Original Article

Axillary versus Rectal Temperature Monitoring in Patients Undergoing Ear, Nose, and Throat Surgery under General Anesthesia

Sasima Dusitkasem, MD[1], Phimyada Rattanasiriphibun, MD[1], Nichawan Wirachpisit, MD[1]

[1] Department of Anesthesiology, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

Background: Inadvertent perioperative hypothermia is a common occurrence during procedures performed under general anesthesia. Core temperature monitoring via esophageal, nasopharyngeal, or rectal temperature measurement has been considered reliable methods. However, placing a temperature probe at these sites might be unsuitable for patients undergoing ear, nose, and throat (ENT) surgery.

Objective: Therefore, the present study aimed to determine the correlation of axillary temperature with that of rectal temperature for temperature monitoring.

Materials and Methods: Forty adults with the American Society of Anesthesiologists physical status I-III that underwent ENT surgery were enrolled. All patients got standard perioperative warming procedures. Intraoperative axillary and rectal temperature measurements were concurrently obtained at 15-minute intervals. The data were analyzed using Pearson or Spearman correlation and repeated measures Bland-Altman analysis.

Results: Axillary and rectal temperatures were well correlated with each other ($r=0.549$, $R^2=0.301$, $p<0.001$). The Bland-Altman plot showed that the mean axillary temperature was 0.9°C less than the mean rectal temperature. Overall, the 95% limit of agreement was 3.4°C (–2.6 to 0.9), yielding a relatively poor agreement between axillary and rectal temperatures. Nevertheless, the mean bias was reduced to 0.6°C when the measurements obtained 90 minutes after anesthesia induction were separately analyzed.

Conclusion: Under standard warming procedures, axillary temperature monitoring may correlate well with rectal temperature starting of 90 minutes after induction of general anesthesia in patients that underwent elective ENT surgery with the difference of 0.6°C.

Keywords: Axillary temperature, General anesthesia, Inadvertent perioperative hypothermia

Received 11 December 2019 | Revised 1 June 2020 | Accepted 2 June 2020

J Med Assoc Thai 2020;103(9):845-9
Website: http://www.jmatonline.com

Inadvertent perioperative hypothermia may occur for many reasons, such as intraoperative skin exposure and interference with normal thermoregulation due to anesthetic drugs[1,2]. Its adverse effects include high intraoperative blood loss[3], increased wound infection rate[4], morbid cardiac events[5], and delayed post-anesthetic recovery[6]. Therefore, close monitoring of core temperature is essential for prompt detection and appropriate management of perioperative hypothermia.

Core temperature can be reliably measured at the tympanic membrane, pulmonary artery, distal esophagus, and nasopharynx temperatures[7,8]. There are several limitations of temperature place in the head and neck regions of patients undergoing ear, nose, and throat (ENT) surgery. The temperature probes could interfere with the operative field and provide an unreliable measurement. Measurement of core temperature via rectal probe may be an option in ENT patients under general anesthesia[9]. However,

Correspondence to:

Dusitkasem S.

Department of Anesthesiology, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok 10400, Thailand.

Phone: +66-2-2011552, **Fax**: +66-2-2011569

Email: sasima1308@gmail.com

How to cite this article:

Dusitkasem S, Rattanasiriphibun P, Wirachpisit N. Axillary versus Rectal Temperature Monitoring in Patients Undergoing Ear, Nose, and Throat Surgery under General Anesthesia. J Med Assoc Thai 2020;103:845-9.

doi.org/10.35755/jmedassocthai.2020.09.10907

rectal temperature monitoring may cause rectal trauma and the temperature probe carries the risk of contamination or infection.

Axillary temperature is a minimally invasive measure found to be well correlated with rectal temperature in afebrile neonates and children[10,11]. Whether axillary temperature may be used as a substitute of rectal temperature to monitor core temperature in adult patients undergoing surgery under general anesthesia remains questionable. Anesthesia-induced vasodilation and depression of thermoregulatory response may influence monitoring of skin temperature monitoring at the axillar. Thus, the present study aimed to determine agreement between perioperative monitoring of axillary temperature and rectal temperature, in ENT patients under general anesthesia.

