In Reply—The title of the letter by Lawson et al., *All That Quakes Does Not Necessarily Shiver*, expresses the basic contention of our article. Many clinical oscillations have been named but not quantified. Consequently, the literature concerning this topic is confusing and includes terms such as "coarse tremor," "fine shake," and "wet dog shakes." In contrast, tremors of unclear etiology have frequently been considered normal thermoregulatory shivering without adequate justification. The purpose of our study was to determine whether postanesthetic tremors resemble normal shivering.

The EMG recording and analysis techniques we used were outlined in our paper. The details were described in 1973 by Stiles, in an article that was referenced in the Methods section of our paper. To prevent signal aliasing, electromyographic data were digitized at 1024 Hz, which is a rate approximately fourfold higher than the fastest shivering component. The signals were then amplitude demodulated, because Fox and Randall demonstrated in 1970 that the resulting bursting pattern correlated well with limb acceleration. Demodulation is a two-step process in which signals are rectified and low-pass filtered. Digital full-wave rectification is easily accomplished by taking the absolute value of each digital amplitude. Many different analog and digital filters have been described: we used a simple (but adequate) "boxcar" filter in which 16 non-overlapping values were averaged. The purpose of this filtration is to separate high frequency signals from the motion-related, low-frequency bursting pattern.

The autocorrelation functions for each signal were then derived to evaluate the dependency of the process at one point in time with values of the same process at other points in time. To determine the intensity at each frequency, the power spectra were computed from the square of the real portion of the last Fourier transform. All Fourier transforms assume that the process is stationary. To provide adequate frequency resolution, 16-s segments were used to analyze the bursting pattern, whereas 1-min segments were needed for the 4–8-cycle/min "waxing-and-waning" pattern.

Lawson et al. find it difficult to believe that the sharp 4–8-Hz spectrum seen in figure 3 of our study could be derived from the EMG signal seen in figure 1D of that study. Power spectral analysis is used commonly because it is frequently impossible to determine component frequencies of complex signals without mathematical assistance. This is particularly true when a complex signal has only a limited frequency range that is of physiological interest (e.g., 1–15 Hz for many tremors).

Certainly, many unprocessed signals appearing to be random (e.g., "white noise") have "tight" power spectra within a particular frequency range. For example, traces A and C in figure 1 (of this communication) appear to be random signals. In fact, 33% of the total signal intensity in trace A is between 5 and 7 Hz. The power spectra in trace B make it obvious that, within the frequency range of physiological interest, virtually all power is between 5 and 7 Hz.

We used the term "spontaneous EMG clonus" to describe an electromyographic pattern identical to that produced by pathological clonus. Because flexion-induced plantar clonus occurred simultaneously, *we hypothesized* that spinal disinhibition is the most likely etiology for this tremor. Other possibilities obviously exist, but were not specifically tested in our study. (In any case, such tests will be difficult in humans.) However, we do know that neither flexion-induced, nor...
spontaneous, clonus occurs during cold-induced thermoregulatory shivering. This indicates that at least one component of postoperative tremor is not normal thermoregulatory shivering.

Lawson et al. are also concerned about figure 2B, in which we present an EMG signal from a patient who is overtly shaking in contrast to a normal subject who is shivering. The point made by Lawson et al. is that the shivering signal seen in figure 2A does not resemble the EMG signals seen in the patient who is overtly shaking in figure 2B. This is exactly our point. They suggest that the signals illustrated in figure 2B could be the tonic stiffening of muscle as seen during a generalized seizure. There is no question that there is tonic stiffening in these patients. But it seems unlikely that our normal patients, who were often awake and alert, were having seizures.

Finally, the authors address the point that the data we presented on normal cold stressed shivering is derived from our single study and has been published only in abstract form. The paper titled “Synchronized slow amplitude modulations in the electromyograms of shivering muscles” is in press (Journal of Applied Physiology).

We would like to stress that the term “shiver” only describes thermoregulatory tremor in cold stressed subjects; it should not be used to explain or describe other overt oscillations. The etiology of a particular shivering-like tremor cannot be ascribed to thermoregulation without mathematical analysis of electromyographic signals combined with multiple temperature measurements.

Our study was a first attempt to quantitatively analyze postoperative tremor. As such, interpretation of our results is subject to certain limitations—which were clearly stated in the text. The two most serious are that our patients were slightly hypothermic and that we didn’t measure thermoregulatory vasconstriction (because we had yet to develop a reliable method to determine peripheral blood flow in patients with vigorous tremor). Consequently, it is difficult to determine the extent to which postoperative tremor is thermoregulatory. Certainly, we agree that normal shivering can occur during recovery from general anesthesia, and specifically stated in our paper under which circumstances it is likely. It should also be obvious that patients who become sufficiently hypothermic during surgery to trigger thermoregulatory responses are likely to shiver postoperatively. However, it was clear from qualitative examination of the raw EMG signals that many did not have the characteristics of normal shivering. We are currently evaluating the extent to which these tremors are derived from other etiologies, including spontaneous clonus and abnormal (e.g., spastically mediated) shivering.

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REFERENCES


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The Use of a Vinyl Glove Does Not Affect Pulse Oximeter Monitoring

To the Editor—Recently Sloan1 reported three cases of finger injury following use of an oxygen saturation monitor probe. To further minimize injury with an oxygen saturation monitor probe, we recommend placing a vinyl glove on the hand to which the probe is to be applied (fig. 1). This would at least decrease the chance of injury occurring from chemical or betadine contamination. We have not found the use of a vinyl glove to have an effect on the pulse oximeter reading.

After obtaining institutional approval, we studied ten healthy female patients who had regional anesthesia for either cesarean section or postpartum tubal ligation to determine what effect a vinyl glove would have on hemoglobin and oxygen saturation readings determined by pulse oximetry (SpO2). A Nellcor® oximeter probe was placed on the right index finger of each patient, and an SpO2 reading was made after 2 min. A Travenol Triflex® vinyl examination glove was then placed on the patient’s right hand, the pulse oximeter probe was again placed on the right index finger, and an SpO2 reading was made after 2 min. There was no significant difference between the SpO2 readings of the

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There were no significant differences between the two groups.

Fig. 1. Gloved hand with oximeter.