The following is the abstract of the article discussed in the subsequent letter:


Lingual, splanchnic, and systemic hemodynamic and carbon dioxide tension changes during endotox shock and resuscitation were studied in a canine model of endotoxin-induced circulatory shock and resuscitation. Sublingual Pco2 (PcO2) was measured by using a novel fluorescent optode-based technique and compared with lingual measurements obtained by using a Stoweseveringhaus electrode [lingual Pco2 (PcO2)]. Endotoxin caused parallel changes in cardiac output, and in portal, intestinal mucosal, and sublingual blood flow (Qs). Different blood flow patterns were observed during resuscitation: intestinal mucosal blood flow returned to near baseline levels postfluid resuscitation and decreased by 21% after vasopressor resuscitation, whereas Qs rose to twice that of the pre-shock level and was maintained throughout the resuscitation period. Electrochemical and fluorescent Pco2 measurements showed similar changes throughout the experiments. The shock-induced increases in Psco2 and PpcO, were nearly reversed after fluid resuscitation, despite persistent systemic arterial hypotension. Vasopressor administration induced a rebound of PpcO2 and PscO2 to shock levels, despite higher cardiac output and Qs, possibly due to blood flow redistribution and shunting. Changes in PpcO2 and PscO2 paralleled gastric and intestinal Pco2 changes during shock but not during resuscitation. We found that the lingual, splanchnic, and systemic circulations follow a similar pattern of blood flow variations in response to endotoxin shock, although discrepancies were observed during resuscitation. Restoration of systemic, splanchnic, and lingual perfusion can be accompanied by persistent tissue hypercarbia, mainly lingual and intestinal, more so when a vasopressor agent is used to normalize systemic hemodynamic variables.

Microcirculation Studies in Dogs

To the Editor: We read with interest the article by Guzman and colleagues (7) on the patterns of sublingual and intestinal mucosal perfusion in endotox dogs, using sublingual capnometry, tonometry, and laser-Doppler flow probes. Although this study sheds some light on the mechanisms and treatment of microcirculatory alterations in circulatory shock, we would like to highlight some possible limitations of the dog model used by these investigators.

Indeed, although most mammals differ slightly in the way they dissipate heat, the dog differs considerably in that it dissipates almost entirely on panting (9). So-called polypneic thermoregulation is a mechanism by which some animals regulate their body temperature through evaporative heat loss by their oral mucosa and upper respiratory apparatus. To fulfill this particular role, the canine tongue possesses important anatomical and physiological particularities, and, consequently, the behavior of its microcirculation may be quite unique.

Dogs present a considerable number of arteriovenous anastomoses (10), richly innervated by adrenergic nerve plexuses (8), on the superficial surface of their tongue. Under these conditions, the laser-Doppler technology used in the study by Guzman et al. (7) may lack specificity. As has been reviewed elsewhere (3, 11), laser-Doppler estimates blood flow by averaging the values from all the vessels present in ~1 mm3 of tissue, this regardless of the spatial distribution and the nature of the vessels (i.e., capillaries, venules, or arteriovenous anastomoses...). Moreover the heterogeneity of microcirculatory disturbances is not taken into account.

Because changes in tissue CO2 concentration primarily reflect alterations in perfusion (6, 14), the CO2 increase that Guzman et al. (7) recorded under the tongue may represent perfusion deficits that were overlooked by the laser-Doppler measurements. Substantial decreases in capillary perfusion secondary to shunting of blood through the arteriovenous anastomoses might have been missed by the laser-Doppler or, even worse, estimated as an increase in blood flow. Other techniques like orthogonal polarization spectral imaging (5) may be useful in this situation (3), with the advantage of being able to visually separate venules, arterioles, and capillaries and assess their respective perfusion. The orthogonal polarization spectral technique revealed that, in patients with septic and cardiogenic shock (1, 2), it is the capillary circulation that is primarily affected, whereas most large vessels remain perfused.

The canine tongue also seems to have a peculiar vasoreactivity. Greenberg et al. (4) reported that the lingual artery in dogs has a very different response to the stimulation of calcium influx than the mesenteric artery or other vessels. Moreover, Tsukada and Chiba (13) showed a depressed vasoconstrictive effect of norepinephrine on the lingual artery that was not reproducible in the mesenteric vessels when they were submitted to changes in temperature. Hence, constitutive differences in tongue arteries compared with gut arteries in the dog may have played a significant role in the findings reported by Guzman and collaborators (7). Finally, work by Skrbic and Chiba (12) suggests that monkey and dog lingual arteries possess distinct subtypes of α-agonist adrenoreceptors, highlighting the possibility that evaluation of the microcirculation of the canine tongue, owing to its quite unique character, may not necessarily be generalizable to other species, especially humans.

In conclusion, we commend Dr. Guzman and colleagues for their excellent work and this important contribution to a better understanding of the regulation of microcirculatory flow in sepsis. However, we raise the possibility that not only the laser-Doppler techniques used but also the unique characteristics of the canine tongue may have significantly influenced their findings. Addressing these issues with other techniques and in other species would be of great value.

REFERENCES

REPLY

To the Editor: We appreciate the insightful comments of Drs. Verdant, De Backer, Creteur, and Vincent. They correctly point out that dogs, unlike humans and many other mammals, dissipate heat by panting and that the canine lingual circulation may therefore have important anatomic and physiologic differences that impact its response to endotoxic shock. However, purely functional effects that occur in the lingual microvasculature during panting would likely be diminished or absent during temperature-controlled general anesthesia.

They also correctly point out that laser-Doppler technology provides an estimation of blood flow by averaging values from all vessels in an area of ~1 mm². As mentioned in our discussion, we acknowledge that the observed changes in lingual blood flow and PCO₂ may be secondary to increased shunting rather than increased capillary perfusion (1). This is further supported by the increase in tissue PCO₂ after vasopressor resuscitation.

We fully agree with Dr. Verdant and colleagues that assessing the lingual circulation with alternative techniques, such as orthogonal polarization spectral imaging, and using other species would provide further insight into the subject and would be of great value.

REFERENCES


Colin L. Verdant
Department of Intensive Care
Sacre-Coeur Hospital
University of Montreal
Montreal, Quebec, Canada
E-mail: cverdant@crhsc.umontreal.ca

Daniel De Backer
E-mail: ddebacke@ulb.ac.be

Jacques Creteur
E-mail: jcreteur@ulb.ac.be

Jean-Louis Vincent
E-mail: jlvincen@ulb.ac.be
Department of Intensive Care
Erasm University Hospital
Free University of Brussels
Brussels, Belgium

Jorge A. Guzman
Division of Pulmonary, Critical Care, and Sleep Medicine
Wayne State University School of Medicine
Detroit, Michigan

James A. Kruse
Critical Care Services
Bassett Hospital
Cooperstown, New York