Materials and Methods

The present study was a prospective study registered at the Thai Clinical Trials Registry (TCTR20180604001) on June 4, 2018 and approved by the Institutional Review Board of the Ramathibodi Hospital, Mahidol University, Bangkok, Thailand (approval number 04-61-08). The study was done between July 2018 and April 2019. Forty patients aged over 18 years with the American Society of Anesthesiologists (ASA) physical status I-III undergoing elective ENT surgery, which was expected to last more than one hour, were enrolled. Written informed consents was obtained from all participants. Patients with hyperthyroidism, hypothyroidism, peripheral vascular disease, and any contraindication to rectal probe insertion were excluded.

The patient received propofol, atracurium, and fentanyl for induction and intubation. Maintenance of general anesthesia was done by using sevoflurane, atracurium with supplemental fentanyl or morphine as needed. All participants were covered with forced-air warming (Bair Hugger, 3M) setting at 38°C to 40°C.

After general anesthesia induction, a YSI Reusable Adult Esophageal or Rectal Temperature Probe was inserted into the rectum. Another similar temperature probe was placed at the tip of the axilla. An adhesive tape (3M micropore) was used to secure the temperature probe, and patients' arms were adducted during surgery. Both temperature measurements were obtained concurrently at 15-minute intervals throughout the surgery.

Demographic data of all patients included age, gender, weight, height, diagnosis, surgical procedure, comorbidities, and ASA physical status. Surgical variables such as intraoperative blood loss, intravenous (IV) fluid infusion volume, blood transfusion requirement, vasopressor use, operation time, operating room (OR) ambient temperature, and use of IV fluid warming device (Barkey autocontrol + Autoline blood and fluid warming devices) were recorded.

Statistical analysis

Sample size was calculated to determine the difference between axillary and rectal temperatures in the same person. Calculations were performed for a conservative medium effect size of 0.5 (Cohen's widely used rule of thumb for interpreting the magnitude of the difference)[12], which was clinically significant with a 5% type I error of 0.05 and type II error of 0.2. Standard deviation was estimated to be 1. The analysis required 32 patients. The researcher increased the sample size to 40 (about 25%) to prevent data loss during the study.

Statistical analyses were performed using PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). Demographic data were presented as mean ± standard deviation (SD) and frequency (%). Correlation between axillary and rectal temperatures was evaluated using Spearman rank correlation analysis. Bland-Altman analysis was used to determine the level of agreement between axillary and rectal temperatures by calculating the mean difference between the measurements (bias). The 95% limits of agreement were calculated as mean ±1.96 SD. A p-value of less than 0.05 was considered significant.

Results

The authors enrolled and evaluated 40 eligible patients. Their demographic and perioperative characteristics are summarized in Table 1. The mean patient age was 56.65±16.02 years, and the mean body mass index (BMI) was 24.06±3.96 kg/m^{-2}. Of the 40 patients, 20 (50%) were women, with 2 (5%), 23 (57.5%), and 15 (37.5%) patients having the ASA physical status of I, II, and III, respectively and only nine (22.5%) patients received IV fluid warming. The mean operation time and the mean duration of recording time were 372±197 minutes and 207.75±52.46 minutes, respectively. The mean ambient and the temperature was 21.75±1.92°C. All participants completed the study and were included in the final analysis.

In total, 1,188 temperature measurements (axillary temperature=594, rectal temperature=594)

Table 1. Patient characteristics

	Statistics (n=40) Mean±SD
Age (years)	56.65±16.02
Sex; n (%)	20 (50)
Male	20 (50)
Female	
BMI (kg·m^{-2})	24.06±3.96
ASA physical status; n (%)	
I	2 (5.0)
II	23 (57.5)
III	15 (37.5)
IV fluid warming; n (%)	9 (22.5)
Operative time (minute)	372±197
Ambient temperature (°C)	21.75±1.92
Duration of recording time (minute)	207.75±52.46
Baseline mean arterial pressure (mmHg)	88.53±15.61
Baseline heart rate (bpm)	77.73±16.54

ASA=American Society of Anesthesiologists; BMI=body mass index; IV=intravenous; SD=standard deviation

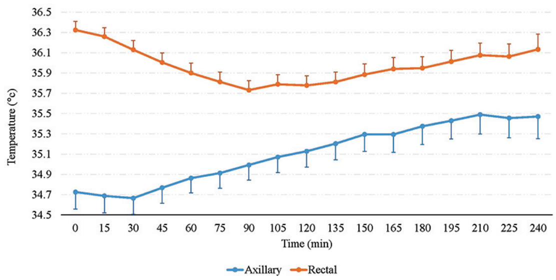

Figure 1. Mean temperatures at different time points.

