

# New Tympanic Membrane Temperature Shows Good Correlation with the Esophageal Temperature

## —Accuracy of a Noncontact Continuous Tympanic Thermometer

Yosuke Tamasaki, Hironobu Ueshima\*, Sakatoshi Yoshiyama, Satoshi Higuchi, Hiroshi Otake

Department of Anesthesiology, Showa University Hospital, Tokyo, Japan

Email: \*ueshimhi@yahoo.co.jp

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### Abstract

**Background:** An ear-fitting thermometer probe “NIPRO CE THERMO®” (Nipro Corporation, Osaka, Japan, new CE thermo) for both ears was newly developed in 2017. Since new release, we have never investigated about an accuracy of the new CE thermo. In this time, the accuracy of the CE thermo was investigated. **Methods:** The correlation between the tympanic membrane temperature, measured using the new CE thermo, and the esophageal temperature of 30 patients (right ear: 16 patients, left ear: 14 patients) was measured in the prospective observational study. **Results:** A good correlation ( $r = 0.721$ ) and no measurement error (within  $1^{\circ}\text{C}$  in mean  $\pm$  2SD) between the two temperatures were observed using Bland-Altman analysis. The correlation and measurement error for each ear yielded the same results. **Conclusion:** The tympanic membrane temperature, measured using the new CE thermo, showed good correlation with the esophageal temperature and could be used as a central temperature in the perioperative period.

### Keywords

Tympanic Membrane Temperature, Esophageal Temperature, Correlation, Measurement Error

## 1. Introduction

The primary function of the thermoregulatory mechanism is to maintain a stable central body temperature. However, general anesthesia inhibits the thermoregulatory mechanism, and leads to decrease in the central temperature and rise in the peripheral temperature. The peripheral temperature releases the outside of

the body, and the temperature of the whole body decreases as a consequence [1]. Such a condition may also lead to complications such as shivering and arousal delay. In addition, hypothermia in the perioperative period leads to severe complications such as massive bleeding, blood coagulation disorder, increased probability of postoperative wound infection, and myocardial ischemia [2]-[7]. Moreover, if acute hyperthermia is lost quickly, the therapy for severe complications such as malignant hyperpyrexia may be slow [8]. Therefore, we must ensure an adequate continuous temperature in the perioperative period to prevent any abnormalities in the body temperature.

Several temperature measurements for each surgery are performed, and each measurement has certain advantages and disadvantages. Among these, tympanic membrane temperature can help estimate the temperature in the external carotid arteries and this temperature has been reported to be as highly trusted for obtaining lung artery and esophageal temperature [9]. An ear-fitting thermometer probe “NIPRO CE THERMO” (Nipro Corporation, Osaka, Japan, CE thermo, **Figure 1**) is a continuous tympanic membrane temperature monitor, and it has been used to measure the perioperative temperature for several surgeries. The new CE thermo was renewed in 2017 and developed an ear-fitting thermometer probe for both ears developed using the same probe. We investigated the correlation between the tympanic membrane temperature, as measured from the new CE thermo device, and the esophageal temperature in the prospective observational study.

## 2. Methods

After obtaining the approval by the Showa University Hospital Institutional Review Board (approval No., 2593), between January and June 2018, we investigated patients; the CE thermo and esophageal temperature measuring thermistor probe (Medtronic Japan, Tokyo) were attached to these patients under general anesthesia. These probes were attached after anesthesia induction and measurement were performed in one-minute intervals from 5 minutes after probe attachment, which the temperatures became constant [10]. The esophageal temperature probe was inserted approximately 10 cm into the mouth of the patient and the tympanic membrane temperature probe was attached with a dressing



**Figure 1.** A picture of new CE thermo.

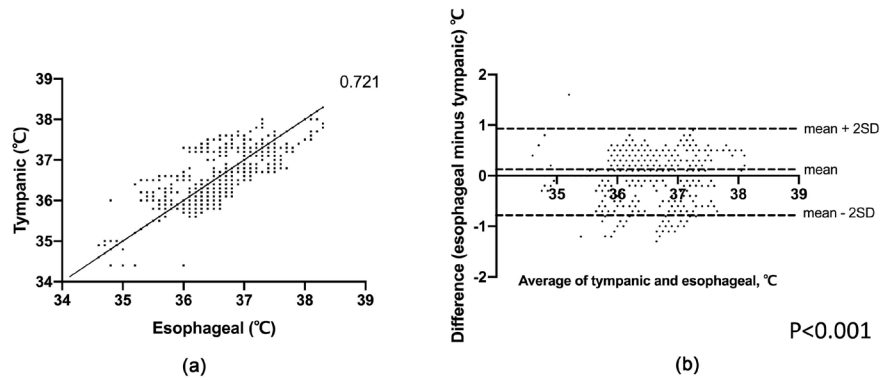
tape to avoid the misalignment of the probe after the attachment of the new CE thermo probe. The patients who could not measure these temperatures because of probe's removal and out of position, were withdrawn in this study. The relationship between the tympanic membrane temperature and the esophageal temperature was investigated using the correlation coefficient in the prospective observational study. The level of high correlation corresponded to a correlation coefficient  $> 0.4$ . Similarly, the significance was less than 0.05, as measured by the Bland-Altman analysis.

