



# Relationship between Systemic and Cerebral Perfusion in Neurocritical Patients

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## Abstract

Perfusion is a continuous and regulated physiological process of distribution of blood volume per unit of time and weight of tissue to guarantee energy requirements. Traditionally, perfusion was evaluated by monitoring systemic variables (macrocirculation), which constituted a limitation given its regional character with heterogeneous distribution according to particular needs of the different regions of the organism, through a micro vascular network (microcirculation). In the present communication highlight the need for systemic perfusion monitoring through macro and microcirculation variables together with monitoring of dependent organ variables to establish an accurate diagnosis of the patient's situation and especially to direct therapeutic actions. The peculiar characteristics of cerebral perfusion make CBF monitoring mandatory along with cerebral metabolic monitoring.

**Keywords:** Systemic perfusion, Cerebral perfusion, Transcranial Doppler, Brain metabolism

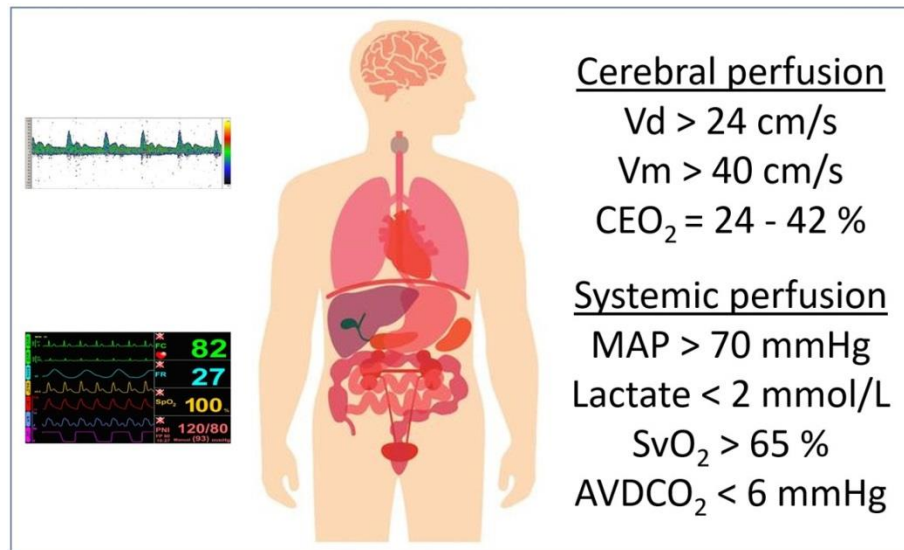
## Introduction

The word perfusion, etymologically derived from the Latin *perfundere*, which means spread. Perfusion is a continuous and regulated physiological process of distribution of blood volume per unit of time and weight of tissue to guarantee energy requirements (nutrients and oxygen). To this end, there is a complex transport network that includes lungs, heart, red blood cells / hemoglobin, macrovasculature and microvasculature that work strictly regulated to receive oxygen from the environment and transport it to the cells for use [1,2].



