UNDERBODY FORCED-AIR WARMER BLANKET IS SUPERIOR TO OVERBODY BLANKET IN PREVENTING HYPOTHERMIA DURING LAPAROSCOPIC DONOR NEPHRECTOMY

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and Sumio Hoka²

Abstract

Background: Forced-air warming device is widely used to maintain patients’ core temperature in the intraoperative period. In recent years, disposable underbody blanket have been available in the operating room. There are few studies have targeted the warming effect of underbody blanket. We compared the heating effects between underbody blanket and overbody blanket in living kidney donors.

Methods: We performed a retrospective observational study in 107 consecutive donors who underwent laparoscopic nephrectomy. We divided the donors into two groups according to the blanket types used during surgery: underbody blanket group and overbody blanket group. The following data were obtained from anesthesia records and hospital records: esophageal temperature, the time from the end of surgery to extubation, shivering and postoperative surgical site infection.

Results: There were few differences in demographics and perioperative variables between the two groups. Postinduction, and lowest intraoperative temperatures were similar between the two groups. However, the temperature at the end of surgery was significantly higher in the underbody than overbody blanket group. In addition, women tended to have lower core temperatures than men in each blanket group. The time from the end of surgery to extubation was shorter in the underbody than overbody blanket group. No surgical site infections occurred. Postanesthesia shivering was slightly more frequent in the overbody than underbody blanket group, but the difference did not reach statistical significance.

Conclusion: We demonstrated that the underbody blanket is superior to the overbody blanket in raising the core temperature during laparoscopic donor nephrectomy, especially in male patients.

Introduction

Inadvertent hypothermia is one of the most common intraoperative complications. This complication occurs due to anesthesia-related impairment of the patient’s central thermoregulatory control combined with a cool operating room temperature¹. Core-to-peripheral redistribution of body heat occurs by peripheral vasodilation and arteriovenous shunting during general anesthesia, and core hypothermia develops rapidly after induction of general anesthesia²³. Hypothermia is associated with many adverse events, including shivering, greater intraoperative blood loss and
a higher risk for transfusion, surgical site infection possibly due to immune system impairment, and reduced clearance of various drugs. These complications may lead to higher mortality rates and longer hospital stays.

The Bair Hugger® (3M Co. Ltd., Tokyo, Japan), a forced-air warming device, is widely used to maintain normothermia during operations. Warming with a forced-air warmer can increase the temperature of peripheral tissue and limit the amount of heat lost from the core by decreasing the core-to-periphery temperature gradient. The Bair Hugger warming device comprises a warming unit and a disposable blanket. In recent years, underbody blanket have been available in the operating room. Underbody blanket can be placed on the surgical table prior to positioning the patient, making it possible to warm the patient immediately. It is difficult to use overbody blanket during thoracic surgery or surgery performed in positions with the upper limbs fixed to the side. Underbody blanket can be used in these situations.

Heating by underbody blanket is restricted to the side of the body because there is no heating in the areas compressed by the body. However, few studies have targeted the warming effect of underbody blanket.

In the current study, we compared the differences of heating effects between underbody blanket and overbody blanket in living kidney donors.

Methods

Subjects and Group Assignment

This study was approved by the Ethical Committee for Clinical Studies of the Kyushu University School of Medicine. One hundred consecutive donors who underwent laparoscopic nephrectomy for kidney transplantation by a single surgical team at Kyushu University Hospital from January 2014 to December 2015 were identified using hospital records. All surgeries were performed in the renal position. We divided the patients into two groups according to the choice of disposable blankets of forced-air warmer: underbody blanket group and overbody blanket group.

Induction and Maintenance of Anesthesia

All patients underwent general anesthesia. Anesthetic, hemodynamic, and fluid management were at the discretion of the attending anesthesiologists. The patients were not premedicated prior to surgery. After the patient’s arrival to the operating room, the lungs were preoxygenated with 100% oxygen via a facemask. The patients then received 50 to 100 µg of intravenous fentanyl prior to induction, followed by 1 to 2 mg/kg of propofol and 0.6 mg/kg of rocuronium for induction. Anesthesia was maintained with isoflurane or desflurane. Remifentanil and fentanyl were administered intravenously for analgesia. Rocuronium was administered as a muscle relaxant. Before the end of surgery, following a loading dose of fentanyl, intravenous patient-controlled analgesia was carried out with an infusion pump programmed to deliver a 20 to 30 µg bolus of fentanyl, and continuous infusion of fentanyl at a rate of 20 to 30 µg/h.

