Acta Anaesthesiologica Taiwanica 51 (2013) 116–119

Contents lists available at ScienceDirect

Acta Anaesthesiologica Taiwanica

journal homepage: www.e-aat.com

Original Article

Thoracotomy for lung lesion does not affect the accuracy of esophageal temperature

Shih-Kai Liu [1,2], Yi-Ying Chiang [1,3], Kin-Shing Poon [1], Yeong-Ray Wen [1,4], Chi-Yuan Li [1,2], Yu-Fang Liu [1], Kuen-Bao Chen [1]*

[1] Department of Anesthesiology, China Medical University and Hospital, Taichung, Taiwan
[2] Graduate Institute of Clinical Medical Science, China Medical University, Taichung, Taiwan
[3] Department of Health Services Administration, China Medical University, Taichung, Taiwan
[4] School of Medicine, China Medical University, Taichung, Taiwan

A R T I C L E I N F O

Article history:
Received 12 September 2012
Received in revised form
24 June 2013
Accepted 27 June 2013

Key words:
esophagus;
one-lung ventilation;
temperature;
thoracotomy

A B S T R A C T

Background: There are several sites for measuring body temperature. Correct reading of core temperature is imperative for patients undergoing major operations under anesthesia. In certain situations, the sites of measurement may be close to the surgical area, and thus the measurement is easily prejudiced by the influence environment. We hypothesized that the body temperature, if monitored in the esophagus, would be lower than obtained from the tympanic membrane during thoracotomy for lung pathology under general anesthesia.
Materials and methods: The study involved 32 patients, of American Society of Anesthesiologists (ASA) physical status I or II, who were to undergo elective thoracotomy for lung disorders. General anesthesia was induced with fentanyl, propofol, and rocuronium and maintained with sevoflurane in oxygen. The tympanic membrane probe was placed prior to when general anesthesia was administered, and the esophageal probe was inserted after administration of general anesthesia. Both the individualized temperatures were recorded at 5-minute intervals, and were compared at each change of surgical situation.
Results: The tympanic membrane temperature was higher than esophageal temperature after initiation of one-lung ventilation (OLV) with statistical significance. The magnitude of decrease in temperature between two individualized temperatures, as compared from start of OLV, was greater in tympanic membrane temperature, especially at 30 minutes after OLV ($p < 0.02$, difference $= -0.09 \pm 0.22$) and at the time point of the lowest temperature ($p = 0.002$, difference $= -0.14 \pm 0.24$). There was no clinical difference of situation found (difference $> 0.5^\circ$C) in the measuring sequences.
Conclusion: The accuracy of esophageal temperature seemed not to be affected during thoracotomy for lung lesion, in comparison with that of tympanic temperature. From clinical viewpoints, the monitoring of esophageal temperature could be more reliable in such surgical situation.

1. Introduction

Accurate monitoring of core body temperature is important in patients under general anesthesia, because of the need for early detection of malignant hyperthermia or hypothermia due to loss of body heat. Temperature disturbances could cause numerous complications, including wound infection, coagulopathy, delayed wound healing, and prolonged postanesthetic recovery.[1–3]

The tympanic membrane, which is almost regarded as an ideal site for measurement,[4] is located in close proximity to the brain and considered to rationally reflect the brain temperature more accurately. However, core temperature also can be measured at various sites, such as the lower esophagus, nasopharynx, pulmonary artery, rectum, and tympanic membrane.[5]

Temperature measurement taken at the distal esophagus is reliable because it is unaffected by even extreme airway cooling.[6] However, during liver transplantation,[7] esophageal temperature

* Corresponding author. Department of Anesthesiology, China Medical University Hospital, Number 2, Yude Road, North District, Taichung City 40402, Taiwan.
E-mail address: d3510@mail.cmuh.org.tw (K.-B. Chen).

1875-4597/$ – see front matter
http://dx.doi.org/10.1016/j.aat.2013.09.003

monitoring can give a seemingly correct but really incorrect core temperature reading because of the close proximity of the temperature probe to the diaphragm, which is subject to extremely cooling.

During thoracotomy, core temperature monitoring is important, and the measurement is usually taken from the tympanic membrane or the esophagus. Both sites are regarded as core temperature compartments; however, the esophagus is close to the site of thoracotomy for lung lesion. We hypothesized that esophageal temperature would be lower than the tympanic temperature during thoracotomy and the difference of the two temperatures, if exceeding 0.5°C, could be regarded as having clinical importance. In this prospective study, we investigated the validity of esophageal temperature by comparing the core temperature readings taken at the distal esophagus and at the tympanic membrane during thoracotomy in the lateral position.

2. Materials and methods

This study was approved by the Institutional Review Board of the China Medical University Hospital, Taiwan. The study group comprised 32 patients of American Society of Anesthesiologists (ASA) physical status I or II, undergoing thoracic surgery for lung disorders in the lateral decubitus position.

