INTRODUCTION

Intraoperative hypothermia occurs commonly,[1] and is associated with a number of complications, including myocardial ischemia,[2] decreased resistance to wound infections,[3] and impaired coagulation.[4] The major causes of intraoperative hypothermia include: (1) decreased metabolic heat production during anesthesia, (2) increased heat loss to the environment from cutaneous vasodilatation, surgical exposure, dry respiratory gases, and cold intravenous fluids, and (3) a reduced compensatory response (e.g., vasoconstriction, nonshivering thermogenesis, and shivering) due to hypothalamic suppression and the effects of muscle relaxants.[5] In clinical practice however, the maintenance of normothermia during surgery has often been neglected, and active warming is utilized infrequently even in surgical procedures of long duration.

Volatile anesthetics contribute to intraoperative hypothermia largely by impairing central thermoregulation.[6] However central thermoregulation is not totally lost, and once triggered, thermoregulatory vasoconstriction would minimize further core hypothermia.[7] Surgical doses of halothane,[6] enflurane,[8] and isoflurane[9] decrease the vasoconstriction threshold (the core temperature that triggers vasoconstriction) by 2-4 °C.

The effects of intravenous anesthetics on thermoregulatory responses in humans are less well understood. Barbiturates in large doses result in abnormal temperature control,[10] and fentanyl with nitrous oxide reduces the vasoconstriction threshold.[11] Studies have shown substantial impairment of thermoregulatory vasoconstriction during propofol-nitrous oxide anesthesia in volunteers demonstrating no thermoregulatory compensation to core temperatures as low as 33 °C[12,13] Midazolam is a commonly used sedative and anesthetic adjuvant.[14,15] It had been shown that sedative doses of midazolam minimally impair thermoregulatory control.[16] But to our knowledge, there are no clinical data reported on how midazolam- fentanyl-nitrous oxide combined with a muscle relaxant affects the threshold of thermoregulatory vasoconstriction during surgery. The present study was undertaken to evaluate the thermoregulatory threshold under midazolam-fentanyl-nitrous oxide anesthesia.

MATERIALS AND METHODS

After approval of the Committee on Human Research at Tao-Yuan General Hospital and informed consent was obtained, we studied 14 unpremedicated, adult patients of ASA class I physical status who were electively scheduled for free flap surgery. No patient had a history of smoking, obesity, drug abuse, hypertension, malignant hyperthermia, Raynaud's syndrome, or thyroid or other endocrine disorders. Upon arrival at the operating room, a continuous ECG, precordial stethoscope, pulse oximeter, noninvasive blood pressure monitor, neuromuscular block monitor, and end-tidal CO_2 monitor were placed on the patients. Our protocol was fashioned after that of Sessler and coworkers which has been accepted as a valid study model.[11] All of the operations began at 08:30. Anesthesia was induced by 0.2 mg/kg midazolam i.v., while 0.1 mg/kg vecuronium i.v. was administered to facilitate endotracheal intubation.

Anesthesia was maintained during surgery with 0.5 μg/kg/min midazolam and N_2O-O_2 (70%:30%) with a total gas flow of 5 L/min; intermittent bolus of 50 μg fentanyl was given when needed to maintain the diastolic blood pressure at below 95 mmHg. Muscle relaxation was maintained with an infusion of vecuronium adjusted to maintain 0-1 twitches in response to supramaximal train-of-four electrical stimulation of the ulnar nerve at the wrist. Mechanical ventilation was adjusted to maintain an end-tidal PCO_2 of 34 ± 1 mmHg, and the inspired oxygen concentration was maintained at around 30% with a Capnomac monitor (Datex, Norme, Canada). All the operations were performed by the same surgeon using the same surgical technique and draping method.

Patients were randomly assigned to receive customary inactive temperature management (control group) or to receive active warming measures (warming group), including warm i.v. fluids at 37 °C, and a warming blanket set at 37 °C and placed over the body. Constant temperature (around 22 °C) of the operating room was maintained for all operations. Core temperatures were recorded using disposable SMS-0460 (Seebook, Cincinnati, OH, USA) thermocouples incorporated into esophageal stethoscopes. A thermocouple in an esophageal stethoscope was inserted through the nose,