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Effects of a forced-air system (Bair Hugger, OR-type) on intraoperative temperature in patients with open abdominal surgery

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Abstract: Intraoperative hypothermia is difficult to avoid and may present a significant clinical risk during the early postoperative phase. We evaluated a forced-air system [Bair Hugger, OR-type (BH)] for warming intraoperative patients with open abdominal surgery. Twenty patients received BH warming [BH(+) group] and another 20 patients, who served as controls, did not [BH(−) group]. Patients in both groups also received circulating blanket warming. Temperatures were measured at 30-min intervals throughout the operation in the rectum and on the tip of the index finger opposite the nail bed. The average operation time was 168.8 ± 16.2 min. Rectal and fingertip temperatures in the BH(+) group were significantly higher than those in the BH(−) group, and central-peripheral temperature gradients in the BH(+) group were significantly smaller than those in the BH(−) group during the study, except at 180 min. No shivering occurred in either group. Therefore, BH is an effective warming device during open abdominal surgery.

Key words: Bair Hugger, Forced-air system, Open abdominal surgery, Temperature, Thermoregulation

Introduction

Intraoperative hypothermia results from exposure to a cold environment, decreased metabolic rate, and anesthetic-induced inhibition of thermoregulation [1]. Hypothermia may present a clinical risk during the early postoperative phase as it may prolong the effect of some drugs and cause shivering [2,3]. In adults, central hypothermia also may prolong the duration of recovery and thus increase the cost [4]. Therefore, a variety of warming devices including various types of blankets (electric and water-filled), heating lamps, and warm cotton blankets [4,5] have been used.

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In this study, a forced-air system [Bair Hugger, OR-type (BH)] (Augustine Medical, Eden Prairie, Minn.) was evaluated for warming patients with open abdominal surgery intraoperatively.

Patients and methods

We studied 40 ASA physical status class 1 or 2 patients undergoing elective abdominal surgery (subtotal gastrectomy, total gastrectomy, or cholecystectomy) scheduled to last at least 2 h. The nature of the study was explained to all of the participants and their informed consent was obtained. The patients were randomly assigned to two groups. Twenty patients received BH warming set at 38°C [BH(+) group]. The other 20 patients received no BH warming and served as controls [BH(−) group]. BH consists of a disposable patient cover, which is adjusted to the patient's thoracic region and upper limbs, and a heat source. The cover is made of plastic and paper bonded into tubular channels with slits through which warm air flows around the patient. The heat source consists of a 400-watt heating element with a fan, a microprocessor-based temperature controller limited to a maximum of 43°C, a hose connecting the heat source output to the patient cover, and a 5-μm filter within a connecting hose [5]. Patients in both groups also received circulating blanket warming (KR-thermia RK600, Baxter Health Care, Valencia, Calif.) set at 37°C.

All patients were premedicated with midazolam 2–3 mg and atropine 0.01 mg·kg^{-1} IM 30 min before induction of anesthesia. anesthesia was induced with thiopental 5 mg·kg^{-1} IV and the trachea was intubated with vecuronium 0.1 mg·kg^{-1} IV. After tracheal intubation, patients were mechanically ventilated with isoflurane (0.8%–2.0% inspired concentration) and 66% nitrous oxide in oxygen to maintain $Paco_2$ between 35 and 40 mmHg. Muscle relaxation was provided, as

needed, by additional vecuronium bromide. Ringer's lactate solution was administered at a rate of 8–10 $ml \cdot kg^{-1} \cdot h^{-1}$ to all patients. All operations were performed by the same two surgeons. Operating room temperatures were maintained at 24°–26°C.

Temperatures were measured in the rectum (CTM-303, Terumo, Tokyo, Japan) and on the tip of the index finger opposite the nail bed (Topnic ET, Top, Tokyo, Japan). The monitored arm did not have an intravenous catheter or blood pressure cuff, and a thermocouple was fully exposed to room air [6]. Temperatures from all sites were recorded at 30-min intervals throughout the operation.

