and systematic review, participants in ROS with $EtCO_2$ level about 25 mm Hg have higher values than people in ROSC with a superficial CPR with differences between 10 to 20 mmHg [13]. Another survey deals $EtCO_2$ higher in people with ROSC than others without a pulse restored (34.5 ± 4.5 vs 23.1 ± 12.9 mmHg, $p < .001$) [23].

Discussion

According to European Resuscitation Council most recent 2018 guidelines, $EtCO_2$ is an early parameter of cardiac output variation; in fact, an increase of this waveform between 2,5 and 2,0 kPa [11] is an indicator of optimal CPR [5] and it can be used like a clinical tool during advanced cardiac life support [23,10].

The literature search revealed a lack of correlation studies between $EtCO_2$ and ECMO. By the retrospective analysis of the clinical case, through the telemetries, it has been analyzed the relation between $EtCO_2$ and ABP and identified an increase in CO_2 at the resumption of myocardial contractility during ECMO support. This is physiologically permitted by cardiac contractility resumption, which allows a recovery of pulmonary circulation and alveolar-capillary exchange between oxygen and carbon dioxide. When contractility is depressed, the values of $EtCO_2$ decrease, because of pulmonary circulation arrest, as reported by figure 1 and figure 2. The use of the $EtCO_2$ could also reduce the IAPB suspension, considering that these interruptions still haven't been declared capable of damage or not by literature.

Therefore, the respiratory CO_2 can be a non-invasive, rapid and early parameter to find the re-establishment of the pulmonary circle and then the activity increasing of the left ventricle and right ventricle.

However, our hypothesis is based on clinical observation of the hemodynamic parameter recordings, determining the limit of the study between the respiratory and circulatory correlation during ECMO to a single case.

The intent of the authors is to continue, retrospectively and prospectively, to a correlation analysis between $EtCO_2$ and cardiac output.

