Original Article

Thermal insulation during recovery from anesthesia: a systematic review and meta-analysis

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Background: Several studies have evaluated the association between thermal insulation (TI) and control after surgery, with various research designs, recruitment and exclusion criteria, and measurements. The current meta-analysis aimed to assess the correlation between TI and stroke during recovery from anesthesia.

Methods: We searched for full-text articles of us of TI during anesthesia recovery in multiple databases including PubMed, Springer, EMBASE and Chinese journal full-text databases. Two reviewers read each article and extracted the relevant data of into a Microsoft Excel table: name of the first author, publication year, year of onset, sample size (TI/control group), patient age range, and other information related to TI patients and control group. The meta-analysis, sensitivity analysis and bias analysis were performed using Review Manager 5.0.

Results: A total of 723 patients from 7 studies met the eligibility criteria and were included in the final analysis. The meta-analysis showed that the recovery time after anesthesia in the TI group was significantly different from that in the control group [mean difference (MD) =–7.02, 95% confidence interval (CI): –10.10 to –3.95, P<0.00001; P for heterogeneity <0.00001, I^2=99%], length of stay in Postanesthesia Care Unit (PACU) score [MD =–20.78, 95% CI: –31.32 to –10.24, P=0.0001; P for heterogeneity <0.00001, I^2=92%] and shivering rate [relative risk (RR) =0.25, 95% CI: 0.08 to 0.77, P=0.02; P for heterogeneity =0.07, I^2=71%].

Discussion: TI is an important measure during recovery from anesthesia.

Keywords: Anesthesia; thermal insulation (TI); meta

Submitted Jul 12, 2021. Accepted for publication Oct 29, 2021.
doi: 10.21037/apm-21-2716
View this article at: https://dx.doi.org/10.21037/apm-21-2716

Introduction

Studies have shown that hypothermia can occur in anesthetized patients during surgery and lead to chills, restlessness and other serious complications that can have a negative impact on both the surgery and postoperative recovery (1-3). At low body temperature, the skeletal muscle shows rhythmic contractions, which can lead to increased oxygen consumption, aggravate the burden on the heart, more likely induce acidosis and increase the risk of cardiovascular and cerebrovascular disease (4-6).

The cause is related to blood distribution during anesthesia, which is less to the kidney and liver and thus increases the metabolic time of narcotic drugs, increasing the postoperative recovery time (7-9). At the same time, intraoperative hypothermia also affects normal coagulation function and material metabolism of patients, thus increasing the surgical risk and affecting the patient's prognosis.

Some studies have pointed out that perioperative hypothermia can increase the incidence of coagulation disease, acidosis, stroke, sepsis, pneumonia and myocardial infarction. Therefore, perioperative monitoring and maintaining normal body temperature are of great significance (10,11).

Thermal insulation (TI) is a special type of nursing for patients with hypothermia during surgery (10-12). Increasing the body temperature significantly improves the pharmacokinetics of narcotic drugs and prevents the delayed recovery caused by slow metabolism.

Several studies have evaluated the association between TI and stroke (2-4), with various research designs, recruitment and exclusion criteria, and measurements, but there is little meta-analyses. We therefore performed a meta-analysis to assess the correlation between TI and stroke. This research comprehensively analyzed effects of thermal insulation during recovery from anesthesia from the beginning of recovery to the end. We present the following article in accordance with the PRISMA reporting checklist (available at https://dx.doi.org/10.21037/apm-21-2716).

Methods

Search strategy

The meta-analysis was planned and implemented based on the PRISMA statement and the Cochrane Intervention System Evaluation Manual's preferred reporting project. We searched for all articles published from January 2000 to January 2018 in PubMed, Springer, EMBASE and Chinese journal full-text databases. Two members of the team searched for articles independently using the following keywords: (I) thermal insulation OR TI; (II) recovery of anesthesia. In order to obtain higher accuracy and more relevant research, the reference list of each article retrieved was also reviewed.

Citation selection

All articles after the first screening were further selected by two other researchers. The titles and abstracts were independently and carefully screened. If the research met the inclusion criteria, full-text was obtained.

Inclusion criteria

(I) Randomized control trial study or a controlled clinical trial study.
(II) Comparison between patients with TI and control group.
(III) Availability of full text.

Exclusion criteria

(I) Not randomized.
(II) Patients with complications other than anesthesia recovery.
(III) Lack of outcome measures or comparable results.

The bibliography of each selected article was manually searched to determine other articles that met the selection criteria. If multiple publications were available, and the number of patients in the same group increased or the follow-up time was extended, only the data from the latest article was used for statistical analysis.

