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Increase in body temperature in pediatric patients after costal cartilage harvest in microtia reconstruction

A retrospective observational study

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Abstract

Background: Previous evidence has clearly shown that maintaining normothermia in children undergoing surgery is difficult and is associated with adverse outcomes. Therefore, this study aimed to retrospectively analyze the changes in body temperature over time in 2 different types of microtia reconstruction surgeries, namely, embedding, and elevation surgeries.

Methods: We performed a retrospective chart review of patients who underwent microtia reconstruction (embedding and elevation) between July 2012 and February 2015 (n = 38). The changes in body temperature between the 2 types of surgeries were compared.

Results: During microtia reconstruction, the body temperature in the embedding surgery group was significantly higher than that in the elevation surgery group from 1 hour after the start of surgery to 1 day after the surgery ($P < .001$). Time, group, and time-group interaction were associated with an increase in body temperature ($P < .001$) but not the warming method.

Conclusion: We found an increase in body temperature in patients with microtia who underwent embedding surgery (autologous costal cartilage harvest surgery), and this was related to the type of surgery and not to the warming method. Therefore, further research is warranted to determine the cause of the increase in body temperature during this surgery.

Abbreviations: EL = elevation operation, EM = embedding operation.

Keywords: body temperature, costal cartilage harvest, microtia

1. Introduction

Maintaining normothermia in children undergoing noncardiac surgery is difficult. Unlike adults, children may have difficulty maintaining normothermia even during minor surgeries, and previous evidence clearly shows that this is associated with adverse outcomes.[1,2]

Anesthesia-induced inhibition of thermoregulatory control together with exposure to cool environments results in major thermal abnormalities.[3–7] However, in some cases, the body temperature may increase. The increase in core body temperature occurs through a multiphasic response of the central body temperature to a central thermoregulatory mechanism localized in the preoptic area of the hypothalamus.[8] This phenomenon is regulated by two types of endogenous cytokines, some of which function as pyrogens and others as antipyretics.

Microtia is a congenital anomaly of the auricle that ranges in severity from mild structural abnormalities to complete absence of the ear.[9,10] Patients with microtia undergo embedding and elevation surgeries for reconstruction. Initially, autologous cartilage is harvested and implanted at the desired location of the ear (embedding surgery). Thereafter, the framework is elevated and inserted (elevation surgery). Secondary surgery is performed at least 6 months later.[11]

We incidentally found that patients with microtia experienced elevated body temperatures during reconstruction surgery. Therefore, we hypothesized that cartilage harvesting might be associated with an increase in body temperature. Thus, the

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

This clinical trial was registered with the Clinical Research Information Service, the Korean registration system for clinical trials (KCT0004109).

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present study aimed to retrospectively analyze the changes in body temperature over time in two different types of microtia reconstruction surgeries, namely, embedding and elevation surgeries.

2. Materials and Methods

The protocol approved by the Medical Device Institutional Review Board of KUAH (2019AN0205). This clinical trial was registered with the Clinical Research Information Service, the Korean registration system for clinical trials (KCT0004109).

2.1. Inclusion and exclusion criteria

Data for this study were obtained retrospectively from the electronic database of the Korea University Anam Hospital. We conducted a chart review of patients who underwent microtia reconstruction surgery (embedding and elevation) between July 2012 and February 2015 at a single university hospital. The exclusion criteria were as follows: patients with fever >37.5 °C before surgery, as well as patients with missing vital sign records during anesthesia, in the recovery room and ward, and on postoperative days (POD) 0, 1, 2, and 3.

2.2. Study design

An overview of the retrospective study design is shown in Figure 1. The following patient information was collected:

1. Basic patient information (height, weight, age, and underlying disease).
2. Data on anesthesia method, drugs used, and surgery time.
3. Patient vital signs during surgery (blood pressure, heart rate, oxygen saturation, end-tidal CO_2, and body temperature).
4. Vital signs of patients in the recovery room (blood pressure, heart rate, oxygen saturation, and body temperature).
5. Patient vital signs (blood pressure, heart rate, oxygen saturation, and body temperature), medications used, and posterior-anterior chest radiography findings on PODs 0, 1, 2, and 3.