Data were expressed as mean ± standard error (SEM). The data were analyzed using Student's non-paired *t*-test for the intergroup comparisons and also using two-way analysis of variance (ANOVA) with repeated measures for the intragroup comparison. Differences were considered significant when $P < 0.05$.

Table 1. Patient characteristics

	BH(+)[b] ($n = 20$)	BH(−)[b] ($n = 20$)
Age (years)	61.8 ± 2.5[a]	61.3 ± 3.0
Gender (male/female)	11/9	16/4
Height (cm)	158.2 ± 1.8	159.5 ± 1.7
Weight (kg)	54.7 ± 2.2	56.7 ± 2.0
Duration of OP (min)	166.2 ± 15.0	171.4 ± 17.4
Blood loss (ml)	288.6 ± 43.5	419.3 ± 95.2
Blood transfusion (ml)	48.5 ± 34.1	114.5 ± 79.9
Room temperature (°C)	25.7 ± 0.2	25.5 ± 0.3

[a] Mean ± SEM.
[b] No significant differences between the BH(+) and BH(−) groups. BH, Bair Hugger (OR-type); OP, operation.

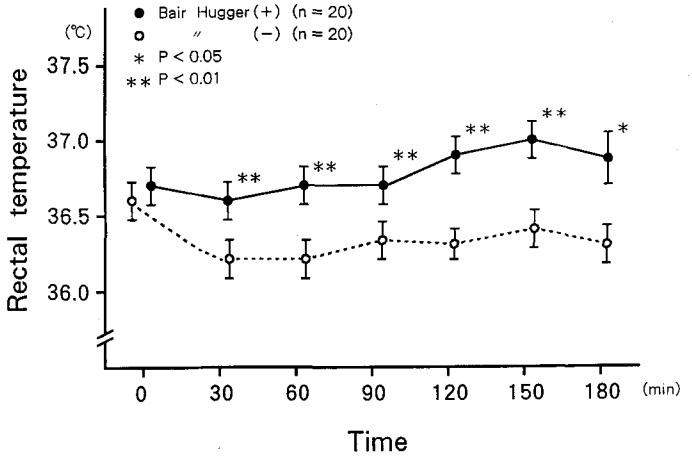

Fig. 1. Changes in rectal temperature. Time zero is at the start of operation

Results

There were no statistically significant differences in age, height, body weight, duration of operation, volume of blood loss, volume of blood transfusion, and operating room temperature between the two groups (Table 1). The temperatures in both groups did not change significantly. However, rectal temperatures in the BH(+) group were significantly higher at all time intervals measured than those in the BH(−) group during the operations (Fig. 1). Fingertip temperatures of the index finger in the BH(+) group were significantly higher than those in the BH(−) group during operation, except at

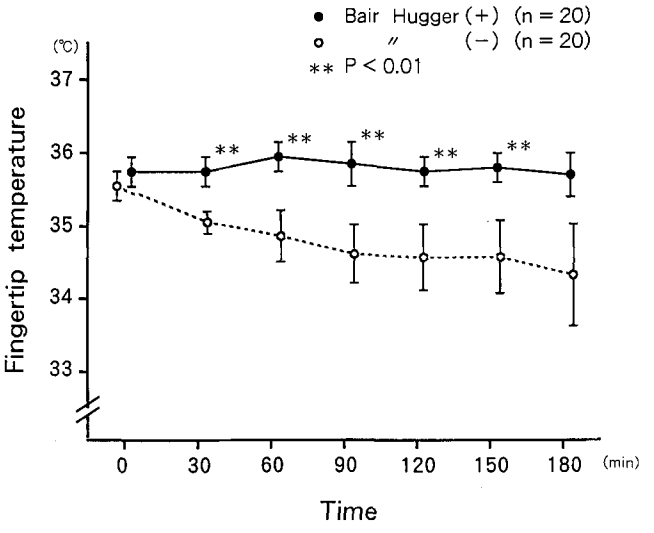

Fig. 2. Changes in fingertip (tip of the index finger) temperature. Time zero is at the start of operation