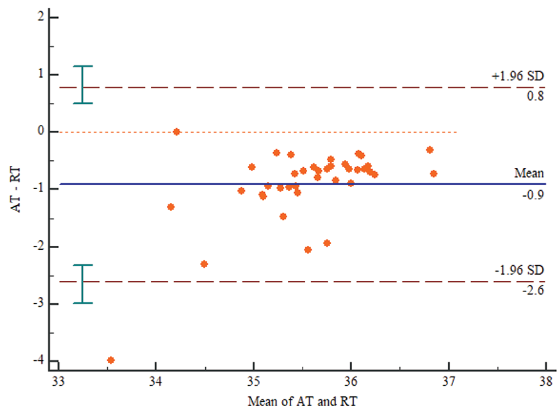

Figure 2. Bland-Altman plot with multiple measurements per participant.

were obtained in the present study. Table 2 shows the association between axillary and rectal temperatures. Overall, the observed rectal temperatures were higher than the axillary temperatures. A strong correlation was observed between axillary and rectal temperatures ($r=0.549$, $R^2=0.301$, $p<0.001$). On plotting the pairs of mean axillary and rectal temperatures at different time points (15-minute intervals) (Figure 1), axillary temperature measurements were found to be closer to the rectal ones at 90 minute after anesthesia induction, with a significant correlation observed between the two measurements ($r=0.706$, $R^2=0.498$, $p<0.001$).

Figure 2 presents the Bland-Altman plot (with multiple measurements per participant) showing the means of and differences between both measurements. The bias was –0.9°C, and the 95% limit of agreement was 3.4°C (–2.6 to 0.9). Less bias (–0.6°C versus –0.9°C) and narrower 95% limits of agreement (2.9°C versus 3.5°C) were noted when data were separately analyzed before and after 90 minute of general anesthesia induction.

The plots showed the mean and the differences between both measurements. The bias was –0.9°C, and the 95% limit of agreement was 3.4°C (–2.6 to 0.9).

The influences of independent variables on axillary-rectal temperature differences (underestimated temperature) were analyzed using multiple linear regression. BMI had an effect on underestimated temperature throughout the operative period. When BMI increased by 1 unit (1 kg/m^{-2}), the underestimated temperature reduced by 0.283°C (the

Table 2. Association between axillary and rectal temperatures

AT×RT	All time (1,188 measurements)	Before 90 minutes (480 measurements)	After 90 minutes (708 measurements)
r	0.549	0.451	0.706
R^2	0.301	0.204	0.498
p-value	<0.001*	<0.001*	<0.001*

AT=axillary temperature; RT=rectal temperature

* p<0.05; Abbreviations

range of difference between the two measurements was close to 0).

Discussion

The present study observed that rectal temperature was always higher than axillary temperature. Axillary and rectal temperatures were well correlated with each other ($r=0.549$, $R^2=0.301$, $p<0.001$). The 95% limits of agreement determined using repeated measures Bland-Altman analysis were wide at 3.4°C (–2.6 to 0.9). The mean bias was reduced to 0.6°C when the measurements obtained 90 minutes after anesthesia induction were separately analyzed. The present study finding was similar to those of previous studies using either mercury or digital thermometers[11,13]. Cattaneo et al[14] have demonstrated that axillary temperature obtained using thermocouple probes underestimates rectal temperature by –2.3±0.3°C.

The general assumption among health practitioners is that axillary temperature is approximately 0.5°C to 1°C lower than the rectal temperature[15,16]. However, this difference applies to outpatients and might not be applicable to patients undergoing surgery under general anesthesia, because core temperature rapidly changes during general anesthesia, particularly during the first hour[17]. Unlike rectal temperature, skin temperature markedly varies with environmental exposure. Thermoregulatory changes during general anesthesia such as vasodilation combined with increased interthreshold range in the hypothalamus may affect axillary temperature.

The results of the present study highlighted some limitations of reliability on axillary temperature for estimating rectal temperature during the first 90 minutes of induction of general anesthesia. The Bland-Altman plot showed that the bias was –1.3°C. The 95% limit of agreement was 3.5°C (–3.1 to 0.4), yielding a relatively poor agreement to rectal temperature. This may be explained by the rapid changes in core temperature due to the redistribution of body heat from core tissues to peripheral limbs during the first 90 minute. After 90 minutes, when the core temperature become more stabilized, the trends of temperature changes at both the sites began to exhibit a parallel change, with the bias being only –0.6°C and the 95% limit of agreement becoming narrower.

