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Original Research

Effects of Two Decurarization Methods on Thermoregulation of Patients Under General Anesthesia

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ABSTRACT

Objective: Evaluate the effects of two decurarization methods on thermoregulation of patients who received general anesthesia.

Method: Sixty-six male patients that are over 18 years of age with an ASA physical status I-III and scheduled for elective thoracotomy. Patients were warmed with (38°C at medium setting) air blowing blankets. Decurarization was achieved with 0.02-0.05 mg/kg neostigmine in group N and 3 mg/kg sugammadex in group S after train of four (TOF) value obtained at the end of the operation.

Results: Core temperatures of tympanic membrane and peripheral skin temperatures of sternum and 1/3 upper part of the arm were measured and recorded at 15th, 30th, 45th, 60th, 90th and 120th minutes after extubation. Core temperature of the tympanic membrane and skin temperatures measured at the chest and arm in the first two hours after extubation were similar between the groups.

Conclusion: Decurarization agents had no effect on spontaneous central and skin temperatures in the actively heated postoperative patients that had previously equal intraoperative temperatures. Whereas the temperatures of the peripheral skin surface of the patients who received sugammadex returned to preoperative control levels earlier than that of patients receiving neostigmine.

Keywords: Decurarization, hypothermia, neostgmine, sugammadex, thermoregulation

INTRODUCTION

Under normal conditions, our body temperature is strictly controlled by various mechanisms (1). However, under general anesthesia, cold response threshold increases 10-fold (2), thereby affecting temperature control after the anesthesia. This occurs because the agents used for the induction and maintenance of general anesthesia stimulate postanesthesia temperature fluctuations. Intraoperative hypothermia is associated with postoperative myocardial ischemia, catecholamine levels, and postoperative infections, and perioperative hypothermia can lead to tremor, sedation, bleeding, and an increase in mortality and morbidity (3, 4).

Hypothermia during anesthesia is the most common thermal disorder that occurs due to a combination of the thermoregulation defect caused by the anesthesia and cold temperature that the patients are exposed to in operating rooms. Generally, about 20% of the patients involuntarily experience hypothermia, where their core body temperature reaches a level of ≤36°C in the preoperative period (3, 5).

Although there are several methods to prevent hypothermia in the intra- and postoperative periods, the methods frequently studied in the last decade include heating and humidification of inhaled gases, heating of intravenously administered fluids and blood transfusion products, and activating the heat production of the patients by increasing the metabolism rate (4, 5). Furthermore, active and passive heat preservation methods are classified as internal and external heating methods, respectively.

There has been a growing concern regarding the importance of temperature control (6, 7), as a result of which many studies have previously investigated the effects of anesthetical techniques and agents used for the induction and maintenance of anesthesia on thermoregulation (8). Although the effect of reversed muscle strength on thermoregulation is known, a MEDLINE survey showed that no study was conducted on the effects of decurarization methods on the postoperative temperature until March 2015.

In recent years, sugammadex, a novel aminosteroid agent, has been used in addition to the traditional decurarization agent neostigmine (9). Therefore, this study aimed to compare the effects of various decurarization methods on thermoregulation.

METHODS

The study included 66 male patients aged >18 years, with an American Society of Anesthesiologists (ASA) physical status I–

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III, and scheduled for elective thoracotomy. The study was approved by the ethics committee of Gaziantep University (no: 2015-184, date: 06.15.2015), and all the patients gave oral and written consent prior to the study. The standard temperature of the operation room was set at 22°C.

In contrast, patients who had diabetes, coronary artery disease, inflammatory disease, neuromuscular disease or dystrophic disorder, hypo-hyperthyroidism, Parkinson's disease, connective tissue disease (Raynaud syndrome, etc.), and a body mass index (BMI) score of >30 kg/m^2 or <20 kg/m^2 and those who were using a thermoregulation-impairing drug (i.e., beta blocker, calcium channel blocker, clonidine, steroids, antiepileptics, or benzodiazepines) and remained intubated after the operation were excluded from the study. Additionally, any life-threatening clinical condition, such as cardiac arrest, was considered as a termination criteria for the study.

Before the induction of general anesthesia, the preoperative body weight and height of the patients were recorded; this was followed by a standard measurement of their vital signs, such as heart beat rate, noninvasive systolic and diastolic blood pressures, peripheral oxygen saturation (SpO_2), and body temperature (core temperatures of the tympanic membrane and peripheral skin temperatures of the sternum and one-third part of the upper arm). After preoxygenation with 3 L/min 100% O_2 for 3 min, general anesthesia was intravenously induced using 1 µg/kg of fentanyl, 1–2 of mg/kg propofol, and 0.5 mg/kg of rocuronium. The patients were mechanically ventilated after intubation. An infusion of 5%-6% of desflurane, 0.1-0.2 mg/kg of rocuronium i.v. bolus, and 0.05-0.1 µg/kg/h of remifentanil was used for maintaining the anesthesia, and a fresh gas flow of 2 L/min was maintained during the operation. Subclavian vein catheterization was performed for each patient. The crystalloid and colloid solutions were kept at room temperature for 24 h. The patients were covered with surgical drapes and heated using a forced air warmer (Tyco Healthcare Group LP Nellcor Puritan Bennett Division Pleasanton, CA U.S.A. 1-800-NELLCOR) at 38°C (medium setting). The duration of the stay in the operating room was recorded for each patient.