Data extraction

Two reviewers read the full text and extracted the relevant data of each study into a Microsoft Excel table: the name of the first author, publication year, year of onset, sample size (TI/control group), patient age range, and other information related to TI patient and control groups.

Statistical analysis

We used Review Manager (RevMan) 5.0 (Cochrane Collaboration, 2011) to conduct a meta-analysis to evaluate the differences between the TI and control groups and assess heterogeneity, sensitivity, and publication bias. The effect size of a numerical variable is expressed as the mean difference of the 95% confidence interval (CI); categorical data are expressed as relative risk (RR) with 95% CI. When data in individual studies were described in terms of median and range, they were converted to estimated mean ± standard deviation (SD) before analysis. We set the percentages at ≈25% (I^2=25), 50% (I^2=50) and 75% (I^2=75), respectively, for low heterogeneity, medium heterogeneity and high heterogeneity. A χ^2-based Q test was also performed to check for heterogeneity between studies. When the I^2 value was >50, a random-effects model could be adopted when calculating moderate heterogeneity between studies, or we used a fixed-effects model. For results with significant heterogeneity among different studies, a sensitivity analysis tested the effect of each study on the aggregated data by omitting each study in turn using RevMan software. The quality evaluation of included articles used a bias risk table in the software for evaluation. In addition, we created a funnel

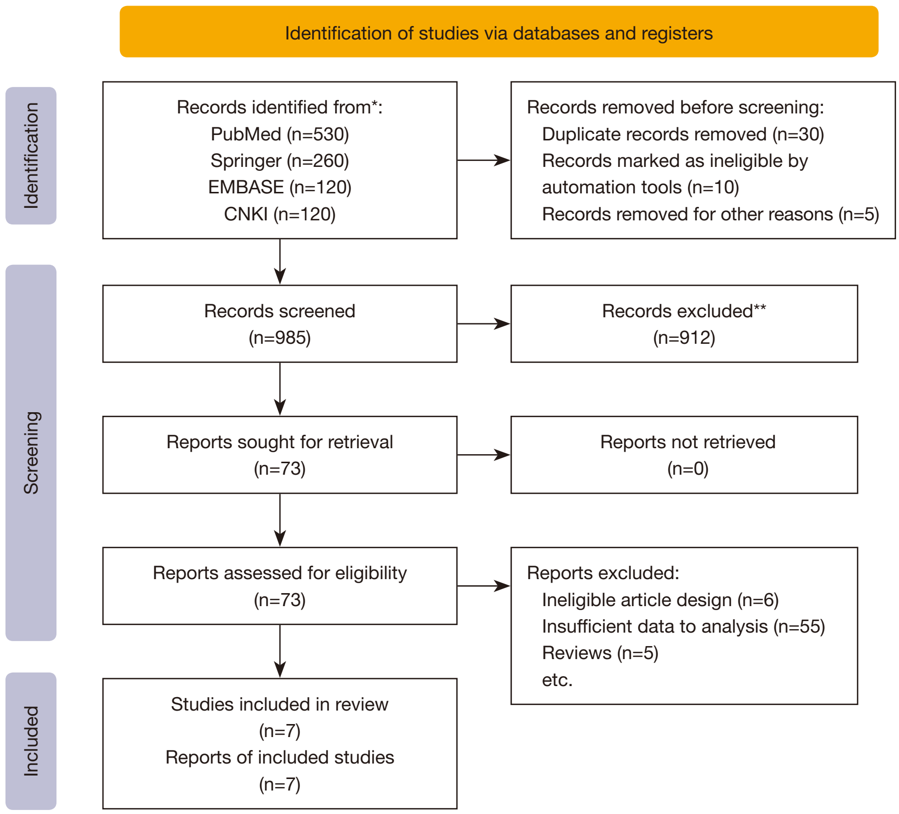

Figure 1 Flow diagram of study identification, inclusion and exclusion. *, consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers); **, if automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

plot to estimate possible publication bias.

Results

Search results

We conducted a preliminary search of 985 related titles and abstracts in the electronic databases. After a comprehensive review, seven papers finally met all the selection criteria. The other 978 articles were excluded because of repeated or irrelevant studies, no controls, incomplete data or comparisons, other operations, reviews, or incomplete articles. *Figure 1* is a flowchart of the search process and the reasons for exclusion.

Characteristics of the included studies

Table 1 lists the parameters for each study that was included. All articles were published between 2000 and 2018, and the sample size was between 20 and 246. The meta-analysis had included 723 patients, with 360 in the TI group and 363 in the control group.

Quality assessment

The deviation table in the Review Manager 5.0 tutorial shows the criteria for evaluating design-related deviations to assess each study's risk. The risk of bias in this study is shown in *Figure 2*, and the risk details of each article are shown in *Figure 3*. The bias and quality assessment graph showed almost no bias between participants and interviewees.