BMI was found to have an effect on axillary and rectal temperature differences throughout the period. If BMI increased by 1 unit (1 kg/m^{-2}), the underestimated temperature reduced by 0.283°C. This suggested that an axillary temperature probe may be more appropriately used as temperature monitor in obese individuals.

The present study had some limitations. The results cannot be generalized to other types of surgery involving higher core temperature changes, such as cardiac or abdominal surgery. Monitoring axillary temperature in ENT patients with operative time less than 90 minutes may not get reliable information. The present study findings cannot be applied to febrile patients. Finally, the main warming technique was forced-air warming blanket.

Conclusion

The present study showed that in patients undergoing elective ENT surgery, the axillary temperature monitoring to estimate rectal temperature depended on the time of measurement. Axillary temperature became more corrected with rectal temperatures starting at 90 minutes after induction of general anesthesia by adding a value of 0.6°C.

What is already known on this topic?

Numerous studies show agreement between axillary temperature and rectal temperature measurement in outpatient setting. However, there is no information of axillary temperature correlated with core temperature (rectal temperature) in adults having non-cardiac surgery.

What this study adds?

Variability in agreement between axillary temperature and rectal temperature was related to the measured time. Limits of agreement were reasonably narrowed only after 90 minutes of induction of general anesthesia.

Acknowledgement

The authors acknowledge the effort of the authors' research assistant Rojnarin Komonhirun.

Ethics approval and consent to participate

This prospective study was approved by the Institutional Review Board at the Ramathibodi Hospital, Mahidol University, Bangkok, Thailand (approval number 04-61-08).

Authors' contributions

Rattanasiriphibun P and Wirachpisit N analyzed and interpreted the patient data. Dusitkasem S supervised the data collection and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Sessler DI. Temperature monitoring and perioperative thermoregulation. Anesthesiology 2008;109:318-38.
2. Sessler DI. Perioperative heat balance. Anesthesiology 2000;92:578-96.
3. Rajagopalan S, Mascha E, Na J, Sessler DI. The effects of mild perioperative hypothermia on blood loss and transfusion requirement. Anesthesiology 2008;108:71-7.
4. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. N Engl J Med 1996;334:1209-15.
5. Frank SM, Fleisher LA, Breslow MJ, Higgins MS, Olson KF, Kelly S, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. A randomized clinical trial. JAMA 1997;277:1127-34.
6. Lenhardt R, Marker E, Goll V, Tschernich H, Kurz A, Sessler DI, et al. Mild intraoperative hypothermia prolongs postanesthetic recovery. Anesthesiology 1997;87:1318-23.
7. Sessler DI. Perioperative thermoregulation and heat balance. Lancet 2016;387:2655-64.
8. Torossian A. Thermal management during anaesthesia and thermoregulation standards for the prevention of inadvertent perioperative hypothermia. Best Pract Res Clin Anaesthesiol 2008;22:659-68.
9. Bissonnette B, Sessler DI, LaFlamme P. Intraoperative temperature monitoring sites in infants and children and the effect of inspired gas warming on esophageal temperature. Anesth Analg 1989;69:192-6.
10. Mayfield SR, Bhatia J, Nakamura KT, Rios GR, Bell EF. Temperature measurement in term and preterm neonates. J Pediatr 1984;104:271-5.
11. Craig JV, Lancaster GA, Williamson PR, Smyth RL. Temperature measured at the axilla compared with rectum in children and young people: systematic review. BMJ 2000;320:1174-8.
12. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Lawrence Earlbaum Associates; 1988.
13. Niven DJ, Gaudet JE, Laupland KB, Mrklas KJ, Roberts DJ, Stelfox HT. Accuracy of peripheral thermometers for estimating temperature: a systematic review and meta-analysis. Ann Intern Med 2015;163:768-77.
14. Cattaneo CG, Frank SM, Hesel TW, El Rahmany HK, Kim LJ, Tran KM. The accuracy and precision of body temperature monitoring methods during regional and general anesthesia. Anesth Analg 2000;90:938-45.
15. Sund-Levander M, Forsberg C, Wahren LK. Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review. Scand J Caring Sci 2002;16:122-8.
16. Lodha R, Mukerji N, Sinha N, Pandey RM, Jain Y. Is axillary temperature an appropriate surrogate for core temperature? Indian J Pediatr 2000;67:571-4.
17. Sessler DI. Temperature regulation and monitoring. In: Miller RD, editor. Miller's anesthesia. 8th ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2015. p. 1627-8.