Introduction. Tremor is common during epidural anesthesia, possibly as a consequence of stimulating spinal cord thermal receptors with cold epidural injectate.\textsuperscript{1,2} To test the hypothesis that epidural/spinal temperature changes provoke thermoregulatory responses, we injected warm and cold saline into the epidural space.

Methods. With approval from our Committee on Human Research, we studied four unpremedicated, healthy volunteers. A Portex\textsuperscript{\textregistered} catheter containing a calibrated thermocouple was placed in the epidural space in each volunteer. Epidural, tympanic, and average skin temperatures\textsuperscript{3} were recorded every 2 min. Oxygen consumption was determined every 5-10 min by measuring expired volume and $\text{O}_2$ and $\text{CO}_2$ concentrations. Electromyograms (EMGs) were recorded from the deltoid, trapezius, quadriceps, and anterior tibialis muscles. EMG signals were amplified and rectified, analog filtered to 15 Hz, digitized at a rate of 32 Hz, and digitally integrated. Two-min EMG epochs were analyzed and recorded on a hard disk in real time using a Macintosh\textsuperscript{\textregistered} II computer.

Each volunteer was given two cold (0°C) and one warm (54°C), 80-ml epidural injections of saline at a rate of 5 ml/min. The first injection was always cold and was given while subjects (who were lightly clothed at an ambient temperature of 19°C) reported feeling cold but had no EMG or clinical evidence of shivering. To provide a positive control for the first injection and assess the effects of epidural temperature changes on pre-existing shivering, shivering was induced by application of cooling blankets and warm and cold epidural saline injected in random order. The epidural catheters were insulated and subjects were not told the injectate temperatures.

Results. Thermoregulatory responses in one subject are presented graphically. In each figure, epidural injections were given at 15, 85, and 155 min and the dark bars under the words "Cold" or "Warm" show the duration of these injections. Epidural temperatures were markedly affected by infusate temperature (figure 1). All subjects felt a warm sensation in their hips and legs during the first cold injection and guessed that the saline was warm. The first cold injection never caused shivering. The second and third injections had no consistent effect on shivering intensity, but this response was difficult to interpret because there was considerable variation with time even during the control periods (figure 2). Changes in oxygen consumption correlated with changes in EMG intensity but not with temperature of the epidural injectate.

Discussion. We were unable to provoke shivering in volunteers even with a large volume of cold saline. Previously, we demonstrated that tremor during epidural anesthesia (for Cesarean section) is more common with cold than warm epidural bupivacaine.\textsuperscript{2} The present data suggest that tremor associated with injection of cold epidural anesthetic does not result simply from stimulation of epidural/spinal temperature receptors. A synergistic effect of cold and pregnancy or cold and local anesthetic is possible.

Figure 1. Tympanic, epidural, and average skin temperatures during three epidural injections.

Figure 2. Sum of the integrated EMG intensities from four muscles during three epidural injections.

References.