**Title:** The thermoregulatory threshold in humans during nitrous oxide/fentanyl anesthesia

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**Introduction.** Hypothermia produces thermoregulatory vasoconstriction in patients anesthetized with halothane\(^1\) and isoflurane,\(^2\) but the response thresholds are \(\sim 2.5^\circ\text{C}\) below normal. Both narcotics and \(\text{N}_2\text{O}\) inhibit thermoregulatory responses in animals.\(^3,4\) We tested the hypothesis that \(\text{N}_2\text{O}/\text{fentanyl} \) anesthesia would decrease the thermoregulatory threshold in humans. We also compared the decrease in cutaneous capillary (nutritional) blood flow to the decrease in arterio-venous shunt (thermoregulatory) flow.

**Methods.** With approval from our Committee on Human Research, we studied 15 unpremedicated patients electively donating a kidney. Anesthesia was induced with halothane/\(\text{N}_2\text{O}\) and maintained with \(\text{N}_2\text{O}\) (70%), vecuronium, and fentanyl (a loading dose of 10 mcg/kg followed by an infusion of 4 mcg/kg h\(^{-1}\)). Patients were randomly assigned to receive no hypothermia precautions (n = 10) or additional warming measures including warm intravenous fluids and breathing circuit humidification (n = 5).

Constriction of thermoregulatory arterio-venous shunts was evaluated using skin-temperature gradients (finger tip surface temperature subtracted from forearm surface temperature). Significant vasoconstriction was prospectively defined as a skin temperature gradient \(\geq 4^\circ\text{C}\)\(^1\) and the thermoregulatory threshold was defined as the esophageal temperature at which vasoconstriction occurred. Peripheral capillary vasoconstriction was evaluated using a Periflux\(^\text{®}\) 3 Laser Doppler monitor which correlates well with \(^{133}\text{Xe} \) washout\(^5\) and dynamic capillaroscopy.\(^6\)

**Results.** The five patients actively warmed remained nearly-normothermic with a mean lowest esophageal temperature of 35.8 ± 0.4°C. Skin-surface temperature gradients were \(< 1^\circ\text{C}\) in all actively warmed patients, and became \(\geq 4^\circ\text{C}\) in 6 of 10 hypothermic patients (p < 0.05) between 100 and 190 min following induction. The thermoregulatory threshold in the six hypothermic patients who vasoconstricted was 34.2 ± 0.5°C (SD) (fig. 1). The perfusion index and the skin-temperature gradient were correlated (regression equation: Perfusion index = -7.9 × Gradient + 67; \(r^2 = 0.63\) (fig. 2).

**Discussion.** The thermoregulatory threshold during \(\text{N}_2\text{O}/\text{fentanyl} \) anesthesia, 34.2 ± 0.2°C, was similar to that during halothane/oxygen, 34.4 ± 0.2°C.\(^1\) Vasoconstriction did not occur in four of 10 hypothermic patients given \(\text{N}_2\text{O}/\text{fentanyl} \), but did in all hypothermic patients given halothane.\(^1\) These four hypothermic patients probably reached a passive thermal steady state (constant core temperature without vasoconstriction).

Total digital skin blood flow is divided into arterio-venous shunt (thermoregulatory) and capillary (nutritional) components.\(^7,8\) Thermoregulatory vasoconstriction is thought to occur primarily in the cutaneous arterio-venous shunts,\(^9\) but we found that capillary flow also decreased significantly.

![Figure 1](image1.png)  
Figure 1. Significant vasoconstriction was observed in 6 of 10 elective kidney donors who became hypothermic (left side of figure). Vasoconstriction did not occur in 5 other patients maintained normothermic (right side of figure).

![Figure 2](image2.png)  
Figure 2. Skin-surface temperature gradient is plotted against the laser Doppler perfusion index (control).

**References.**