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Microcirculation in the intensive care unit

Microcirculação na unidade de terapia intensiva

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The maintenance of tissue oxygenation is a main goal in the care of critically ill patients. Unfortunately, there is no gold standard for its monitoring. For many years, research was focused on the behavior of systemic oxygen-derived parameters. In this way, a large number of studies attempted to address the meaning of the different relationships between oxygen transport (DO_2) and consumption (VO_2).

Sepsis is characterized by abnormalities in oxygen extraction, but the significance of a plateau of VO_2 or a linear VO_2/DO_2 relationship (the so-called pathological dependency) remains uncertain.[1] Moreover, severe tissue hypoperfusion might be present even under conditions of normal or increased systemic and intestinal VO_2. In contrast, parallel changes in VO_2 and DO_2 might not be a pathological phenomenon but rather reflect the physiological behavior of the system, in which cardiac output and DO_2 are modified to satisfy changing oxygen demands. These parameters may in fact be misleading because of methodological drawbacks related to their measurements and calculations. Surrogates of VO_2/DO_2 such as central venous or mixed venous oxygen saturations are usually normal in ICU patients.[2] Consequently, its usefulness, if any, seems to be related only to patients who do not receive resuscitation.[3]

The development of gastrointestinal tonometry and the subsequent introduction of different forms of tissue capnometry were important steps in the monitoring of tissue perfusion. Gastrointestinal tonometry rapidly became a useful tool in basic research. In addition, and for the first time, a regional parameter was used to detect and to treat hypoperfusion in the critically ill.[4] Despite a large body of evidence demonstrating their value, gastric tonometry and sublingual capnography are no longer used. Different methodological pitfalls as well as commercial issues could explain this situation.

In this issue of RBTI, two articles have been published reviewing recent advances in the monitoring of tissue oxygenation and perfusion.[5,6] Both are comprehensive evaluations of emerging technologies that could potentially help clinicians to better understand, monitor and treat critically ill patients.

In the last few years, the direct evaluation of microcirculation was translated from the basic research laboratories to intensive care units. The advances in videomicroscopic techniques, first with OPS and later with the improved SDF imaging device, now make it possible to visualize the microcirculation of any mucosa without contrast injection, at the bedside.[7] Dr. Penna et al. review recent basic and clinical research performed in sepsis with these techniques.[5]

A number of issues are worthy of comment: first, the main limitation

for the clinical implementation of videomicroscopic techniques is the evaluation of the images. Beyond the cautions needed to properly record the videos of the microcirculation, the analysis is both cumbersome and time consuming. Measurements of density, velocity and heterogeneity are the main parameters to analyze.[8] This can be done by the human eye or by the use of specific software. Future developments in this area should include new software that could rapidly provide objective information to clinicians.

In contrast to the hyperdynamic systemic circulation, the septic microcirculation is characterized mainly by hypoperfusion (decreased perfused capillary density, fraction of perfused capillaries and microvascular flow index) and increased heterogeneity.[9,10] In contrast, capillaries with increased blood flow are absent in the sublingual microcirculation of septic patients. Data from our group -still unpublished- show that only 4% of capillaries of septic shock patients show red blood cell velocities higher than the 75th percentile of the velocities of the normal volunteers.

Another relevant issue related to the microcirculation in sepsis is the heterogeneous behavior of different microvascular beds. Although Verdant et al. showed a similar pattern of sublingual circulation and intestinal villi hypoperfusion, this experimental study has an important limitation.[11] The microcirculatory derangements were much more severe than those described in septic patients. Therefore, it is possible that a more critical condition affects every territory homogeneously. In contrast, in a model of endotoxemic shock, the normalization of systemic and intestinal hemodynamics by fluid resuscitation corrected the sublingual and ileal serosal microvascular alterations. Villi hypoperfusion, however, remained present.[12] Accordingly, Boerma et al. showed a dissimilar behavior of sublingual and gut microcirculation in postoperative septic patients with intestinal ostomies. Consequently, different microcirculatory beds could behave differently.[13]

Although heterogeneity is present, strong evidence suggests that the monitoring of sublingual microcirculation in critically ill patients provides valuable information in terms of the severity of illness, outcome and monitoring of the treatment response.

In another review published in this issue of RBTI, Drs. Lima and Bakker comprehensively discussed the basics and new developments of near infrared spectroscopy (NIRS), with special emphasis regarding the monitoring of skeletal muscle oxygenation.[6] Remarkably, NIRS allows for the continuous and non-invasive monitoring of tissue oxygen saturation (StO_2). Although these characteristics are appealing, values of StO_2 are only clearly reduced in low-flow states. In sepsis, in which cardiac output is usually normal or elevated, StO_2 values may not differ from those of normal volunteers. In contrast, the dynamic response of StO_2 provides relevant information. As a manifestation of the severe microvascular disorders in sepsis, the slope of the recovery of StO_2 (ΔStO_2) after an occlusion test sharply differentiates healthy from septic subjects and survivors from non-survivor septic patients.[14] The ΔStO_2 reflects the adequacy of the reactive hyperemia. Reactive hyperemia is the increase in blood flow in response to a period of ischemia and reflects the ability to recruit the microcirculation. Accordingly, Georger et al. showed that the increase in mean arterial blood pressure from 54 ± 8 to 77 ± 9 mmHg improves ΔStO_2.[15] This finding could be interpreted as an improvement in microvascular perfusion in response to the elevation of blood pressure above the lower limit of the autoregulation of blood flow.

In this way, it is expectable that different microcirculatory territories might display heterogeneous behaviors owing to characteristics of the underlying disease or to the response to treatment. Therefore, the monitoring of microcirculation should ideally be targeted to different microvascular beds. A complete approach should include sublingual SDF imaging, muscle ΔStO_2 and tissue capnometry. Several methodological problems, however, need to be addressed. Moreover, clinical trials aimed at improving the microcirculation should demonstrate the actual value of these approaches. In the meantime, sublingual microcirculation and muscle StO_2 remain attractive windows for improving our pathophysiologic knowledge.

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