The importance of hemodynamic monitoring in patients with SARS-CoV-2

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The whole world is facing the challenge against the novel coronavirus 19 (nCOV-19). Hospital setting, Emergency Departments (ED) and Intensive Care Units (ICU) required deep changes of their organization to give a rapid response to the huge number of patients presenting with severe acute respiratory failure (SARS-CoV-2).

Severe SARS-CoV-2 falls under the acute respiratory distress syndrome (ARDS) definition (1) and the same ventilatory strategy used for ARDS has also been suggested for SARS-CoV-2, including low tidal volume and high positive end expiratory pressure (PEEP) level (2,3). However, different lung patterns have been described in patients with SARS-CoV-2 and the typical ARDS ventilatory management has been questioned (4). It has been reported that many patients with SARS-CoV-2 had higher lung compliance than expected for typical ARDS patients. Less cases showed low lung compliance due to extensive lung consolidations. Consequently, it has been argued that patients presenting with normal/high lung compliance may less benefit from high PEEP strategy, commonly used for typical ARDS pattern, as hypoxia is primarily due to alveolar perfusion alteration and ventilation/perfusion mismatch with near normally aerated lungs. Instead, high PEEP strategy in these patients may lead to hemodynamic impairment. Moreover, less importance has been given to small tidal volume when plateau and driving pressure are maintained within safe limits. Thus, first of all, recognition of lung phenotype is fundamental for correct ventilatory management and to avoid lung overdistension. Even if chest computed tomography (CT) scan is the gold standard to discriminate between patients with interstitial syndrome with relatively aerated lungs and patients with consolidations, lung ultrasound (US) has been proposed for rapid screening and lung pattern detection (5,6). Lung US may be particularly useful especially when a huge number of infected patients must be managed. Lung US may be rapidly performed at bedside with minimal training, avoiding patients' transfer to radiological area. The lung pattern found will be helpful to guide initial ventilator setting.

Anyway, monitoring the effects of mechanical ventilation is fundamental to employ the right intervention tailored to the single patient. In pandemic situation, as for other aspect of patients' management during a mass casualty or disaster, staff and stuff are limited, and our best practice needs to be revised. Therefore, we might be forced to choose the easiest and useful tools for monitoring interventions' effects and following trends, omitting more sophisticated practices. Managing patients undergoing mechanical ventilation for severe respiratory failure, after ensuring that plateau and driving pressure lie within safe range and PEEP level is not causing overdistension (resulting in reduction of lung compliance), we should not forget to look at hemodynamics. Although the amount of patients presenting with shock and requiring vasopressor support is relatively low (7,8), the need of careful hemodynamic assessment comes from the potential adverse effects that high ventilatory support level may produce on cardiovascular system. Unfortunately, arterial pressure monitoring is not enough to completely understand heart-lung interaction. As pulmonary artery catheter or calibrated pulse contour method for continuous cardiac output monitoring are not feasible for everyone due to the number of patients requiring interventions, a feasible way to monitor patients' hemodynamics is echocardiography. Echocardiography is a non-invasive technique performed at bedside able to give useful and complete information about cardiac function. A fundamental assessment for these patients is right ventricular function. Pulmonary embolism and/or micro-thrombi formation at pulmonary micro-vessels level have been described in patients with SARS-CoV-2 (9). The potential negative effects of PEEP will be applied over a potentially high resistance pulmonary system, increasing right ventricular afterload furthermore. Therefore, it is important to know the effect of PEEP on right ventricular function because the risk of pressure overload is concrete. Setting PEEP, we should not solely look at oxygenation improvement, but we must be sure that the selected PEEP value does not impact on right ventricle or cardiac preload with consequent reduction of cardiac output and oxygen delivery. For this purpose, tracking central venous oxygen saturation ($ScvO_2$), lactate level and the venous-arterial difference of carbon dioxide ($Pv\text{-}aCO_2$) may be an easy way to assess cardiac output adequacy and to early detect an increasing oxygen extraction. Central venous pressure (CVP) may also give useful information, as it rises when right ventricle function is impaired (10). Moreover, a high CVP may be suggestive of reduced venous return and venous blood stagnation has negative effects on organ function, first of all the kidney. In fact, impaired renal function has been associated with high CVP values (11,12).

In conclusion, as for other clinical conditions, the ventilatory strategy must be personalized according to the patient's pathophysiology. For this purpose, as ventilator setting may have a great impact on hemodynamics, the role of hemodynamic monitoring is fundamental even in the pandemic context. During limited resource availability, arterial and central venous blood gas analysis, arterial and central venous pressure monitoring (the latter even intermittently) and at least daily echocardiographic assessment seem reasonable to recognize and limit the potential adverse effects of mechanical ventilation on cardiovascular system.

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Footnote

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