Temperature Management

All patients received intravenous fluids via a HOTLINE® fluid warmer. A forced-air warming system was routinely used for all patients during these procedures to prevent hypothermia. Temperature management, including the choice of disposable blanket type (3M Bair Hugger® underbody blanket Model 585 or overbody blanket Model 522), was at the discretion of the attending anesthesiologist. The overbody blanket covers the upper torso, arms, neck and head of the patient. On the other hand, the underbody blanket is put under patients and covers the whole torso, hip, neck and head but does not cover the arms. The environmental temperature in the operating room was set at 18°C until the end of surgery. This extraordinary cold temperature is routine during donor nephrectomy in our hospital because graft trimming is performed in the same operating room. After intubation, a temperature probe (Smiths Medical, London, UK) was inserted into the distal esophagus to measure the core body temperature. Body warming was subsequently started by the forced-air warmer.

Measurements

Our primary outcome was intraoperative core temperature. The temperature was continuously displayed and stored in the patient’s anesthesia records. These temperature data were collected every minute and downloaded by digital file. Secondary outcome was intraoperative blood loss, transfusion, the time
from the end of surgery to extubation, shivering and postoperative surgical site infection. These data were obtained from anesthesia records or hospital records.

**Statistical Analysis**

Normality of the data was assessed by the Shapiro-Wilk test. A t-test or Mann-Whitney U test was used to compare between the two groups if appropriate. Chi-square test was used to examine the association between two categorical variables. All analyses were performed using JMP Pro (ver. 11) software (SAS Institute Inc., Cary, NC, USA). A P value of <0.05 was considered statistically significant. Data are presented as mean ± SD in Tables and presented as mean ± SEM in Figures.

**Results**

There were no differences in demographics and perioperative variables between underbody blanket and overbody blanket group (Table 1). The preoperative, post-induction, and lowest intraoperative temperatures were similar between the two groups (Table 2). Likewise, the incidence of mild hypothermia (34°C-36°C) at any point during the operation was similar between the underbody and overbody blanket groups (13.9% and 9.4%, respectively). However, the temperature at the end of surgery was significantly higher in the underbody than overbody blanket group (Figure 1). The core temperature decreased similarly for 30 minutes in both groups. Subsequently, the core temperature was significantly higher in the underbody blanket group than overbody blanket group (Figure 2). Furthermore, there was a significant gender related difference in core temperature (Figure 3); women tended to have lower core temperatures than men in each blanket group. The operation time was similar between the two groups, but the time from the end of surgery to extubation was shorter in the underbody than overbody blanket group (Table 2). Intraoperative blood loss was similar between the two groups, and no patients required a blood transfusion. No surgical site infections occurred. Postanesthesia shivering was slightly more frequent in the overbody than underbody blanket group, but the difference did not reach statistical significance.

![Fig. 1](image1.png)

**Table 1**

Demographics of the Overbody Blanket and Underbody Blanket Groups

<table>
<thead>
<tr>
<th></th>
<th>Overbody (n=65)</th>
<th>Underbody (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>56 ± 11</td>
<td>55 ± 11</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>160 ± 9</td>
<td>160 ± 9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.5 ± 11.6</td>
<td>59.6 ± 12.2</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.2 ± 3.4</td>
<td>22.9 ± 3.4</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>38 (58%)</td>
<td>23 (55%)</td>
</tr>
<tr>
<td>Male</td>
<td>27 (42%)</td>
<td>19 (45%)</td>
</tr>
<tr>
<td>ASAPS, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1</td>
<td>28 (43%)</td>
<td>20 (48%)</td>
</tr>
<tr>
<td>Class 2</td>
<td>37 (57%)</td>
<td>22 (52%)</td>
</tr>
</tbody>
</table>

ASAPS: The American Society of Anesthesiologists Physical Status

![Fig. 2](image2.png)