Results of meta-analysis

Meta-analysis of awakening time after anesthesia

Five articles studied awakening time after anesthesia. *Figure 4* is a forest plot for awakening time after anesthesia (min) in the TI and control groups. Four studies showed statistically significant differences in awakening time

Table 1 Characteristic of the studies included in the meta-analysis

Study	Year	Language	Country	No. of patients (female/male)	Age range (years, mean)	Group	n	Study time period
Jun *et al.* (13)	2018	English	Korea	20/30	65.5±9.1	TI	25	January 2017 to March 2018
						Control	25	
Li (14)	2016	Chinese	China	68/52	40.8±13.3	TI	60	May 2015 to August 2016
						Control	60	
de Oliveira *et al.* (15)	2017	English	Brazil	1/20	44.5±8.7	TI	10	January 2012 to November 2013
						Control	11	
Peng (16)	2016	Chinese	China	92/68	47.8±11.6	TI	80	April 2014 to June 2015
						Control	80	
Torossian *et al.* (17)	2016	English	Germany	188/58	45.7±14.4	TI	122	September 2009 to May 2015
						Control	124	
D'Angelo Vanni *et al.* (18)	2007	English	Brazil	6/14	39.2±5.9	TI	10	January 1999 to December 2005
						Control	10	
Wang (19)	2017	Chinese	China	36/70	44.6±2.7	TI	53	October 2015 to March 2016
						Control	53	

TI, thermal insulation.

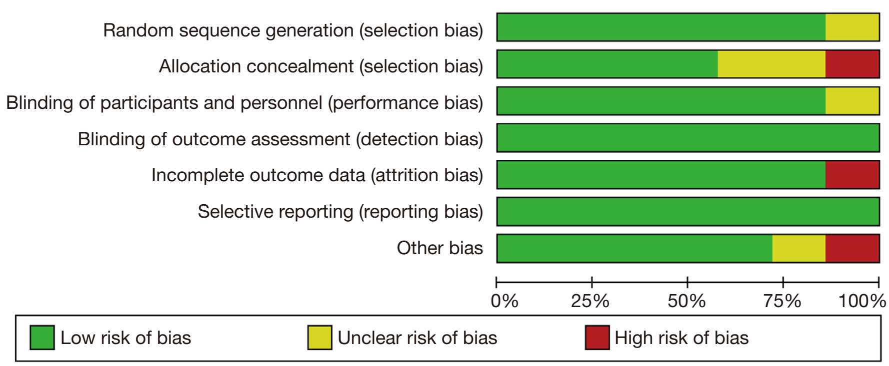

Figure 2 Assessment of the quality of the included studies from low to high risk.

after anesthesia between groups. The meta-analysis also suggested a significant difference in awakening time after anesthesia in the TI and control groups [MD =–7.02, 95% CI: –10.10 to –3.95, P<0.00001; P for heterogeneity <0.00001, I^2=99%]. The awakening time after anesthesia in the TI group was shorter than that of the control group.

Meta-analysis of length of stay in Postanesthesia Care Unit (PACU)

A forest plot of the meta-analysis of the length of stay in PACU (min) is presented in *Figure 5*. The results demonstrated that the length of stay in PACU in the TI group was shorter than that of the control group (MD =–20.78, 95% CI: –31.32 to –10.24, P=0.0001; P for heterogeneity <0.00001, I^2=92%).

Meta-analysis of shivering rate

Four studies included the shivering rate (*Figure 6*). The overall result indicated a significant difference in shivering rate between patients with TI and controls (RR =0.25, 95%

CI: 0.08 to 0.77, P=0.02; P for heterogeneity =0.07, I^2=71%).

Sensitivity analysis

The meta-analysis showed high heterogeneity of awakening time after anesthesia (I^2=99%). *Figure 7* shows that the heterogeneity of awakening time after anesthesia might be attributed to the different results of each study. When the article of Li *et al.* in 2016 was excluded, I^2 changed from 99% to 93%, which implied that the results of this meta-analysis were robust.