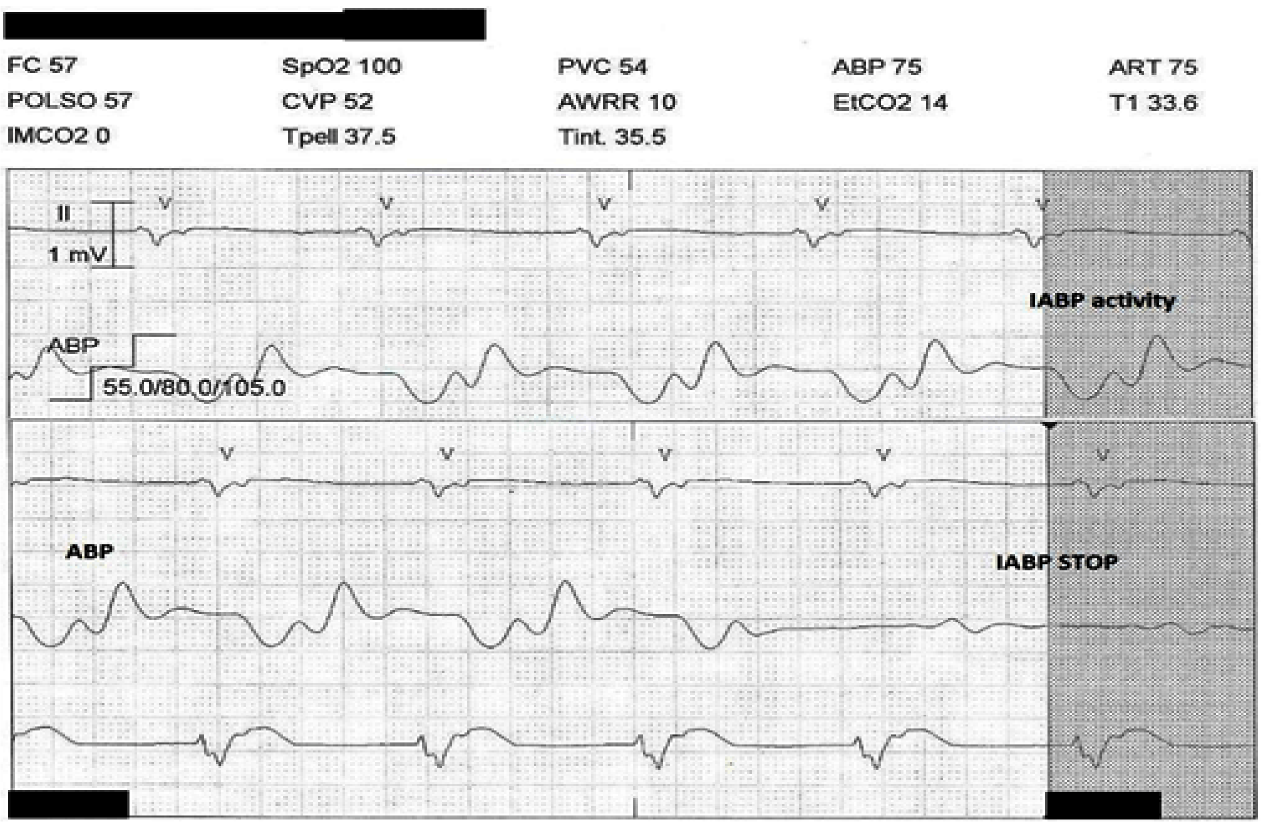

Figure 1: Correlation between $EtCO_2$ – ABP in no cardiac output

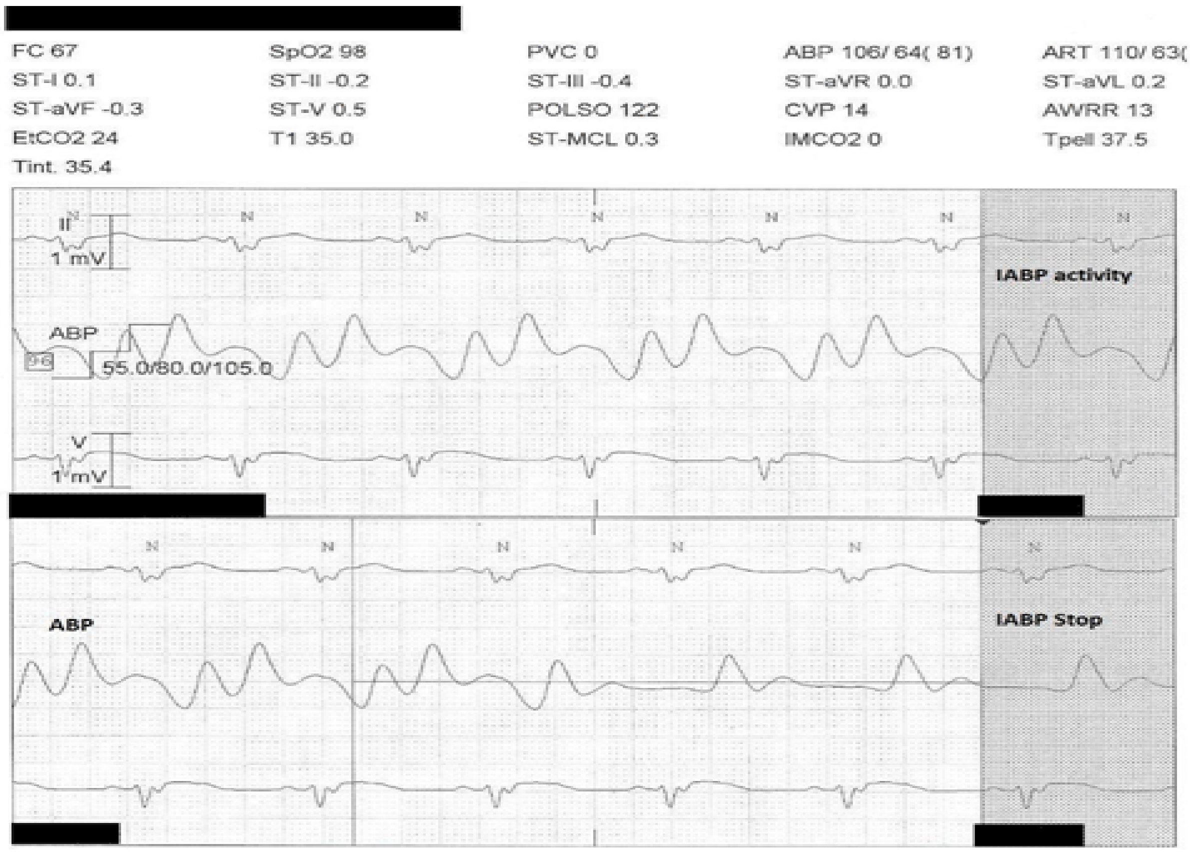

Figure 2: Correlation between $EtCO_2$ – ABP in return of cardiac output

References

1. Aminiahidashti H, Shafiee S, Zamani Kiasari A, Sazgar M. Applications of End-Tidal Carbon Dioxide (ETCO2) Monitoring in Emergency Department; a Narrative Review. Emerg (Tehran). 2018;6(1):e5.
2. Brechot N. Indications and Physiopathology in Venoarterial ECMO. In Nursing care and ECMO. 2017;11-23.
3. Bulleri E., Fusi C. (2015) *Manuale di monitoraggio grafico della ventilazione meccanica.* Milano: Farelibri Editore.
4. Pantazopoulos C, Xanthos T, Pantazopoulos I, Papalois A, Kouskouni E, Iacovidou N. A Review of Carbon Dioxide Monitoring During Adult Cardiopulmonary Resuscitation. Heart Lung Circ. 2015;24(11):1053-1061. doi: 10.1016/j.hlc.2015.05.013
5. Chiaranda M. (2016) *Urgenze ed emergenze.* Padova: Piccin.
6. Cusmà PR. Bystander CPR: The Role Play of the Fist Ring of the Chain of Survival. J Family Med Community Health. 2017;4(3):1110.
7. De Somer F. What is optimal flow and how to validate this. J Extra Corpor Technol. 2007;39(4):278-280.
8. Extracorporeal Life support Organitation (2013a) Guidelines for ECPR Cases ELSO ECPR Supplement to the ELSO General Guidelines. Version 1.3
9. Extracorporeal Life support Organitation (2013b) Guidelines for adult cardiac failure. Version 1.3
10. European Resuscitation Council Guidelines for Resuscitation. Part 5. Resuscitation. 2015;95:202-222.
11. European Resuscitation Council (2015) *Advanced Life Support.* Bologna: IRC Edizioni, 93-103.
12. French Society of Intensive Care Medicine. Guidelines for indications for the use of extracorporeal life support in refractory cardiac arrest. French Ministry of Health. Ann Fr Anesth Reanim. 2009;28(2):182-190. doi: 10.1016/j.annfar.2008.12.011
13. Hartmann SM, Farris RWD, Di Gennaro JL, Roberts JS. Systematic Reviw and Meta-Analysis of End-Tidal Carbon Dioxide Values associated With Return of Spontaneou Circulation During Cardiopulmonary Resuscitation. J Intensive Care Med. 2015;30(7):426-435. doi: 10.1177/0885066614530839
14. Justison G. Is timing everything? *J Extra Corpor Technol*. 2017;49:13–18.
15. Marino PL. (2014) *The ICU Book.* New York: Wolters Kluwer Health/ Lippincott Williams & Wilkins.