**Fig. 1**

Mean core temperature (postinduction, lowest intraoperative, at the end of surgery). *P <0.01

![Fig. 2](image3.png)

**Fig. 2**

Time course of the core temperature. *P < 0.05, **P < 0.01
Fig. 3
Comparison of the intraoperative core temperatures between men and women.
* P<0.05, ** P<0.01 vs overbody-women. † P<0.05 vs. underbody-women

Comparison of the Temperature data and Secondary outcomes

<table>
<thead>
<tr>
<th></th>
<th>Overbody (n=65)</th>
<th>Underbody (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical time (min)</td>
<td>177±47</td>
<td>184±40</td>
</tr>
<tr>
<td>Anesthesia time (min)</td>
<td>231±53</td>
<td>224±43</td>
</tr>
<tr>
<td>Time to extubation (min)</td>
<td>29±22</td>
<td>16±7*</td>
</tr>
<tr>
<td>Estimated blood loss (g)</td>
<td>190±158</td>
<td>222±231</td>
</tr>
<tr>
<td>Perioperative transfusion</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine volume (ml)</td>
<td>489±383</td>
<td>311±199</td>
</tr>
<tr>
<td>Body temperature (°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>36.3±0.4</td>
<td>36.2±0.3</td>
</tr>
<tr>
<td>After induction</td>
<td>36.4±0.4</td>
<td>36.4±0.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>36.7±0.5</td>
<td>37.3±0.6**</td>
</tr>
<tr>
<td>End of surgery</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Shivering (%)</td>
<td>6±1</td>
<td>7±2</td>
</tr>
<tr>
<td>Length of stay (d)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* P < 0.05
** P < 0.01

Discussion

In the current study, we showed that underbody blanket were more effective in raising the core body temperature than overbody blanket during laparoscopic donor nephrectomy. One of the most important determinants of heat transfer with any surface warming system is the amount of surface covered. In a study using a manikin, forced-air warming systems using blanket with larger warming areas were more effective than smaller blanket10. Overbody blanket used in this study covered the upper torso, arms, neck and head of the patient. On the other hand, underbody blanket covered the entire upper body. Thus, heating area by underbody blankets is larger than overbody blanket. Other possible mechanism to explain our results is the position of the patients. Convective heating area is larger in the side-lying position than in the supine position because there is no heating in the areas compressed by the body.

We also showed a significant gender related difference in core temperature. A previous study indicated that women have lower thermal conductivity than men because of the greater thickness of the subcutaneous tissues in women11. We speculate that the warming effect is greater in male than female patients because of higher thermal conductivity in men.

Morris and Wilkey showed a strong relationship between ambient operating room temperature and patient core temperature12. The ambient operating room temperature was adjusted to 18°C in all of the patients in this study, suggesting that room temperature did not affect the difference in body temperature between the two groups.

The association of hypothermia with greater intraoperative blood loss and a higher rate of surgical site infection are now widely accepted. However, there were few differences in blood loss, infection, or hospital stays between the two groups in the current study, possibly because living kidney donors generally had fewer preoperative complications with a low risk for bleeding and infection.

The main adverse effect associated with forced-air warming devices is thermal burn injury13,14. In this study, forced-air warming units were always used with new blanket in accordance with the manufacturer’s instructions, and all patients were protected from thermal injury. Further studies are needed to evaluate complications of underbody blanket.

Some limitations exist in this study. First, the exact time at which each warming device was turned on was unknown in 30% of patients. However, we believe that the start time of heating did not significantly affect the results of this study because the warming duration did not differ in the remaining 70% of patients (data not shown), and the lowest intraoperative core temperature was similar between the two groups. Second, the patients’ hands were covered with blanket.
in the overbody blanket group whereas the hands were exposed to room temperature in the underbody blanket group. We did not evaluate the peripheral temperature in this study because it is not possible to simply compare the peripheral temperature. Finally, we investigated the heating effect of underbody blanket only in the renal position. Further studies are needed to evaluate it in the supine position because the area compressed by patients’ body is large in this position.

In conclusion, we demonstrated that the underbody blanket is superior to the overbody blanket in raising the core temperature during laparoscopic donor nephrectomy, especially in male patients.
References