Based on these data, the patients were divided into the following two groups: the embedding operation group (Group EM, n = 38) and the elevation operation group (Group EL, n = 38). Thereafter, the patients' vital signs were compared between the 2 groups. A body temperature above 37.5 °C was defined as fever.

2.3. Anesthetic procedure

Anesthesia was induced with propofol (1.5–2 mg/kg) or pentothal (4–5 mg/kg) and maintained with an end-tidal concentration

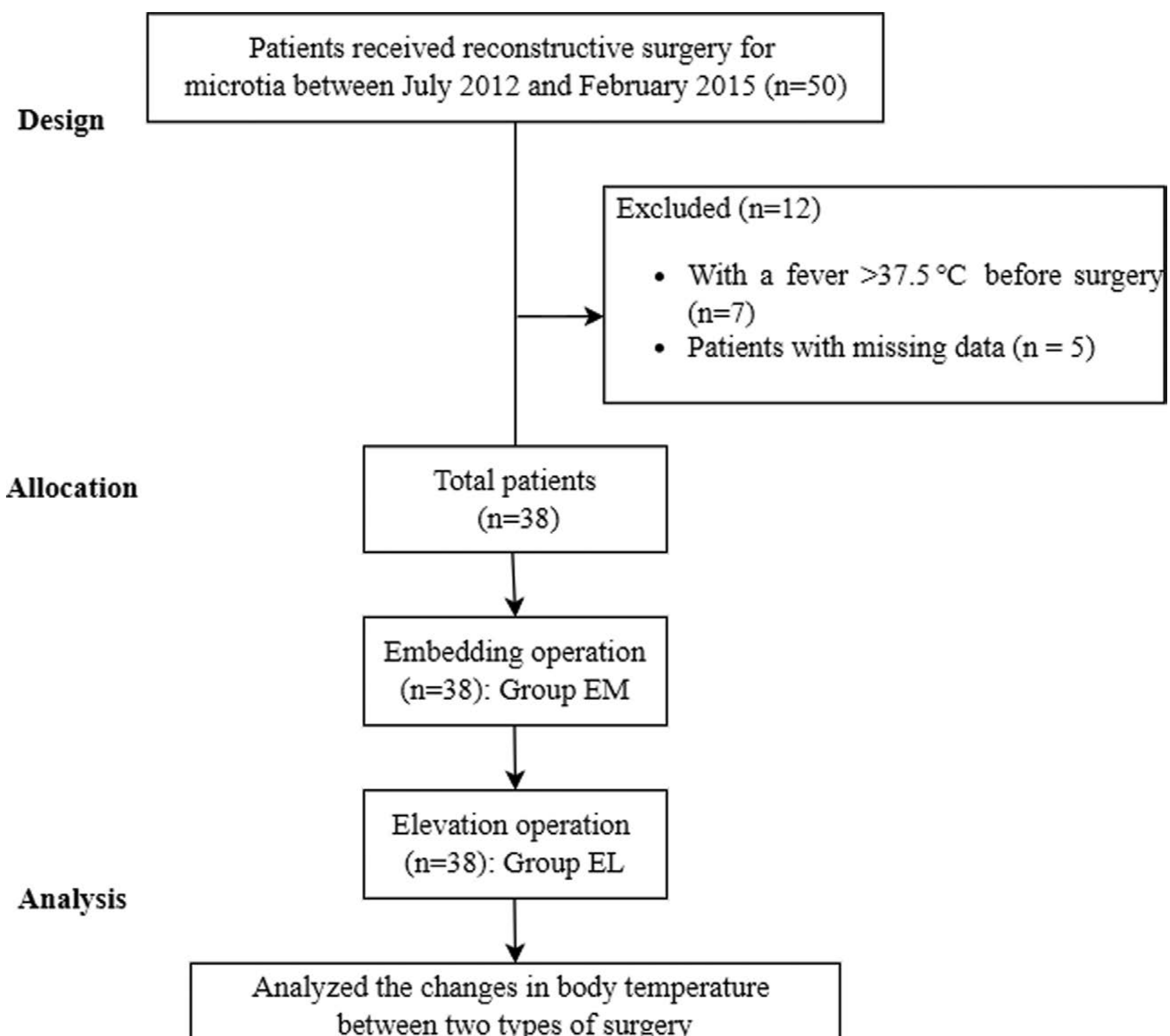

Figure 1. Flow chart showing the selection of the study participants.

