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## Skin Circulation and the Thermoregulatory Threshold

*To the Editor:*—Sessler *et al.*<sup>1</sup> recently published their results of temperature measurements during general anesthesia with halothane, in support of a hypothermic threshold for thermoregulation. Their study was thought-provoking and serves to highlight some of the problems associated with skin circulatory physiology.

Skin temperature is a useful indirect measure of serial changes in skin blood flow (SBF). However, it is a relatively insensitive modality being affected by various factors, such as equipment design, skin texture, contact of thermocouple with skin, and ambient temperature. In Sessler's study, a gradient of 4° C between forearm and fingertip skin temperature during hypothermia was proposed as evidence of cutaneous vasoconstriction and "thermostatic" hypothalamic temperature regulation in 12 patients, corroborated by Laser Doppler and hand venous P<sub>O</sub><sub>2</sub> measurements in two additional patients. The designation of the 4° C skin temperature gradient was determined by the authors in preliminary studies.<sup>2</sup>

The skin circulation is noted for its regional variations of anatomy and physiology. Total SBF consists of nutrient or capillary flow and arteriovenous (a-v) anastomosis flow. During body cooling, vasoconstriction of a-v anastomoses occurs,<sup>3</sup> so that a-v shunt flow decreases significantly more than nutrient flow.<sup>4</sup> Anastomoses are numerous in the digits, particularly the fingertips, and virtually absent in the forearm skin.<sup>5</sup> Vasomotion of cutaneous precapillary vascular beds, accounting for changes in SBF velocity, occurs less frequently in the digits, compared to more proximal skin areas.<sup>5</sup> One researcher concluded that "observations in one skin area cannot necessarily be applied to others at the periphery."<sup>6</sup>

This study raises a number of interesting issues related to the demonstration and interpretation of cutaneous vasoconstriction. Since the characteristics of SBF to the fingertip and forearm differ considerably, hypothermia would be expected to produce a larger temperature drop at the fingertip, compared to forearm skin, since a-v shunt flow would be predominately affected. Therefore, the observed skin temperature gradients in hypothermic patients could be explained on the basis of local blood flow phenomena instead of "thermostatic" hypothalamic mechanisms. It is not known whether halothane modifies this response,

compared to other pharmacologic agents. The Laser Doppler used in this study can measure cutaneous blood flow velocity in any skin area of the body, even if conditions are changing. Photoplethysmography of the fingertip could provide information about the cutaneous pulsatile microcirculation. Thermography could be used to demonstrate skin temperature changes over a wider area compared to a single thermocouple. A combination of these monitors from various sites would provide more information about regional changes in skin circulation, and further characterize central thermoregulatory mechanisms.

I commend Sessler and colleagues for an interesting study. The review of thermoregulation was most informative.

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## More on Thermoregulatory Thresholds with Halothane

*To the Editor:*—We applaud the elucidation by Sessler *et al.* of mechanisms of human thermoregulation during anesthesia;<sup>1</sup> also, we would like to comment on the interpretations of esophageal temperatures measured during the study.

First, when an esophageal stethoscope is positioned at the site of "maximum heart tones," a subjectively determined location, its tip, with temperature sensor, may still be lying in a retrotracheal position. A previous study by Whitby and Dunkin elegantly demonstrated the nonuniform distribution of temperatures along the esophagus, both longitudinally and laterally. These investigators noted that the lower fourth of the esophagus was both the warmest and the most thermally

stable segment.<sup>2</sup> Of note was the observation that temperature varied almost 1° C with as little as a 2-cm change in depth of esophagus. In a more recently published study that confirms a temperature gradient along the esophagus, a shift of as little as 2 cm had "very little effect on the sounds," the highest temperatures being recorded at a site 12-16 cm deeper than where best heart and breath sounds occurred (38-42 cm from the incisors).<sup>3</sup>

Second, esophageal temperature can be influenced by active warming of airway gases with a heated humidifier. In a study of how esophageal temperature is influenced by airway temperature, we demonstrated that even passive warming of inspired gases with a heat and moisture