Assessment of splanchnic circulation : which relevance ?

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Shock is characterised by severe hemodynamic alterations leading to tissue hypoperfusion and, sometimes, tissue hypoxia. Once global hemodynamic alterations are corrected, alterations in regional blood flow and metabolism may persist, especially in sepsis, participating in the development and the maintenance of multiple organ failure. Although a direct cytotoxicity of nitric oxide or cytokines can be evoked, several arguments suggest that the maintenance of an adequate balance between oxygen supply and demand in the splanchnic area may be useful.

Anatomic and physiologic considerations

The liver is supplied by a dual circulation. The hepatic artery provides around one fifth of liver blood flow at a high oxygen content while portal blood flow provides the major portion of liver blood flow but with a low oxygen content. Hepatic arterial and portal vein blood flows are closely inter-regulated by the hepatic arterial buffer response, an increase in hepatic artery blood flow compensating for a decrease in portal vein blood flow. Hepatic artery and portal blood flows mix at the entry of the hepatic acinus, the functional liver unit. Before being drained by the hepatic vein, blood provides O2 and nutrients to the hepatocytes located in the sinusoids. Hence a wide PO2 gradient can be observed between the periportal the centrilobular zones, so that the latter is much more sensitive to decreases in oxygen supply. In normal circumstances, the hepatic vein saturation (ShO2) is close to mixed venous oxygen saturation (SvO2) so that the gradient between ShO2 and SvO2 is usually less than 10%.

The vascularisation of the gut is also complex. In normal conditions, the distribution of blood flow to the different components is related to metabolic requirements. The amount of blood flow (by unit of weight) directed to the small intestine is twice the amount directed to the stomach or the colon, the mucosal and submucosal regions receiving 70% of total gut blood flow. Metabolism is also very high in this area since the gut mucosa accounts for 10-15% of total body protein production. The typical vascularisation of the microvilli makes the gut mucosa particularly sensitive to alterations in blood flow. First, the artery to the villus forms a right angle with the mesenteric artery so that plasma skewing occurs. In consequence, the hematocrit of blood perfusing the villi is lower than systemic hematocrit. Second, the artery is located in the center of the villus, surrounded by two veins in which the flows are in opposite direction. At the top of the villus, the artery forms a dense capillary network. This particular anatomical vascular network provide better absorption of the nutrients but also allows countercurrent exchange of oxygen from the artery to the vein along their parallel course. Consequently, PO2 decrease from the base of the villus to its tip, reaching values as low as 30 mmHg.

Effects of sepsis on hepato-splanchnic blood flow and metabolism

The normal splanchnic O2 consumption (VO2) represents 20-35% of total VO2 while splanchnic blood flow is equal to 25% of cardiac output. In sepsis, hepato-splanchnic metabolism is markedly elevated and exceeds the increase in splanchnic blood flow so that the gradient between SvO2 and ShO2 is increased, ranging between 20 and 40% (1). Importantly a gradient higher than 10% is associated with covariance of hepato-splanchnic VO2 and hepato-splanchnic O2 delivery , suggesting flow limitation of liver metabolism in septic patients (2).

The effects of sepsis on the gut are more difficult to investigate. In experimental studies on septic shock, mesenteric blood flow had been reported to be reduced , unchanged, or increased. Such differences may depend on the animal species, the technique used to investigate regional blood flow and the amount of fluid administered. Even in experimental models in which mesenteric blood flow was increased, alterations in the gut mucosal permeability, gut mucosal acidosis and histologic lesions can be observed. In humans, gut mucosal acidosis can also be observed and is associated with a poor outcome (3,4).

What is the evidence that alterations in hepato-splanchnic blood flow and metabolism affect outcome ?

Several studies (5,6) have implicated the hepato-splanchnic area in the development of multiple organ failure. Although some studies have found histologic alterations in the gut and the liver during sepsis, these findings can be questioned as most other studies have

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found that patients dying from septic shock do not present gut or liver necrosis on histologic examination. Several studies have related liver (3,7) or gut (3,4) dysfunction to outcome. However therapeutics using gastric mucosal pH as a goal yielded controversial results (8,9), mostly because some of the interventions that were used failed to affect gastric mucosal pH (8,9) rather than to a lack of survival benefit induced by the correction of mucosal acidosis.

How can we assess hepato-splanchnic blood flow and metabolism in critically ill patients ?

Various methods can be used to estimate splanchnic blood flow and / or metabolism. Hepato-splanchnic blood flow can be measured by the infusion of dyes eliminated by the liver or by radiologic techniques. In the ICU echographic measurements of splanchnic blood flow are not reliable. The dye techniques are the most reliable even though these techniques cannot separate hepatic artery from portal vein blood flow. Several dyes can be used, including indocyanine green (ICG), sorbitol, lidocaine and bromesulftalein. ICG is the most commonly used substance. In the absence of hepatic vein catheterisation, the decay of the dye will represent blood flow and metabolism. Although this may be considered as a disadvantage, the gold standard technique requiring the insertion of a catheter into one hepatic vein to measure hepatic vein concentration of the dye (this is mandatory when extraction of the dye is incomplete, which occurs in sepsis or in liver cirrhosis), this method can be used to screen patients and to exclude both abnormal splanchnic blood flow and metabolism. This measurement can even be obtained in a completely non invasive way, measuring the decay curve by light absorbance with a fingerprobe (Limon system, by Pulsion) (7).

Alterations in gut mucosal blood flow can occur even if liver blood flow is normal. Gut mucosal blood flow cannot be measured actually. Laser Doppler probe can be applied on the gastric mucosa, but these only give arbitrary units, so that only relative changes can be evaluated. Gut mucosal acidosis can be evaluated by gastric tonometry. This technique measures PCO2 of the gastric wall, which reflects the balance between blood flow and metabolism in the gut mucosa. The measurements of splanchnic blood flow and gastric PCO2 investigate different aspects of the splanchnic circulation and can be used in combination.

Effect of various interventions

Although increasing splanchnic blood flow may not be beneficial, various interventions may affect the balance between oxygen supply and demand in the splanchnic area. Hypovolemia should be avoided since it promotes hepato-splanchnic hypoperfusion, however the effects of fluid loading in apparently adequately fluid resuscitated patients are more variable. The effects of red blood cell transfusions are also variable.

Vasoactive agents could increase oxygen demand and may alter blood flow distribution. In physiological conditions, hepato-splanchnic blood flow is increased by β-adrenergic and dopaminergic stimulation and decreased by α-stimulation. The various adrenergic agents usually combine α-, β- and sometimes dopaminergic actions, so that their effects on hepato-splanchnic blood flow would differ. Furthermore, the underlying condition, the dose used, the volume status, and the use of other vasoactive agents may all influence the response to these agents. An extensive review of the effects of theses drugs on splanchnic blood flow can be found elsewhere (10).

Conclusions

Hepato-splanchnic hemodynamics can be significantly altered patients with shock, and especially in septic patients, as indicated by decreased ShO2 and gastric mucosal pH, and, possibly in some cases, hepato-splanchnic VO2/DO2 dependency. The effects of the different interventions on hepato-splanchnic blood flow are variable and could not be inferred from the evaluation of global hemodynamic parameters. The assessment of splanchnic circulation may be of value, but, to our point of view, the use of non-invasive measurements such as gastric tonometry and ICG decay should be used first to identify patients with persisting abnormal splanchnic blood flow or metabolism, which may most benefit from invasive measurements.

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