

Dangers in using beta-blockers in patients with venovenous extracorporeal membrane oxygenation

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Dear Editor:

We have read with interest the review “Awakening in extracorporeal membrane oxygenation as a bridge to lung transplantation” by Lee [1] published in your journal, explaining how the application of awake venovenous extracorporeal membrane oxygenation (VV-ECMO) performed by an appropriately trained ECMO multi-disciplinary team, can be useful as a bridging strategy, in patients waiting for lung transplantation.

We fully agree with the awake ECMO management proposed by Lee [1]. However, the section “Problems during Awake ECMO” discusses the problem of hypoxemia due to excessive patient cardiac output (CO). The proposed solution is to use beta-blockers to resolve hypoxemia in patients with high CO, as a result of increased heart rate. We would like to point out the possible inaccuracy of this recommendation for managing refractory hypoxemia in patients with VV-ECMO.

Since the work of Guarracino et al. [2], there have been numerous publications recommending the use of beta-blockers to increase oxygen saturation (SaO₂) in situations of high CO [3]. The blood propelled by the heart is a mixture of the flow coming from the VV-ECMO, with an SaO₂ in the blood exiting the oxygenator (membrane) (SmO₂) of approximately 100%, and the desaturated venous flow, with a central venous oxygen saturation (ScvO₂) of approximately 40%–70%, which returns to the heart through the vena cava. By using beta-blockers and slowing the heart rate, the total CO will be lowered. Whereas the ECMO flow will remain constant, the desaturated venous flow will decrease. Less venous flow will be needed to complete the total CO, and therefore the blood mixture will have a higher SaO₂, as derived from the following formula described by by Messaï et al. [4]:

$$\text{SaO}_2 \approx \text{SpaO}_2 = \left(\frac{\text{EF}}{\text{CO}}\right) \text{SmO}_2 + \left(1 - \frac{\text{EF}}{\text{CO}}\right) \text{ScvO}_2 + \Delta\text{SaO}_2,$$

in which SpaO₂ is SaO₂ in the pulmonary artery, EF is the effective flow rate (EF=(1–recirculation)×pump flow) and ΔSaO₂ is the increase in SaO₂ due to dissolved oxygen (%). The increase in oxygen consumption stimulates the general visceral afferent fibers (by mechanoreceptors, nociceptors, and chemoreceptors) that activate the autonomic nervous system, generating a response (in this case, tachycardia) to increase the supply of oxygen according to the formula:

DO₂=CO × CaO₂, where CaO₂ is the arterial oxygen content according to the formula
CaO₂=1.34×SaO₂×Hb+pO₂×0.0031

, where pO₂ is the partial pressure of oxygen and Hb is the hemoglobin content. SaO₂ is only part of the equation in oxygen supply.

Letter to the Editor

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Following the mathematical model of Zanella et al. [5], we can confirm that increasing the CO while keeping the rest of the variables constant will lead to an increase in oxygen delivery (DO_2) despite a decrease in SaO_2 . As the heart rate increases, the CO will increase. If CO is increased by a value of k, SaO_2 can be calculated using the following formula:

$\frac{EF(SmO_2 - ScvO_2) + kCO(ScvO_2 + \Delta SaO_2)}{kCO}$ obtaining a decrease in SaO_2 for any value k increase in CO. Substituting SaO_2 in the DO_2 equation results in the following formula:

$DO_2 = EF \times 1.34 \times Hb(SmO_2 - ScvO_2) + kCO \times 1.34 \times Hb(ScvO_2 + \Delta SaO_2) + (kCO \times pO_2 \times 0.0031)$

, where for any value k increase in CO, there will be an increase in DO_2 . These formulas show that by increasing the CO by a proportion k, the SaO_2 will decrease, while the total DO_2 will increase.

The study by Guarracino et al. [2], on which numerous review articles are based, corresponds only to a series of three patient cases that did not report their SaO_2 , did not indicate how CO was calculated, and observed that DO_2 decreased when the heart rate decreased. The objective for patients with VV-ECMO assistance should be to prevent hypoxia rather than hypoxemia, and maintain adequate DO_2 . We believe that more studies are necessary along these lines to be able to make a strong recommendation against the use of beta-blockers in VV-ECMO patients with high CO.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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