of 2 to 3 vol% of sevoflurane or 5 to 6 vol% of desflurane. Tidal volume was controlled to maintain 30 to 35 mm Hg of end-tidal CO_2. The operation room temperature was kept at 20 to 22 °C using the air conditioning system. Standard monitoring (including noninvasive blood pressure monitoring, body temperature measurement using an esophageal stethoscope, heart rate measurement, O_2 saturation measurement, and electrocardiography) was applied. Body temperature was recorded every 30 min, and the use of warming tools was discontinued when the body temperature was above 36.0 °C. The peak body temperatures in the recovery room and on PODs 0, 1, 2, and 3 were recorded. The urine volume was maintained at >0.5 mL/kg/h.

2.4. Outcome measurement

The primary outcome measure for the difference in body temperature was the core body temperature during surgery, in the recovery room, and on PODs 0, 1, 2, and 3. The secondary outcome measures for factors that could affect body temperature changes included induction agents, premedication drugs, antibiotics, inhalation anesthetics, warming methods, and infusion drugs administered during surgery.

2.5. Statistical analyses

All data are expressed as mean ± standard deviation or the number of patients (%). Normal distributions were examined using Q-q plots and Shapiro–Wilk tests. For comparisons between groups, normally distributed data were compared using the independent t test, and non-normally distributed data were compared using the Mann–Whitney *U* test. For frequency comparisons between the 2 groups, the χ^2 test or Fisher exact test was used. A *P* value <.001 was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY).

3. Results

3.1. Patient demographics

The study included 50 patients. Among them, 7 patients with a fever greater than 37.5 °C before surgery and 5 patients with missing data were excluded. The remaining 38 patients were confirmed to be eligible. Among them, 28 were males (73.68%), and 10 were females (26.32%), with a mean age of 15.89 ± 1.98 years and ages ranging between 11 to 21 years at the time of surgery (Table 1). Based on the type of reconstruction surgery, the data from the patients were divided into Group EM and Group EL (Fig. 2).

Table 1

Demographics of the patients that were included in the retrospective study.

	Total
Age (yrs)	15.89 ± 1.98
Height (cm)	162.9 ± 6.90
Weight (kg)	55.7 ± 8.99
BMI (kg/m^2)	21.0 ± 2.93
Sex (male/female)	28 (73.68)/10 (26.32)
Past medical history	
Asthma	1 (2.63)
Pediatric asthma	1 (2.63)
Bronchitis	1 (2.63)

All data are expressed as mean ± standard deviation or the number of patients (%).
BMI = body mass index.

3.2. Temperature changes between the two types of surgeries

The mean operation time was 6.62 ± 1.33 hour in Group EM and 4.27 ± 1.33 hour in Group EL. Of the total patients, 26 (68.42%) had a fever during the embedding surgery (Group EM, n = 38). However, only 2 (5.26%) patients developed a fever during the elevation surgery (Group EL, n = 38). In Group EM (n = 38), 12 (31.58%) patients developed a fever, and 14 (36.84%) of them had a fever in the recovery room or on POD 0 after the surgery. In Group EL, the 2 (5.26%) patients developed a fever in the recovery room or on POD 0 after the surgery.

Compared to Group EL, Group EM had a higher body temperature from 1 hour after the start of surgery to the end of surgery (*P* < .001; Fig. 2), and it was higher up to POD 1 (*P* < .001). In Group EM, the body temperature was significantly higher from 3 hour after the start of the surgery to the end of the surgery than that at the baseline (0 h) (*P* < .05). In contrast, Group EL showed a statistically significant decrease in body temperature from 1 hour after the start of the surgery to the end of the surgery than that at the baseline (0 hour) (*P* < .05).