A sealed-envelope method was used for randomization, with the envelope being opened only at the time of skin closure. Based on this method, the patients were classified into two groups: Group N comprised patients decurarized with neostigmine–atropine (n=33) and Group S comprised patients decurarized with sugammadex (n=33).

When the train-of-four (TOF) value was obtained after the operation was over and administration of the inhalation of the anesthetic agent was ceased, the decurarization process was performed using 0.02-0.05 mg/kg i.v. of neostigmine and 0.01-0.02 mg/kg i.v. of atropine in Group N and 3 mg/kg i.v. of sugammadex in Group S. The patients who had a TOF of 90%, as observed under neuromuscular monitorization, were extubated.

After the operation, the patients were covered with a single-layer cotton blanket and directly transferred to the postoperative intensive care unit (ICU). As the patients were transferred to the ICU, the core temperature of their tympanic membrane and the peripheral skin temperature of the sternum and one-third part of the upper arm were measured and recorded at the 15th, 30th, 45th, 60th, 90th, and 120th min after extubation; these measurements were recorded by experienced ICU nurses. While the tympanic membrane core temperatures were measured using the Braun thermoscan (designed in Germany, made in Mexico), the skin temperatures were measured using an HT-F03B infrared thermometer.

Statistical Analysis

The sample size of the patients in each group was calculated using the G*Power application. To accept a 25% difference between the groups, by means of returning to the preoperative temperatures, as statistically significant, the minimum number of patients required was found to be 64 (α=0.05, β=0.95).

The normality of the data was evaluated using the Shapiro–Wilk test, the means of independent samples were compared using the Student's *t*-test, and the groups were compared at various times intervals using the two-way analysis of variance with repeated measures. While the correlation between categorical variables was tested using the Chi-square test, the correlation between numerical variables was tested using the correlation analysis. The data were analyzed using the Statistical Package for the Social Science (IBM Corp., Armonk, NY, USA) version 22.0, and a p-value<0.05 was considered as statistically significant.

RESULTS

This study initially included a total of 71 patients. However, five patients were later excluded, of which four experienced extubation failure in the operating room and one was reoperated upon after 2 h, owing to surgical bleeding.

Interestingly, no statistically significant difference was observed between the two groups with respect to age, ASA, BMI, and duration of the operation (p>0.05) (Table 1) as well as in terms of the preoperative skin temperatures (chest and arm) and core tympanic membrane temperatures (p>0.05) (Figure 1).

While there was no statistically significant difference between the two groups in terms of the tympanic membrane temperatures recorded at the 15th, 30th, 45th, 60th, 90th, and 120th min after the extubation (Figure 2) (p>0.05), the tympanic membrane temperatures measured at the 15th, 30th, and 45th min of the postoperative period were significantly lower than those of the preoperative control values (p<0.05) (Figure 2) in both the groups. Moreover, with respect to the time taken for the patients to return to the preoperative tympanic membrane temperature, no statistically significant difference was observed between the two groups (p>0.05) (Figure 3). Furthermore, the skin temperatures of the chest recorded at the 15th, 30th, 45th, 60th, 90th, and 120th min after the extubation were also statistically similar between the two groups (p>0.05) (Figure 4); however, the skin temperatures of the chest recorded at the 15th, 30th, and 45th min of the postoperative period were significantly lower than those of the preoperative control values (p<0.05).

Table 1. Demografic values

Group	Age (year)	ASA	Operation time (Min)	BMI
Group N	54.09±16.7	2.45±0.56	138.48±29.88	25.63±2.66
Group S	51.24±18.07	2.48±0.61	139.39±31.11	25.66±2.67