### 3. Results

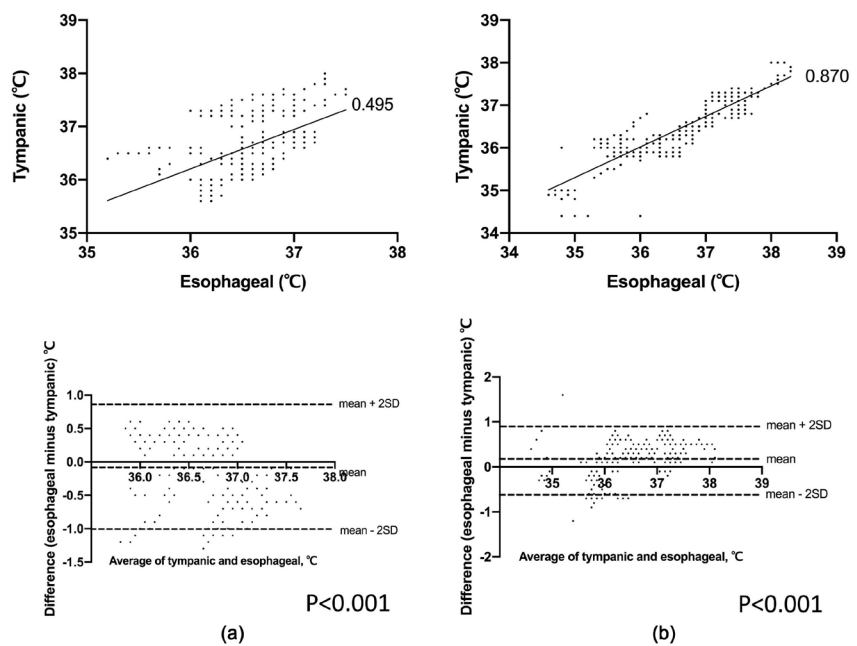
In total, 30 patients (3310 points; 16 patients of right tympanic thermometer and 14 patients of left tympanic thermometer, **Table 1**) were measured to determine the correlation and measurement error between the tympanic thermometer and esophageal temperatures. No patients were withdrawn. As reported in **Figure 2**, we found a good correlation ( $r = 0.721$ ) and no measurement error (within  $1^{\circ}\text{C}$  in mean  $\pm 2\text{SD}$ ) between two temperatures. Although the correlation and the measurement error for each ear was the same result, the correlation for the left ear (1650 points,  $r = 0.495$ , within  $1^{\circ}\text{C}$  in mean  $\pm 2\text{SD}$ ) was greater than that for the right ear (1660 points,  $r = 0.870$ , within  $1^{\circ}\text{C}$  in mean  $\pm 2\text{SD}$ ) (**Figure 3**).

**Table 1.** Patient's characteristic.

Data items	Value
Age	
Mean (SD), year	52.9 (22.4)
Sex, number (%)	
Male	16 (53)
Female	14 (47)
Body mass index	
Mean (SD), $\text{kg}/\text{m}^2$	23.4 (4.9)
ASA classification, number (%)	
1	7 (23)
2	14 (47)
3	9 (30)
Anesthesia time	
Mean (SD), minutes	180.8 (88.4)
Operation time	
Mean (SD), minutes	126.0 (79.4)
Region tympanic membrane, number (%)	
right	16 (53)
left	14 (47)



**Figure 2.** Correlation (a) and measurement error (b) between tympanic thermometer and esophageal temperatures for all 30 patients (3310 points).



**Figure 3.** Correlation (upper row) and measurement error (lower row) between tympanic thermometer and esophageal temperatures for each ear ((a) right, (b) left).

#### 4. Discussion

These results showed that the tympanic temperature in the perioperative period had a high correlation with the esophageal temperature. Therefore, the tympanic thermometer temperature may be used as one of the central temperatures, and in the evaluation of the perioperative period. Moreover, the tympanic thermometer temperature can be attached before the general induction because it is minimally invasive, and it is possible to manage the change in temperature from the stage of entering an operating room to leaving it. It is highly likely that the tympanic thermometer temperature will be the first choice in several temperature measurements in the future.

A significant difference was noted between the tympanic membrane temperature for the left and right ears. Although we do not know why the significant

difference had, the correlation coefficients of measured temperatures in left ear was lower than previously reported values [10]. It is possible that something may be wrong with the measurement method such as attachment to the left ear.

There are also some limitations associated to the procedures. The new CE thermo probe has only two configurations, with tip diameters of 5.5 and 6.2 mm. Hence, the tympanic thermometer temperature for pediatric and young patients cannot be measured using the new CE thermo. Thus, the CE thermo should be available for all generations and ages. Furthermore, the CE thermo cannot be used in some surgeries associated with the ear, such as tympanoplasty surgery. The CE thermo must be performed further improvement in the future.

The tympanic membrane temperature measured using the new CE thermo showed good correlation with the esophageal temperature. Hence, it could be used as a central temperature in the perioperative period.

### Assistance with the Letter

None.

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None.

### Conflicts of Interest

None.

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