Exclusion criteria were hypothermia (<36°C), hyperthermia (>38°C), significant esophageal pathology, and nasogastric tube insertion. The measurement of tympanic membrane temperatures might be less accurate in the accumulation of cerumen or in the presence of otologic disease; therefore, under direct otoscopy we removed the cerumen prior to inserting the probe for measuring tympanic membrane temperature. Each patient was kept warm with a circulating-water mattress at 40°C until he or she left the operating room. The temperature of the operating room was maintained at 22 ± 1°C. Anesthetic gases were not intentionally warmed and the intravenous fluids were infused at room temperature. Crystalloid fluid was maintained using the 4:2:1 rule (4 mL/kg for the first 10 kg, 2 mL/kg for the next 10 kg, and 1 mL/kg for each additional 10 kg), and adjusted by hemodynamic status. Tympanic membrane temperature was measured prior to the administration of general anesthesia with placement of the aural probe while the patient was awake, and the probe was fixed firmly when the patient felt that the probe had touched the tympanic membrane. Esophageal temperature was measured with the adult esophageal/rectal reusable temperature probe, which was en route through a nostril to the esophagus after general anesthesia; the insertion length of the probe was calculated according to the following formula: length (cm) = 0.228 × standing height (cm) − 0.194.[8]

All patients received fentanyl (1–1.5 μg/kg), propofol (1.5–2.5 mg/kg), and rocuronium (0.5–0.6 mg/kg) for induction of general anesthesia. General anesthesia was maintained with sevoflurane in 50–100% oxygen, and the fresh gas flow was maintained at a constant rate of 2 L/min throughout the surgery. Patients were mechanically ventilated at a tidal volume of 8–10 mL/kg to maintain normocapnia (end-tidal carbon dioxide = 30–35 mm Hg). All core temperatures were recorded at 5-minute intervals throughout the surgery.

The paired Student *t* test was used to assess temperature differences and variations at two locations (tympanic membrane and esophagus) at each time point and time events. Furthermore, the mixed model was used to evaluate the effect of locations at which temperature was measured and the times of temperature readings after adjusting for age, sex, weight, height, and the side of the surgical site (left or right). The dependent variable was core temperature. The within-factors were locations and time points (or time events). The between-factors and covariates were age, sex, weight, height, and the side (left or right) on which the surgery was performed. Adjusted means were reported from mixed model. Simple effects analysis combined with Bonferroni-type multiple comparisons was performed to assess the effects of the time points (or time events) and locations (tympanic membrane and esophagus). SAS 9.1 (SAS Institute, Cary, NC) software was used for all statistical analysis.

Table 1
Patients' characteristics ($n = 32$).

Age (y)	61 ± 13
Sex (M:F)	17:15
Height (cm)	163 ± 9
Body weight (kg)	62 ± 12
Chest surgical-site (left:right)	13:19
Surgical time (min)	162 ± 59
Crystalloid infusion (mL/h/kg)	6 ± 2
Start time of one lung collapse	23 ± 14
Finish time of one lung collapse	112 ± 44

Data are presented as numbers of patients or mean ± standard deviation.

3. Results

The demographics (age, sex, weight, height, fluid infusion, chest surgical-site, and duration of surgery) are shown in Table 1. The tympanic membrane temperature was overall higher than esophageal temperature after initiation of one-lung ventilation (OLV), inclusive of the lowest temperatures ($p < 0.001$), the one taken at the end of OLV ($p < 0.001$), and the one taken at the end of surgery ($p = 0.004$; Table 2). Additionally, similar results were found in the following time points after OLV, including the temperatures at 30 minutes ($p < 0.001$), 60 minutes ($p < 0.001$), 90 minutes ($p < 0.001$), and 120 minutes ($p = 0.007$) after OLV (Table 3). Taking the temperature at the start of OLV as a standard, similar results (higher temperature in tympanic membrane) were also found in time events and time points by mixed model to adjust parameters (Figs. 1 and 2). Treating the tympanic membrane as the standard, the difference of decreasing temperature variance, as compared with that at the start of OLV, was smaller in esophageal temperature in the event of the lowest temperature ($p = 0.002$, difference = −0.14 ± 0.24) and 30 minutes after OLV ($p = 0.02$, difference = −0.09 ± 0.22; Tables 2 and 3). There was no temperature difference > 0.5°C in the measurements in time sequences.

4. Discussion

We found that the esophageal temperature was significantly lower than the tympanic temperature from 30 minutes after

Table 2
Temperature in different time events.

	N	TM (°C)	ET (°C)	p	Difference (°C)
Start of surgery	32	36.2 ± 0.4	36.2 ± 0.4	0.89	0.03 ± 0.22
Start of OLV	32	36.0 ± 0.5	35.9 ± 0.5	0.31	—
Lowest temperature	32	35.4 ± 0.6	35.2 ± 0.6	<0.001	−0.14 ± 0.24[a]
End of OLV	32	35.6 ± 0.6	35.5 ± 0.7	<0.001	−0.07 ± 0.21
End of surgery	32	35.8 ± 0.7	35.7 ± 0.7	0.004	−0.04 ± 0.2

Data are presented as mean ± standard deviation.
[a] $p = 0.002$, difference between TM and ET in variance of core temperature decrease, compared with start of OLV.
Difference = the difference between two core temperatures in variance of decreasing temperature, compared with start of OLV, in the measuring sequences; ET = esophageal temperature; N = number of patients; OLV = one-lung ventilation; TM = tympanic membrane temperature.