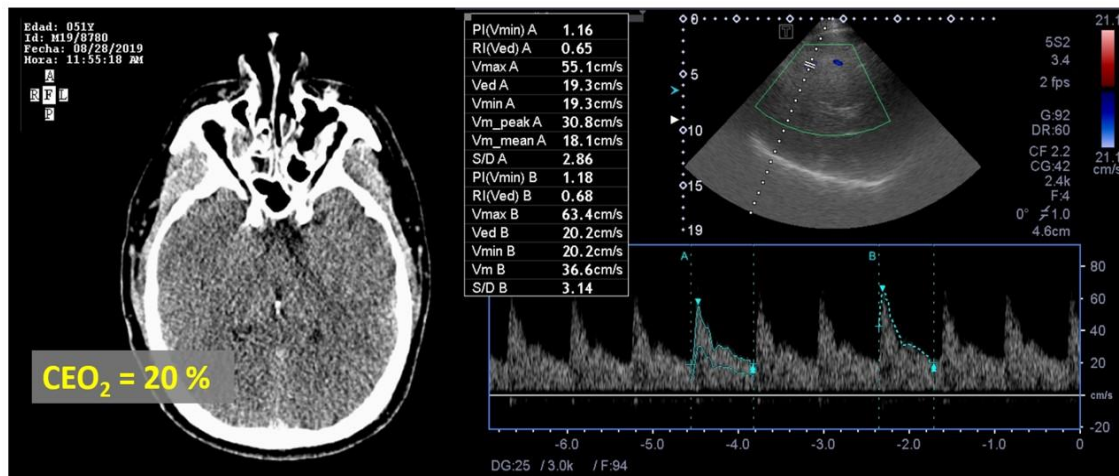
Traditionally, perfusion was evaluated by monitoring systemic variables (macrocirculation), which constituted a limitation given its regional character with heterogeneous distribution according to particular needs of the different regions of the organism, through a micro vascular network (microcirculation) [3,4]. In the case of the human brain, which represents 2% of body weight, given its energy need, it uses 15% of cardiac output, 25% of glucose and 20% of oxygen consumption of the entire organism. Approximately 50% of oxygen and 10% of arterial blood glucose that reaches through a cerebral blood flow (CBF) of 50 ml / 100 g / min is used for its metabolism [5,6]. Under physiological conditions, CBF is coupled to brain metabolism, which is known as metabolic regulation. The need to maintain an adequate and constant CBF in the face of changes in cerebral perfusion pressure

(CPP) requires the existence of compensatory mechanisms such as cerebral auto regulation [7,8]. Physicians attending critical patients should direct their actions to achieve adequate perfusion. To achieve this goal, the first step is to monitor the perfusion to be able to define whether it is suitable for the patient's needs. Even with monitoring systemic perfusion with both macro and microcirculation variables; it is necessary to incorporate specific regional or organic variables that will allow diagnosing and acting in abnormal situations [9,10]. By way of illustration of the previous statements, preliminary data are shared on a series of neurocritical cases that were monitored for systemic perfusion variables and cerebral perfusion variables through transcranial Doppler ultrasound and oxygen saturation at the jugular bulb level, figure 1.



**Figure 1.** Main monitoring variables of systemic and cerebral perfusion.  $V_d$ : diastolic velocity,  $V_m$ : mean velocity by transcranial Doppler ultrasound,  $CEO_2$ : cerebral oxygen extraction,  $MAP$ : mean arterial pressure,  $SvO_2$ : central venous oxygen saturation,  $AVDCO_2$ : venous arterial difference of carbon dioxide ( $CO_2$ ).

Result of interest, that in the entire series there were 52.4 % of patients with some element of systemic hypoperfusion; 63.3 % of them showed normal cerebral perfusion, at the same time of monitoring. Moreover, in that group of normal cerebral perfusion, 61.5 % showed CBF decoupling pattern / metabolism, compatible with luxury cerebral perfusion or hyperemia. Even 18.2 % of patients with cerebral hypoperfusion pattern, according to transcranial Doppler ultrasound; through the monitoring of cerebral oxygen extraction they showed a pattern of hyperemia, and therefore the CBF was above the needs according to real brain metabolism, figure 2.



**Figure 2.** Studies of a 51-year-old male patient diagnosed with hypoxic encephalopathy. Computerized tomography of the skull, cerebral oxygen extraction (CEO<sub>2</sub>): 20% and transcranial Doppler ultrasound with diastolic velocity: 19.3 cm / s, mean velocity: 30.8 cm / s in the middle cerebral artery. The transcranial Doppler pattern is compatible with cerebral hypoperfusion, however the study of CEO<sub>2</sub> suggests relative hyperemia.

In summary, the authors of the present communication highlight the need for systemic perfusion monitoring through macro and microcirculation variables together with monitoring of dependent organ variables to establish an accurate diagnosis of the patient's situation and specially to direct therapeutic actions. The peculiar characteristics of cerebral perfusion make CBF monitoring mandatory along with cerebral metabolic monitoring.

## Ethical Considerations

### Compliance with ethical guidelines

There was no ethical considerations to be considered in this article.

### Conflict of interest

The authors declared no conflict of interest.

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perioperative hemodynamic strategies. *Microcirculation*. 2015; 22(4): 267–75.

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