16. Mossadegh C (2017) Nursing care and ECMO. Springer

17. Naruke T, Inomata T, Imai H, Yanagisawa T, Maekawa E, Mizutani T, et al. End-tidal carbon dioxide concentration can estimate the appropriate timing for weaning off from extracorporeal membrane oxygentaion for refractory circulatory failure. Int Heart J. 2010;51(2):116-120.
18. Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, et al. Adult Advanced Cardiovascular Life Support: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation.* 2010;122(18 Suppl 3):S729-767. doi: 10.1161/CIRCULATIONAHA.110.970988
19. O'Leary MJ, Macdonnel SP, Fergus CN. Oxygenation exhaust capnography as an index of arterial carbon dioxide tension during cardiopulmonary bypass using a membrane oxygenator. Br J Anaesth. 1999;82(6):843-846.
20. Paiva EF, Paxton JH, O'Neil BJ. The use of end-tidal carbon dioxide (ETCO2) measurement to guide management of cardiac arrest: A systematic review. Resuscitation. 2018;123:1-7. doi: 10.1016/j.resuscitation.2017.12.003
21. Ranucci M, Carboni G, Cotza M, de Somer F. Carbon dioxide production during cardiopulmonary bypass: pathophysiology, measure and clinical relevance. Perfusion. 2017;32(1):4-12. doi: 10.1177/0267659116659919
22. Sandroni C, De Santis P, D'Arrigo S. Capnography during cardiac arrest. Resuscitation. 2018;132:73-77. doi: 10.1016/j.resuscitation.2018.08.018
23. Sheak KR, Wiebe DJ, Leary M, Babaeizadeh S, Yuen TC, Zive D. Quantitative relationship between end-tidal carbon dioxide and CPR quality during both in-hospital and out-of-hospital cardiac arrest. Resuscitation. 2015;89:149-154. doi: 10.1016/j.resuscitation.2015.01.026
24. The Intensive Care Foundation. Handbook of Mechanical Ventilation. London: The Intensive Care Foundation. 2015;13-20,39-43.
25. Totapally BR, Sussmane JB, Torbati D, Gelvez J, Fakioglu H, Mao Y, et al. Cardiovascular stability during arteriovenous extracorporeal therapy: a randomized controlled study in lambs with acute lung injury. Crit Care. 2004;8(6):R495-503.
26. Walsh B., Crotwell D., Restrepo R. Capnography/Capnometry during mechanical ventilation AARC Clinical Practice Guideline. Respiratory Care. 2011;56(4):503-509.
27. Ward K. A comparison of chest compressions between mechanical and manual CPR by monitoring end-tidal PCO_2 during human cardiac arrest. Ann Emerg Med. 1993;22(4):669-674.