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Original research

Risk factors for hypothermia in patients under general anesthesia: Is there a drawback of laminar airflow operating rooms? A prospective cohort study

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HIGHLIGHTS

- The use of a laminar airflow operating room is one risk factor for hypothermia.
- Older patients are at risk of operating room hypothermia.
- Patients scheduled for general surgeries are also at high risk.

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ABSTRACT

Introduction: The aim of this study was to estimate the prevalence and risk factors of hypothermia under general anesthesia in a large domestic hospital.
Method: All of the consecutive 1840 patients who underwent scheduled surgery between August and December 2013 were admitted to the study. The nasopharyngeal temperature was measured, and the following variables were also recorded: sex, age, type of surgery, duration of anesthesia, active warming devices and type of operating room. Univariate and multiple regression binary logistic analyses with odds ratios (ORs) and 95% confidence intervals (95% CIs) were used to assess the relationship between each clinical risk factor and hypothermia.
Results: The prevalence of hypothermia under general anesthesia was 25.7%. In the univariate analysis, the risk factors of hypothermia were age, the duration of anesthesia, the type of operating room and the type of surgery. Sex was not included. In the multiple logistic regression analysis, the significant risk factors of hypothermia were advanced age, laminar airflow operating rooms and general surgeries.
Conclusion: Intraoperative hypothermia is still common and should therefore receive serious attention. Advanced age, the use of a laminar airflow operating room and general surgeries are high risk factors of hypothermia.

1. Introduction

Mild hypothermia is defined as a core temperature between 34 °C and 36 °C, which is under the normal core temperature of 36.5~37.5 °C [1]. Unintentional hypothermia during anesthesia is a common phenomenon in the perioperative period. In 1995, Forstot RM et al. reported that up to 50%~70% of surgical patients could develop mild hypothermia in the perioperative period [2]. A decade ago, Abelha FJ et al. also revealed that 57.8% of patients who underwent non-cardiac surgeries developed mild hypothermia postoperatively in the Surgical Intensive Care Unit [3]. Furthermore, 50% ~90% of patients who underwent certain short-term surgeries (lasting 1~1.5 h) would develop hypothermia if no preventive measurements were taken [4].

Several factors contribute to the development of perioperative hypothermia such as the suppression of thermo autoregulation due

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to general anesthesia and long-term exposure of the surgical wound to the low temperature of the operating room [5]. Perioperative hypothermia can lead to several complications such as inflammation [6,7], prolonged surgical wound healing, increased oxygen consumption, cardiovascular event occurrence [8], slowed drug metabolism [9], delayed waking up, tremor after surgery [10], coagulation problems [11], increased perioperative blood loss and transfusion [12,13], and prolonged postoperative rehabilitation and hospital stays [14,15]. According to Mahoney and Odom's analysis, the expenses of treating complications due to hypothermia were much higher than those of preventing hypothermia. Complications resulting from a 1.5 °C drop in body temperature may increase a patient's hospital expenditure by 2500–7000 USD, whereas, at the same time, an air-circulating blanket only costs 15.82 USD (air warming system 0.82 USD/patient) [16].

However, not until recently is temperature monitoring listed as a recommended standard for general anesthesia [17]. The importance of temperature monitoring during operations has long been underestimated. The occurrence of operating room hypothermia in patients under general anesthesia is virtually unknown.

This study aimed to compare the occurrences of hypothermia during different types of surgeries and in different ages, sexes, and operating room types (laminar airflow or traditional non-laminar airflow) and to investigate the risk factors associated with intraoperative hypothermia.

2. Method

This study was approved by the ethical committee of Sun Yat-Sen University in October 2013 (No. [2013]111). The Unique Identifying Number (UIN) in the Research Registry is “researchregistry6”. This study conforms to criteria of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [18]. From October 2013 to December 2013, the first operation performed under general anesthesia in every operating room in the First Affiliated Hospital of Sun Yat-Sen University was surveyed.

The inclusion criteria were as follows: operating time >90 min, ASA Class I~III, preoperative normothermia (36–37.3 °C), aged >3 years old, signed patient consent agreement by the adult patients or the parents of minors.

The exclusion criteria were as follows: unable to monitor oropharyngeal temperature (surgeries on oral cavity or larynx), operating time <90 min, ASA Class IV, preoperative hyperthermia (preoperative temperature >37.3 °C), lesion of the hypothalamus.

