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EDITORIAL

Central venous pressure in critically ill patients: do we still need it?

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Central venous pressure (CVP) measurement in acute circulatory failure patients is a tricky issue. On the one hand its pathophysiological rationale may be not clear for every emergency and critical care physician. On the other hand, it should be acknowledged that even scientific societies guidelines do not always clarify this issue. As an example, in the 2012 Surviving Sepsis Campaign (SSC) guidelines[1] CVP measurement was recommended for all septic shock patients, with the suggestion of targeting fluid resuscitation to a value of CVP between 8-12 mmHg during the first 6 hours (12 to 15 mmHg in patients under mechanical ventilation and those with reduced ventricular compliance).[1] This recommendation was evaluated as "strong," but with a "low quality of evidence" (1C). As a matter of fact, one year before Boyd *et al.*[2] had demonstrated that a CVP <8 mmHg was associated with a reduced mortality compared to values between 8-12 mmHg and >12 mmHg. Interestingly, the same authors of the 2012 SCC guidelines[1] have completely removed CVP measurement from the new ones,[3, 4] not only as a guide for fluid resuscitation, but also as an element for hemodynamic monitoring, whilst other variables (such as heart rate, respiratory rate and arterial blood pressure) are still suggested for patients monitoring. Thus, the risk is either to neglect CVP, or to misunderstand its values. Nevertheless, a deeper look into the existing literature may provide reasonable indication on why and when to measure CVP in acute circulatory failure patients.

Should we use CVP to guide fluid resuscitation? The answer is no. Traditionally, CVP has been used for therapeutic management of patients, in particular to decide whether fluids should be administered. The idea behind this is that if a patient has a low CVP, it is highly probable that he is on the steep portion of the Frank-Starling curve and with volume expansion cardiac output (CO) will increase. However, it is well known that there is not "a" Frank-Starling curve, but rather a "family" of curves, according to the patients' ventricular function, so that for the same static value of CVP, one could be either fluid responder or fluid non-responder (Figure 1). Thus, the major risk is to give volume expan-

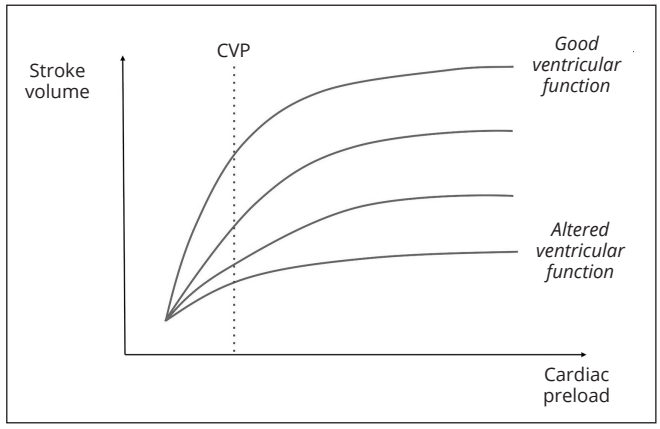

Figure 1—Frank-Starling relationship, according to different performance of ventricular function.
CVP: central venous pressure.

sion to a patient who will not subsequently augment CO, increasing the risk of fluid overload, which is associated to increased mortality.[2] To reduce the negative impact of the 2012 SSC guidelines message regarding CVP, a task force of the European Society of Intensive Care Medicine (ESICM), one year later recommended to use dynamic rather than static indices to guide fluid resuscitation,[5] a suggestion that will be likely be confirmed in the forthcoming recommendations. The inadequacy of CVP to predict the response to fluid administration in terms of CO increase has been demonstrated by many studies.[6] Among them, Osman *et al.*[7] had already shown in 2007 that there is no difference in terms of baseline CVP values between fluid responders and fluid non-responders. Interestingly, the best threshold found by the authors was 8 mmHg, with an area under the receiver operating characteristic (AUROC) curve of only 0.58: in practice, when the PVC was 8 mmHg, the positive predictive value for an increase in CO after fluid administration was 47%.[7] Subsequently, this concept was confirmed by two meta-analyses of Marik *et al.*,[8, 9] where the AUROC curve for CVP to predict preload responsiveness was 0.56, and by one of Eskesen *et al.*[10] A further confirmation of the inadequacy of CVP for this scope comes from the recent study of Hamzaoui *et al.*:[11] in 50 critically ill patients, the authors elegantly showed that an increase in CVP during passive leg raising cannot predict even preload unresponsiveness. Despite all these evidences, CVP is still used all over the world to guide fluid administration, as demonstrated by the FENICE study, conducted in 46 countries.[12]

The answer to the question "is the CVP useless during fluid resuscitation?" is no. If CVP should not be used to start volume expansion, a possible implication as "safety limit" has been proposed for it, to promptly detect when fluid administration becomes ineffective. To better understand this, one should recall the concept of systemic venous return, which mainly depends on the gradient between the mean systemic filling pressure (MSFP) and the CVP. During fluid resuscitation, the goal of a fluid bolus is to increase CO: to do so, the increase in MSFP should be higher than the increase in the CVP. Guerin *et al.*[13] have shown that in fluid responders both MSFP and CVP increased during volume expansion, but that the rise in MSFP was higher than the one in CVP, leading to an increase in venous return. Conversely, in fluid non-responder patients, the increase in MSFP and CVP was similar, so that venous return could not augment.[13] As the formula for the measurement of the MSFP has recently been disclosed,[14] and since its calculation can be easily performed through open-source mobile applications at the bedside, its use may now be implemented, giving precious clues to emergency and critical care physicians: by monitoring both the CVP and the MSFP during volume expansion, once the CVP is seen to increase more than the MSFP, fluid administration should be stopped.[15, 16]

Is CVP useful after the initial phase of fluid resuscitation? The answer is yes. Beyond venous return, one of the major roles of CVP is its implication in the determination of organ perfusion. In fact, organ perfusion depends on the entrance pressure, which is the mean arterial pressure (MAP), and on the pressure that goes against the exit of blood flow from the organ, which is, indeed, the CVP. Now, in normal conditions, the CVP value can be ignored compared to MAP, as normal values are 0-2 mmHg and 90-95 mmHg, respectively. However, in case of acute circulatory failure, if MAP decreases, the relative weight of elevated CVP becomes higher, impairing organ perfusion with direct consequences on survival. As an example, in the study of Varpula *et al.*[17] it was shown that an elevated CVP in the first 48 hours of shock is the third independent factor related to mortality. Furthermore, a high CVP is associated with an increased risk of acute renal failure due to venous congestion, as demonstrated by Legrand *et al.*[18] and confirmed by a meta-analysis of Chen *et al*.[19] Again, as CVP is the backward pressure of the pulmonary lymphatic system, high values contribute to the persistence of lung edema in conditions such as acute respiratory distress syndrome.[20-22]

As the efforts taken by the physician for the resuscitation of shock patients is aimed at restoring organ perfusion, thus reaching the "plateau" of the pression/perfusion curve, knowing the CVP value is as important as knowing the value of MAP. Indeed, being aware of what the obstacle to organ blood flow exit is, allows the physician to target MAP more conscientiously and to understand the underlying risks of developing acute organ dysfunction, with concrete impact on patients' mortality.

In conclusion, to answer to the main question: yes, the central venous pressure still represents a fundamental information in acute circulatory failure patients. However, one must know its limits and correctly interpret its values: not to predict fluid responsiveness, but to have a real-time information regarding organ perfusion and the risk of organ failure, as well as a possible safety limit during fluid resuscitation.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
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