BMI: Body Mass Index

Figure 1. Comparison of preoperative temperatures of the groups

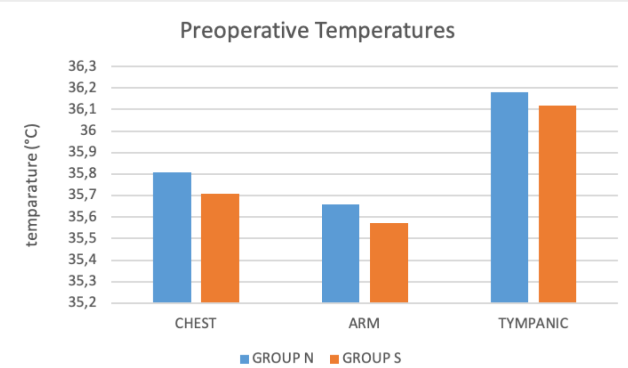


Figure 2. Tympanic temperatures of the groups

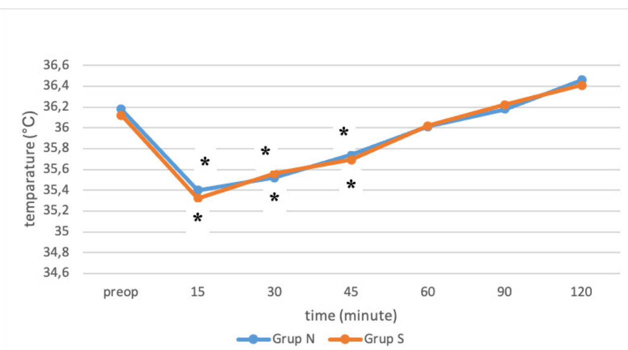


Figure 3. Patient distribution of the groups according to time of reversal to tympanic temperature

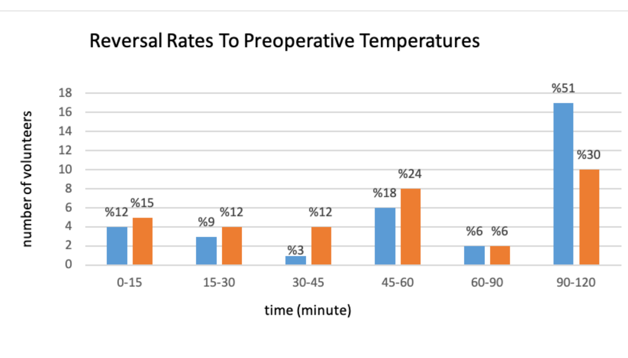


Figure 4. Chest skin temperatures of the groups

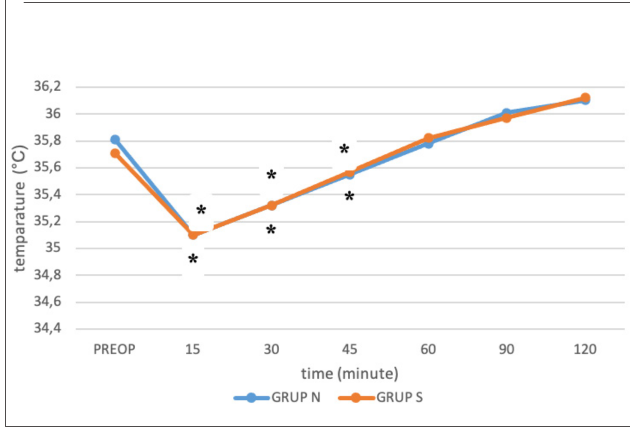
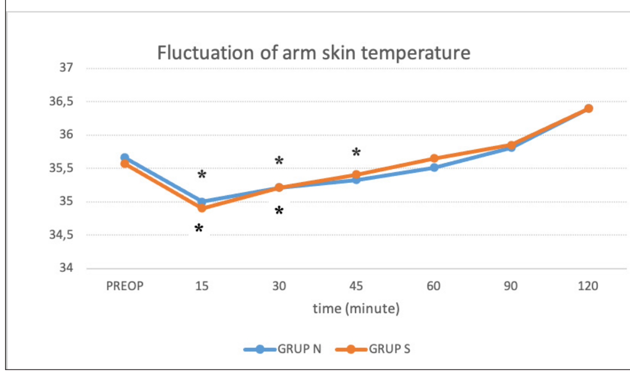


Figure 5. Arm skin temperatures of the groups



A similar observation was made with respect to the skin temperatures of the arm recorded at the 15th, 30th, 45th, 60th, 90th, and 120th min after the extubation, which revealed no statistically significant differences between the two groups ($p>0.05$) (Figure 5). In Group N, the skin temperatures of the arm recorded at the 15th, 30th, and 45th min of the postoperative period were found to be significantly lower than those of the preoperative control values ($p<0.05$); in Group S, the skin temperatures of the arm recorded only at the 15th and 30th min of the postoperative period were significantly lower than the those of the preoperative control values ($p<0.05$).

DISCUSSION

General anesthesia, especially when administered in long-lasting surgical procedures, can compromise the thermoregulation mechanisms (10, 11). Therefore, in this study, the male patients who underwent thoracotomy with long-lasting anesthesia and were transferred to the postoperative ICU were included. Another reason for including only the male population was to avoid a physiological bias due to the presence of progesterone in females (12, 13).