Nevertheless, all patients with a fever regained a normal body temperature within POD 3.

3.3. Factors affecting the changes in body temperature

Among the covariates, induction agents, muscle relaxants, inhalation anesthetics, premedication drugs, antibiotics, infusion drugs, and warming methods, such as a humidifier circuit, air blanket, or warm pad, were not statistically significant (Table 2).

Considering the fixed effect of group, age, sex, antibiotics, time, warming methods, and the time-group interaction in a linear mixed model, the results of age, sex, antibiotics, and warming methods were not statistically significant (Table 3). Time, group, and time-group interactions were statistically significant in the linear mixed model (*P* < .001).

4. Discussion

This study revealed elevated body temperatures in patients undergoing autologous costal cartilage harvest surgery during microtia reconstruction. In addition, our retrospective analysis of risk factors for an increase in the body temperature revealed that only the type and duration of surgery were related to an increase in the body temperature.

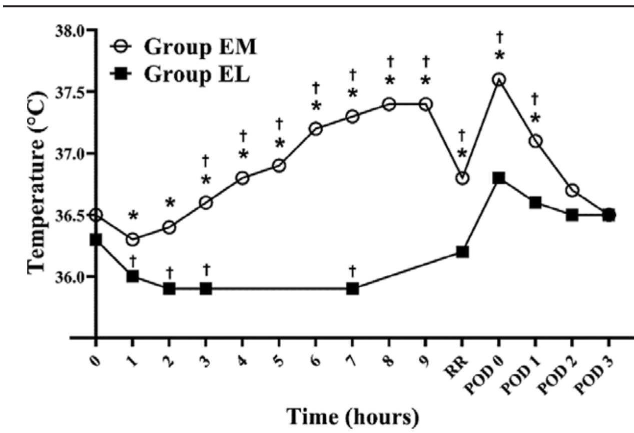

Figure 2. Body temperature changes in the two types of surgeries. Group EL = elevation operation, Group EM = embedding operation; RR = recovery room, POD = postoperative day. *: *P* < .05, Group EM versus Group EL, †: *P* < .05 versus baseline (0 h).

Table 2

Characteristics of the study population.

Variable, n (%)	Group EL (n = 38)	Group EM (n = 38)	*P* value
Induction agents			.164
Propofol	23 (60.53)	28 (73.68)	
Thiopental	15 (39.47)	10 (26.32)	
Muscle relaxants			.828
Rocuronium bromide	36 (94.74)	36 (94.74)	
Cisatracurium	0 (0)	2 (5.26)	
Rocuronium bromide/cisatracurium	2 (5.26)	0	
Inhalation anesthetics			.769
Sevoflurane	31 (81.58)	28 (73.68)	
Desflurane	7 (18.42)	10 (26.32)	
Premedication drugs			.162
Atropine	34 (89.47)	32 (84.21)	
Midazolam/glycopyrrolate	4 (10.53)	6 (15.79)	
Antibiotics			.013
Cefazedone	28 (73.68)	24 (63.16)	
Cefazedone/amikacin	7 (18.42)	3 (7.89)	
Cefotiam	3 (7.89)	11 (28.95)	
Warming methods			.015
None	10 (26.32)	5 (13.16)	
Warm pad	1 (2.63)	2 (5.26)	
Humidifier circuit	24 (63.16)	29 (76.32)	
Air blanket	3 (7.89)	0	
Humidifier circuit/warm blanket	0	2 (5.26)	
Infusion drugs			.036
None	38 (100)	27 (71.05)	
Remifentanil	0	11 (28.95)	

All data are expressed as the number of patients (%). Group EM: the embedding surgery group; Group EL: the elevation surgery group.
EL = elevation operation, EM = embedding operation.

Table 3

Effect of risk factors on body temperature in a linear mixed model.

Effect	Num DF	Den DF	F Value	Pr > F
Group	1	37	75.06	<.0001*
Age	1	788	5.45	0.020
Sex	1	36	2.1	0.156
Time	14	428	26.49	<.0001*
Warming	4	12	2.27	0.122
Antibiotics	2	9	2.82	0.112
Time-group	12	331	6.67	<.0001*

*A *P* value <.001 is considered statistically significant.

