EXTRADURALS AND SHIVERING: EFFECTS OF COLD AND WARM EXTRADURAL SALINE INJECTIONS IN VOLUNTEERS†

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SUMMARY
We tested the hypothesis that cooling the extradural space may provoke shivering, by giving three 80-ml extradural injections of warm (39.8±1.2 °C) or cold (17±2.2 °C) saline to four healthy volunteers, whilst recording central temperature and electromyographic activity from four muscles. The first injection (always cold) did not induce shivering in any of the subjects. The second and third injections, randomly cold or warm, were given after induction of shivering with cold blankets, but had no detectable effects on the intensity of shivering. This suggests that shivering in extradural anaesthesia does not result solely from cooling of the extradural space.

KEY WORDS

Previous work has shown that shivering during extradural anaesthesia for Caesarean delivery is more common after administration of cold than after warm bupivacaine [1], suggesting that the extradural space is sensitive to temperature changes. We report here the effects of injecting warm and cold saline into the lumbar extradural space of non-pregnant volunteers. As shivering results from a convergence of peripheral and central factors [2], we decided to start experiments with a cold injection in a moderately cool ambience, but in the absence of shivering. We then cooled the subject's skin until shivering was triggered and observed the effects of cold and warm extradural saline upon the intensity of the tremor.

METHODS AND RESULTS
With approval from the U.C.S.F. Committee on Human Research and written informed consent, we studied two male and two female healthy volunteers: ages 20-41 yr, weights 54-62 kg, heights 159-171 cm. None was obese, a smoker, taking medication or had a history of thyroid disease; they refrained from taking coffee, tea and food during the 4 h preceding the study.

Using standard techniques, an 18-gauge catheter (Portex, Inc.) was introduced 2-3 cm into the extradural space (L3-4) and isolated from the skin with foam; 0.75 % bupivacaine 4 ml was injected s.c. at the puncture point. The catheter tip contained a calibrated thermocouple, constructed of two thin wires which did not occlude the lumen, and with a 90 % step response time of less than 1 s.

Volunteers wore shorts and a light cotton shirt and rested supine on a padded operating table. Ambient temperature was 20.1 (SD 1.4) °C.

Syringes with isotonic saline were stored in ice and in a water bath at 54 °C before extradural injections. Each volunteer was given two cold and one warm 80-ml extradural injections of saline at a rate of 5-10 ml min⁻¹, by means of a Harvard 975 pump, whilst the temperature was monitored continuously at the tip of the catheter. Temperature of the cold saline was in the range 14.8-19.2 °C and that of warm saline was 38.6-41.0 °C. These volumes and rates of infusion were safe, as rapid therapeutic extradural injections of 145 ml saline have been reported to be devoid of adverse effects [3]. The first injection was always cold and given while subjects had no evidence of shivering. Shivering was induced by placing cooling blankets (at 5 °C) around each

subject and two further saline injections (one cold and one warm) were given in random order. Subjects were not aware of the temperature of the injectate.

Tympanic membrane, ambient, forearm and fingertip temperatures were measured with thermocouples (Mon-a-Therm). Temperature values were displayed and stored every 40 s in a Macintosh II computer.

Pairs of ECG electrodes were placed over the deltoid, trapezius, quadriceps and anterior tibialis muscles and electromyographic (EMG) signals amplified and processed digitally (LABVIEW 1.2). Traces were obtained of integrated activity, either of all muscles added or from upper and lower limbs separately. Recording of elapsed time started at 15 min before the first injection. The second injection was started at 85 min and the third at 155 min. The 15 min preceding each injection was used as a control period for purposes of comparison, and data collection continued for 30 min after each injection. Although the order of the warm and second cold injection was random, grouped data are presented as if the warm injection was always given second, for clarity.

EMG intensities were analysed using repeated-measures ANOVA and Student–Newman–Keuls test (significant difference at \( P < 0.05 \)).

Forearm–fingertip temperature gradients at the time of the initial cold injection were 6.3 (SD 3.5) °C, indicating that all subjects were vaso-constricted. Catheter tip temperature returned to within 1 °C of baseline approximately 20 min after cold injections and 6 min after warm injections. Injections produced a mild feeling of pressure in the back which resolved within seconds of stopping injection.

The first cold injection never caused shivering. EMG activity increased approximately three-fold during application of cold blankets, but the second and third injections produced no consistent change in EMG activity. There was considerable variation in EMG intensity, especially during shivering (fig. 1).

There was a small but statistically significant decrease in total EMG intensity from the end of the cold injection during shivering to the end of the respective recovery period. No other changes in the total or legs-only EMG intensities were significant. The cold injections produced a transient sensation of warmth in the lower abdomen.

**Fig. 1.** Sum of EMG intensities from four muscles (deltoid, trapezius, quadriceps, and anterior tibialis) (●) and from the legs only (○) during three extradural injections given at 15, 85 and 155 min and lasting 8–16 min. Each point represents the mean from four subjects and error bars indicate SD (onesided error bars for every other point).

**COMMENT**

Spinal thermoreceptors contribute some 20% of thermal input to the hypothalamus in most mammals [3]. Consequently, cold local anaesthetic solution might induce shivering by increasing spinal input. Our inability to induce shivering with cold injections does not exclude a thermal input from the spinal cord in man, but weakens the hypothesis that the temperature of the anaesthetic contributes significantly to the shivering observed clinically.

It is possible that the thermal stimulus used in this study was inadequate. In most mammals the cervical and upper thoracic spinal cord is most sensitive to local temperature changes [2]. Our lumbar injections may have been inadequate to reach the upper thoracic cord, in spite of considerable lumbar cooling. The lack of shivering after the first cold injection was reinforced by the lack of effects of the subsequent cold and warm injections upon the intensity of established shivering. These results are difficult to reconcile with the previous claim that 5–10 ml of warm local anaesthetic stops shivering [4]. A more recent study in non-pregnant subjects supports our present results [5].
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To reconcile our previous [1] with our present findings, we postulate that either pregnancy enhances the contribution of spinal thermo-regulatory input, or local anaesthetic facilitates shivering.

Although we evaluated only four subjects, each received two cold injections and the thermal stimulus used was greater than a patient would experience during extradural anaesthesia. In the clinical setting, the contribution of the anaesthetic temperature to shivering in extradural anaesthesia, in non-pregnant subjects, is likely to be minimal.

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REFERENCES