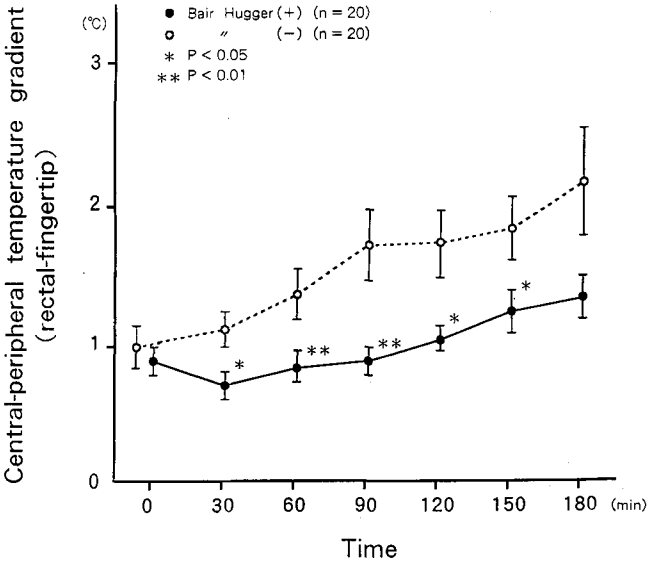

Fig. 3. Changes in central (rectal)—peripheral (fingertip) temperature. Time zero is at the start of operation

180 min (Fig. 2). Central (rectal)-peripheral (fingertip) temperature gradients in the BH(+) group were significantly smaller than those in the BH(−) group during operation at all times except 180 min (Fig. 3).

No shivering occurred in either group. There were no complications with either method which affected the intraoperative warming of patients.

Discussion

Despite various intraoperative efforts at prevention, hypothermia during anesthesia and surgery is often unavoidable [7]. In response to hypothermia, patients increase heat production by shivering. Shivering may increase oxygen consumption by as much as 400 to 500% [2]. Therefore, anesthesiologists should prevent perioperative hypothermia and postanesthetic shivering.

There are many methods of warming intraoperative patients such as various types of blankets, heating lamps [4,5,8], a blood warmer [9], and artificial noses [10]. More recently, there have been some studies on the BH [4,5]. Heat loss to the environment may be altered by many factors influencing conduction, convection, and radiation from the skin. The microenvironment surrounding the skin temperature is the dominant factor determing the skin-surface temperature. Thus, BH is the most effective because it covers the skin surface with warm air [4].

In Japan, a circulating warming blanket seems to be the most popular warming device during surgery. Its effectiveness has been well evaluated [11]. In our study, both central and peripheral temperatures of patients in the BH(+) group were significantly higher than those in the BH(−) group. These results indicate that a combination of warming techniques (circulating warming blanket and BH) is advocated to minimize hypothermia.

The effect of ambient temperature on body temperature during anesthesia has been discussed. Morris et al. [12,13] defined 21°C as the critical ambient operating room temperature at or above which body temperature should be maintained during general anesthesia. However, Frank et al. [14] showed that an ambient temperature of 21°C was adequate during epidural anesthesia, although a warmer environment was required for similar maintenance during general anesthesia. Goldberg and Roe [15] reported that 90% of operating rooms were maintained at 20°–23°C. However, the operating room temperatures in this study were kept at 24°–26°C, and were therefore sufficiently warm to maintain rectal temperatures at 36.0°–37.0°C and to prevent postanesthetic shivering.

In conclusion, these results indicate that Bair Hugger, a forced-air system, is effective intraoperatively to maintain body temperature and to warm up patients with open abdominal surgery.

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