During surgery under general anesthesia, thermal imbalances are common.[1,7,12] In general, the core body temperature is known to drop by 1 to 2° after anesthesia induction.[1] In particular, children show more rapid changes in core body temperature than adults because of their lower body-mass-to-surface ratio. This difficulty in maintaining body temperature increases the risk of side effects even when the body temperature changes for a short period of time. In the case of minor or major surgery, thermal imbalances are caused by conduction, convection, and evaporation through the body surface or airways by radiative mechanisms. Inadvertent body temperature changes expose patients to the risk of postoperative complications, including postoperative myocardial ischemia, coagulation disorders, surgical bleeding, wound infection, and delayed recovery from anesthesia.[13–20]

The prevalence of intraoperative fever is relatively rarer than that of postoperative fever.[21,22] However, our study showed that 28 (73.68%) patients developed a fever. Among them, 12 (31.58%) developed an intraoperative fever, and 16 (42.10%) developed a postoperative fever, but all regained normal body temperatures within POD 3. Similarly, a prospective study of 81 patients with postoperative fever found that 80% of patients with a fever had no infection on POD 1.[21] Another search also showed that early fevers emerging between POD 1 and POD 4 rarely represented an infection.[23] In most patients, the fever resolves during the postoperative period in the absence of continuous surgical trauma, and a benign course can be expected.

Specifically, the body temperature of patients undergoing embedding surgery was significantly higher than that of patients undergoing elevation surgery from 1 hour after the start of the surgery to 1 day after the surgery. Moreover, the body temperature increased between 1 and 2 hour after the start of the surgery, example, at the time point when the costal cartilage was harvested. The incidence of early postoperative fever varies depending on the type and duration of surgery, the patient's age, preexisting inflammation, and surgical site.[24–27] In our study, body temperature during surgery was related to the type and duration of surgery and was not related to the warming method.

In this study, pediatric patients undergoing elevation surgery experienced a decrease in their body temperature during the surgery. The type of surgery and the temperature of the operation room are the main factors affecting the decrease in the core body temperature in pediatric patients.[14] Moreover, the core body temperatures may be less stable in pediatric patients; hence, they can decrease more significantly at 1 hour after anesthesia induction than at the baseline.[28]

This study has limitation. Because this is a retrospective study, we were unable to confirm laboratory data to verify our hypothesis. In the future, it is necessary to proceed with prospective studies including confirmation of the level of proinflammatory cytokines (e.g. TNF-α, IL-6, etc).[29,30]

In addition, the EM group has a longer operation time (EM group: 6.62 ± 1.33 hour, EL group: 4.27 ± 1.33 hour), which may affect the patient's body temperature increase. However, the EM group showed a higher body temperature than the EL group from 1 hour to 9 hours after the start of surgery (Fig. 2).

Therefore, as hypothesized in this study, the type of surgery itself is thought to be the cause of increase in body temperature.

This study reports the findings of pediatric patients who developed unintentional hypothermia and hyperthermia while undergoing microtia reconstruction surgery, including both embedding and elevation. Since thermal disturbances are associated with serious consequences, the body temperature should be monitored, and efforts should be made to maintain a normal body temperature during general anesthesia. Anesthesiologists should proactively monitor the children's body temperature during surgery, especially during embedding surgery, and should use various methods to avoid gross disturbances in the children's body temperature.

Author contributions

Conceptualization: Piao Longhao, Seung Zhoo Yoon, Yoon Ji Choi, Guo-Shan Xu.
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Formal analysis: Seung Zhoo Yoon, Yoon Ji Choi, Dahyeon Kim.
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Supervision: Seung Zhoo Yoon, Yoon Ji Choi, Choon-Hak Lim.
Validation: Yoon Ji Choi.
Visualization: Yoon Ji Choi.
Writing – original draft: Piao Longhao, Yoon Ji Choi, Guo-Shan Xu.
Writing – review & editing: Piao Longhao, Yoon Ji Choi, Guo-Shan Xu.

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