In a study by Jung et al. (14), inhalation anesthesia was compared between desflurane and TIVA (propofol and remifentanil) in patients who had undergone tympanoplasty. Although the postoperative core temperatures of patients administered with TIVA were reported to be significantly higher than those administered with desflurane, peripheral thermoregulatory vasoconstriction was found to occur earlier and more frequently in the TIVA-administered group than in the desflurane-administered group. Contrary to our study, the patients in the study by Jung et al. (14) were not actively heated during the intraoperative period. Therefore, the absence of a significant difference in the postoperative central and skin temperatures can be attributed to this situation. Intragroup analysis revealed that the postoperative core tympanic membrane temperatures statistically reached the preoperative tympanic membrane temperature values at the 60th min in both the groups. Furthermore, in Group N, the postoperative temperatures of the arm skin recorded at the 15th, 30th, and 45th min were found to be significantly lower than the preoperative control values ($p<0.05$); in Group S, the postoperative temperatures of the arm skin recorded only at the 15th and 30th min were significantly lower than the preoperative control values ($p<0.05$). However, the postoperative skin temperatures measured from the arm region in Group S reached the preoperative temperatures 15 min earlier compared to those in Group N. This could be attributed to two reasons: first, it is possible that sugammadex might have caused more peripheral thermoregulatory vasoconstriction; second, the patients in Group S could have achieved peripheral heat control more rapidly due to a better muscle function reversal.

Anticholinergic agents decrease heat loss by reducing perspiration and increasing the central temperature. Furthermore, atropine is suggested to lead to a temperature rise via central mechanisms (15, 16). Mirakhur and Dundee (17) have reported that atropine and glycopyrrolate, in clinical doses, might result in a 0.3°C-increase in oral temperatures in resting and exercising states. Furthermore, Simpson et al. (18) found that the anticholinergic agents could increase the core body temperature in the resting and exercising states; however, no statistically significant difference was observed when these data were compared to that of a saline-administered group. In our study, 0.02-0.05 mg/kg i.v. of neostigmine and 0.01-0.02 mg/kg i.v. of atropine were used. Therefore, rather than assessing the efficiency of neostigmine in thermoregulation, our data show the efficiency of the neostigmine–atropine combination traditionally used in clinical practice.

In another study conducted by Frank et al. (19), 44 patients who had undergone radical prostatectomy under spinal anesthesia and were not actively heated intra- and postoperatively were given warmed blood products and intravenous fluids, after which their core tympanic membrane temperatures were recorded. It was found that age, lipid rate, and spinal anesthesia level were correlated with the development of hypothermia. An analysis of the patients in terms of age, spinal blockage level, operating room temperature, and BMI revealed that the age and spinal anesthesia level, in particular, were correlated with hypothermia. Furthermore, it was found that every increase in age led to up to a 0.3°C-loss in the core temperature. However, in our study, the patients were aged between 18 and 77 years, and no significant correlation was found between their age and postoperative tympanic membrane temperatures, irrespective of the groups.

One of the limitations of this study was the wide distribution of the patients' age. Additionally, in our study, the tympanic membrane temperatures of the patients were recorded and assessed only till the 120th min of the postoperative period and not at the 180th min. Typically, the tympanic membrane temperatures at the 180th min of the postoperative period are found to be lower than those of the preoperative period; however, in our study, the preoperative tympanic membrane temperatures were restored at the 120th min of the postoperative period in all the patients. This difference can be explained by the fact that the patients in our study were actively heated intraoperatively.

Interestingly, Washington et al. (20), in their study administered anesthesia to healthy volunteers on two different days. The volunteers were similar in age and had similar body lipid rate, weight, and height. Enflurane and nitrous oxide were used for the anesthesia and vecuronium was used for muscle relaxation. The patients were actively warmed with forced air during the anesthesia and were administered with electrical pain stimulation. Thermoregulatory vasoconstriction was defined as a temperature difference of >4°C between the forearm and fingertip. Thermoregulatory vasoconstriction threshold was found to be significantly higher when a painful stimulus was administered. Therefore, it was reported that intra- or postoperative pain control can lower the thermoregulatory vasoconstriction threshold, thereby increasing heat loss. Since the postoperative scores of the patients were not evaluated in our study, this could be another limitation of our study.

CONCLUSION

This study reported that decurarization agents did not have any significant effects on the spontaneous postoperative core and skin temperatures of the patients who were actively warmed in similar intraoperative heating conditions. However, the peripheral temperatures measured from the arm skin of the patients in Group S reached up to the preoperative control levels more 15 min earlier compared to those in Group N, which shows that a successful recurarization can improve thermoregulation. Nevertheless, further studies that include age-matched groups, need to be conducted without applying active heating.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gaziantep University (no: 2015-184/15.06.2015).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

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Conflict of Interest: Authors have no conflicts of interest to declare.

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