Editorial

Reliable assessment of perfusion is the Holy Grail of intensive care

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Optimizing oxygen delivery is the main goal of critical care. Inadequate oxygen delivery to tissues is an important cause of mortality and morbidity in children. Therefore, an early detection of inadequate perfusion and prompt correction of oxygenation will potentially improve outcomes of these patients. Hemodynamic assessment in the form of heart rate and blood pressure are routinely done in any hospitalized child. Clinical parameters such as blood pressure, heart rate, and capillary refill time by themselves have been found to be unreliable in early detection of inadequacy of perfusion and oxygen delivery. Blood pressure may be normal in clinical conditions with inadequate tissue perfusion and tachycardia is not always associated with poor perfusion. Inadequate perfusion may be associated with low, normal, or high cardiac output (CO). However, CO measurement combined with other clinical parameters may be useful for shock treatment algorithms. The gold standard for CO measurement remains the thermodilution technique with pulmonary artery catheterization (PAC). PAC is an invasive procedure and not suitable for routine use in children and has not been used in most clinical situations in children. Noninvasive hemodynamic monitoring is attractive, especially for the use in children.

Noninvasive methods of CO measurements are attractive in that they can be used early in the disease process and without associated complications of PAC. However, the measurement variability is high for any device for CO assessment. Even the gold standard method of CO measurement (thermodilution method by PAC) against which all other methods are compared has a high variability.[1] In addition, the use of PAC has not shown to improve clinical outcomes. Several noninvasive or less invasive methods of CO measurements have been evaluated in recent decades, including transpulmonary thermodilution, pulse contour analysis, tranesophageal Doppler, partial carbon dioxide rebreathing using Fick principle, transthoracic bioimpedence, and transthoracic bioreactance.[2]

Reliable and valid noninvasive method of monitoring perfusion is the Holy Grail of intensive care. In this issue, Dubost *et al.*,[3] compared the performance of bioreactance with esophageal Doppler method of measuring CO. It is no surprise that the correlation was not strong between these two methods. In general, the variability of CO measurement is high for all methods. In addition, the algorithm for calculation of CO in each device with various methods differs and what exactly is measured and extrapolated also varies. For practical reasons stated in the article the bioreactance technology was compared with esophageal Doppler method rather than the more reliable PAC. Most currently available noninvasive devices for measurement of CO are not reliable or validated for pediatric use and cannot be recommended for routine use to monitor CO.

There are several methods of hemodynamic monitoring that are available for use in critically ill patients.[4] CO

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monitoring is only one of them. Central venous saturation has been shown to be useful and is recommended for goal-directed therapy for septic shock patients.[5] Enthusiasm for tissue oxygen saturation, gastric tonometry, and tissue arterial carbon dioxide gradient[6] as targets for endpoint of resuscitation has waned as they have not shown to improve the patient outcomes.

Recently, indices (static and dynamic) of fluid responsiveness have shown to be beneficial in the management of critically ill-patients. Fluid administration is a cornerstone of management of many conditions with shock. Assessing whether a patient is fluid responsive or not has a significant implication for ongoing therapy. Changes in central venous pressure (CVP), CO, and global end-diastolic volume with a fluid challenge have been used as static indices of fluid responsiveness. There are many limitations to using them as surrogates of perfusion adequacy and the methods used to measuring them have many drawbacks. Respiratory variation in stroke volume, pulse pressure, systolic pressure, and CVP are the dynamic measures of fluid responsiveness and can be easily measured noninvasively with currently available technologies. These indices have shown to be valuable in mechanically ventilated adults to assess fluid responsiveness. However, their role in the assessment of the adequacy of perfusion and fluid responsiveness in spontaneously breathing children is neither validated nor found to be useful.

Dubost *et al*.,[3] have done an important study to pursue the quest for a simple, reliable, and noninvasive tool to measure CO. It is unlikely that measuring any one single parameter will help us reliably assess the adequacy of perfusion in all clinical situations and be useful to predict the outcomes. It is a sobering thought that although we use several monitors in hospitalized critically ill-patients, there is no broad evidence that any form of monitoring improves outcome of patients in intensive care unit and most commonly used devices are not evaluated by randomized control trials.[7] The integration of multiple hemodynamic parameters will be feasible with the expanding capabilities of computing power and the availability of many invasive and noninvasive devices based on various technologies and the multimodal monitoring to assess perfusion may be the future.

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