In Reply—As Introna et al. correctly point out, there has been considerable controversy during the last 10 yr as to the interpretation of data derived from measurements of heart rate variability in the frequency domain, particularly with regard to the low-frequency range. In fact, no solid proof has been provided indicating that low-frequency spectral power of heart rate variability is specifically related to efficient cardiac sympathetic drive. Furthermore, what exactly is the physiologic meaning of heart rate variability, what are the neural pathways involved, what, to quote a reviewer of our paper, “is the science behind the technique”? The comments of Introna et al. do not provide an answer to these questions. What appears to be needed at this point is rigorous testing of hypotheses related to the physiologic meaning of heart rate variability measures and neural pathways involved.

We tested in humans the hypothesis that thoracic epidural anesthesia attenuates low-frequency spectral power of heart rate variability, as assumed by some to reflect cardiac sympathetic modulation. Based on the data obtained, however, we found no attenuation and, consequently, proposed that low-frequency spectral power may not reflect specifically cardiac sympathetic modulation.

In their critique, Introna et al. expressed several arguments against our conclusion:

1. They argue that the state of health of our patients studied may have influenced the results obtained. As stated in the methods section of our paper, all patients were free of cardiovascular disease (by medical history, physical examination, chest x-ray, and 12-lead electrocardiogram), did not receive drug medication or premedication, and were studied before elective surgical procedures. Thus, it remains unclear in which manner “the state of the patient’s health could have contributed to the results."

2. That norepinephrine plasma concentrations did not increase during the 40 deg head-up tilt can by no means be taken as (implicit) evidence that the sympathetic nervous system is not activated during tilt. In fact, substantial activation of the sympathetic nervous system has been documented by direct sympathetic nerve recordings during a 40 deg head-up tilt. It is also known that norepinephrine plasma concentrations do not necessarily reflect such sympathetic activation. Furthermore, even with apparent activation of the cardiac sympathetic system (threshold increase in cardiac norepinephrine spillover) in patients suffering from cardiac failure, low-frequency spectral power decreased rather than increased. Thus, sympathetic activation was likely present in our study during a 40 deg head-up tilt but not reflected by changes in low-frequency spectral power. Again, this may relate to the fact that this method does not specifically measure what its proponents claim.

3. Introna et al. argue that a low-frequency window other than 0.04–0.15 Hz may have yielded different results. As Introna et al. are aware, there is no consensus on the definition of the low-frequency band, and more than different window proposals for selection of a low-frequency spectral power band have been published in highly esteemed journals. Our frequency range is in line with the literature in this field, like that chosen by Introna et al. (0.04–0.15 Hz) or Montano et al. (0.04–0.13 Hz). Furthermore, we have analyzed our data using a different low-frequency window (0.02–0.15 Hz), yet results obtained were similar.

4. Introna et al. claim that thoracic epidural anesthesia may have resulted in an incomplete cardiac sympathetic block. As outlined in the discussion section of our paper, all data based on direct nerve recordings of sympathetic efficients, the neurophysiologic correlate of sympathetic tone, indicate that epidural blockade abolishes sympathetic nerve activity, at least within the borders of sensory blockade. However, even if sympathetic outflow to the heart had been only attenuated rather than abolished, a diminution of low-frequency spectral power should have occurred during epidural anesthesia with 0.75% bupivacaine. However, this was not the case. Again, therefore, Introna et al. should entertain the possibility that low-frequency spectral power may not measure what the proponents of this methodology seek for granted.
CORRESPONDENCE

In addition, our conclusion is strongly supported by recent data assessing (fast Fourier transformation) heart rate variability in young men with chronic complete cervical spinal cord transection as well as in healthy volunteers. In this study, a substantial amount of low-frequency spectral power is present in patients with transected spinal cord, related to arterial blood pressure, and nearly abolished by atropine in both the tetraplegic and healthy subjects. This suggests that low-frequency spectral power is related to central baroreflex mechanisms and, at least in a major fashion, to vagal rather than sympathetic cardiac outflow. In addition, the same results were obtained by another group. However, this study did not include absolute integrals, or integrals divided by total power, which may provide meaningful estimates of sympathetic traffic to the heart, or of the balance between sympathetic and vagal neural outflows.

Thus, whether any measure of low-frequency spectral power provides a simple, meaningful, specific, sensitive, and reproducible estimate of cardiac sympathetic modulation in the hand of unbiased investigators appears questionable.

Hans-Bernd Hopf, M.D.
Andreas Skyschally, Ph.D.
Gerd Heusch, M.D., F.E.S.C., F.A.C.C.
Jurgen Peters, M.D.
Institut für Klinische Anaesthesiologie
Gebäude 12.42
Heinrich-Heine-Universität Düsseldorf
Moorenstraße 5
D-40225 Düsseldorf, Germany

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(Accepted for publication July 18, 1995.)

The Penn State Anesthesia Electronic Case Conference

To the Editor—The Internet, once the domain of the military and research scientists, is becoming a useful resource for the anesthesia community. The ease of use and richness of information within the World Wide Web is quickly making it the most popular area of the Internet.

Anesthesia Case Conferences, held within virtually every academic center in the United States, is a place where anesthesiologists gather to discuss patient management issues. Rarely, if ever, events are presented and discussed by more than a few. In the past, access to these discussions was limited to the hospital of occurrence. Access by the private practitioner was almost nonexistent.

The Penn State Anesthesia Electronic Case Conference combines