A double-needle body temperature probe (MR401B, Mindray, Shenzhen, China) was placed in the nasal pharynx. The laminar airflow operating room temperature was 21 °C~24 °C with a humidity of 40%~60%, and the non-laminar airflow operating room temperature was 21 °C~24 °C. As a preoperative routine in our hospital, no pre-warming procedure [19] for the patient was taken as a basic protection against intraoperative hypothermia. All fluid products were routinely stored and used in room temperature. Blood products were thawed to room temperature before use. Fresh gas flows were set at 2 L/min for all patients after the intubation. Diagnostic criteria of hypothermia was a nasopharyngeal temperature under 36 °C. Active interventions were initiated only when the patient's monitored temperature dropped below 36 °C. Measures of intervention included forced-air warming, fluid warming and thermal blankets.

The age groups were as follows: juvenile (3–18 years old), young (18–40 years old), middle age (40–60 years old), and senior (≥60 years old).

The outcome measurements were as follows: T0 (axillary temperature measured by Ward nurses on the morning of the operation), T1 (the monitored temperature immediately after the induction of anesthesia), T30 (the monitored temperature 30 min after the induction of anesthesia), T60 (the monitored temperature 60 min after the induction of anesthesia), T90 (the monitored temperature 90 min after the induction of anesthesia) and Tend (the monitored temperature at the end of operation), which were recorded a total of 6 time points in all patients, as well as the temperature values.

Sample size was estimated as follow: Based on a pilot study, 15 out of 60 patients develop hypothermia under general anesthesia, assuming that the prevalence of hypothermia in the population was approximately 25%. With level of significance of 5% and a sampling error of 8%, the sample size was calculated to be 1801 subjects.

Statistical analysis was as follow: The data were summarized by the frequency for categorical variables and the mean ± standard deviation (SD) for continuous variables. Prevalence values for categorical variables were compared using the Chi-square test and the Cochran–Armitage trend test for proportions, and differences in continuous variables were compared with the *t*-test for independent samples. Odds ratios (ORs) with 95% confidence intervals (CIs) adjusted for sex and age were estimated by multivariate logistic regression using the stepwise selection criteria to determine the association of the surgical variables with hypothermia. All statistical analyses were conducted using SPSS software, version 17.0 (SPSS Inc., Chicago, IL). Two-sided *p* values are reported with a statistically significant level of <0.05.

3. Results

A total of 1882 patients were investigated; 42 cases were excluded due to incomplete data records, and 1840 were finally included in the data analysis. Of the 1840 surgical patients in the survey, 472 developed hypothermia (25.7%).

The prevalence of hypothermia was 27.1% and 23.8% in male and female patients, respectively, and the difference was not statistically significant ($\chi2 = 2.711$,$P = 0.100$). The prevalence of hypothermia increased with age ($\chi2 = 28.607$,$P < 0.001$, Cochran–Armitage trend). With prolonged anesthesia, the prevalence of hypothermia also significantly increased ($\chi2 = 21.678$,$P < 0.001$, Cochran–Armitage trend). The incidence of hypothermia at T30, T60, T90 and Tend was 17%, 13.7%, and 22.3%, respectively ($\chi2 = 21.849$,$P < 0.001$ Cochran–Armitage trend). As for surgeries lasting less than 2 h, 2–3 h, and above 3 h, the prevalence of hypothermia was 14.9%, 21.1%, and 29.6%, respectively.

As for the operating room type, the laminar airflow room had a higher prevalence of hypothermia compared with the traditional non-laminar airflow operating room (34.8% vs. 22.7%, $\chi2 = 26.106$,$P < 0.001$). In addition, the incidence of hypothermia in different types of surgeries was also significantly different ($\chi^2 = 61.719$, $P < 0.001$), with the highest incidence in General Surgeries (37%), followed by Urology (30.4%). These results are shown in Table 1.

Multivariate logistic regression analysis showed that increased age and laminar airflow operating room were significantly associated with an increased prevalence of hypothermia, whereas the non-general surgery types were significantly correlated with a decreased risk (Table 2). Compared with the traditional operating room, the OR for developing hypothermia in the laminar airflow room was 1.53 (95% CI: 1.19~1.96). Patients over the age of 60 had an OR of 2.58 (95% CI: 1.64~4.06).

4. Discussion

Although multiple studies had reported the high incidence of perioperative hypothermia and serious complications due to the