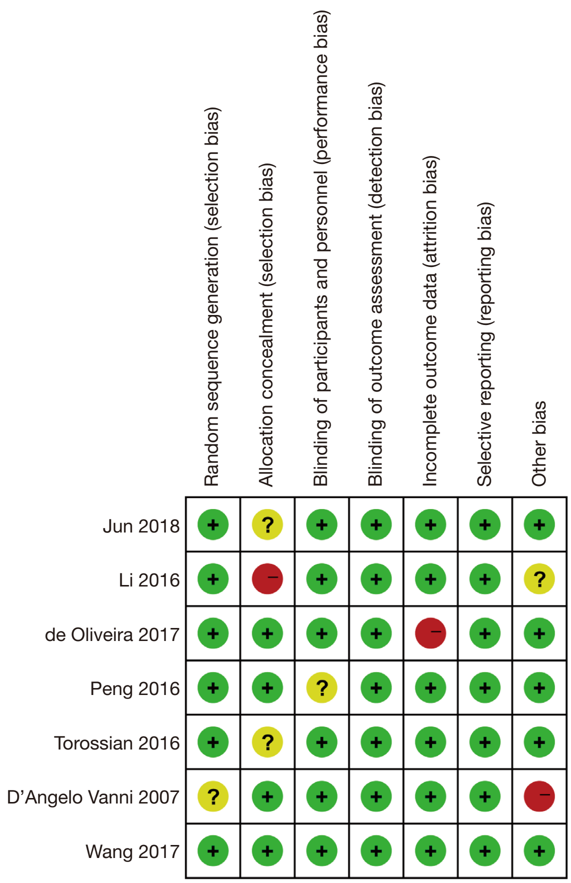

Figure 3 Quality assessment of included studies. (Red: high risk, Green: low risk, Yellow: unclear risk).

Bias analysis

A funnel plot of awakening time after anesthesia among patients with TI and controls is presented in *Figure 8*. All studies were included in the plot, which had good symmetry and little publication bias. The result of Begg's test suggested that no significant evidence of potential publication bias existed (z=1.31; P=0.172). The result of Egger's test suggested that no significant evidence of potential publication bias existed (t=1.19; P=0.321).

Discussion

In this study, we focused on the difference between thermal insulation and control after surgery in the recovery of anesthesia. General anesthesia reduces the normal metabolic rate of the human body by 30%, and is thus more likely to induce postoperative hypothermia than other forms such as intraspinal anesthesia (20-22). Poor management of hypothermia could increase the incidence of postoperative infection and fluid requirements, prolong anesthesia recovery time and hospital stay, and thus increase medical costs (23-25). Therefore, it is of great clinical significance to monitor and control hypothermia after general anesthesia.

The use of heating blankets, liquid heating and other methods to maintain the perioperative body temperature of patients improve the shivering of patients during operation, and shorten the time to extubation after operation (26-29). Maintaining normal body temperature

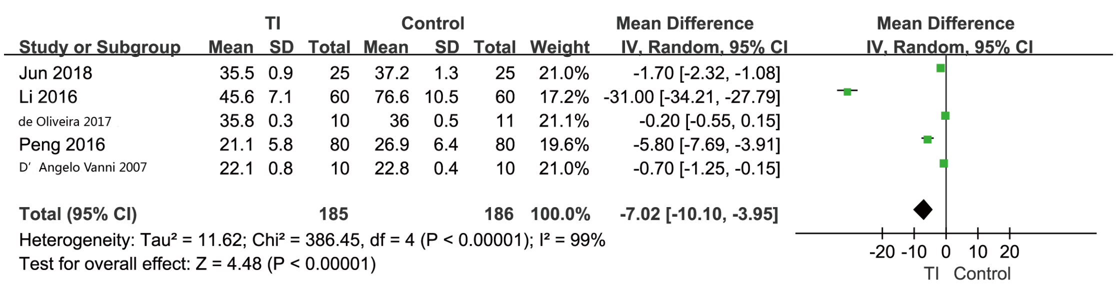

Figure 4 Forest plot of awakening time after anesthesia among patients with TI and controls. TI, thermal insulation.

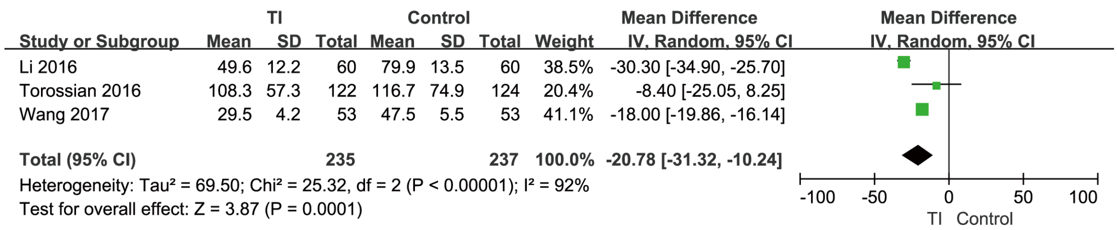

Figure 5 Forest plot for length of stay in PACU between patients with TI and controls. PACU, postanesthesia care unit; TI, thermal insulation.

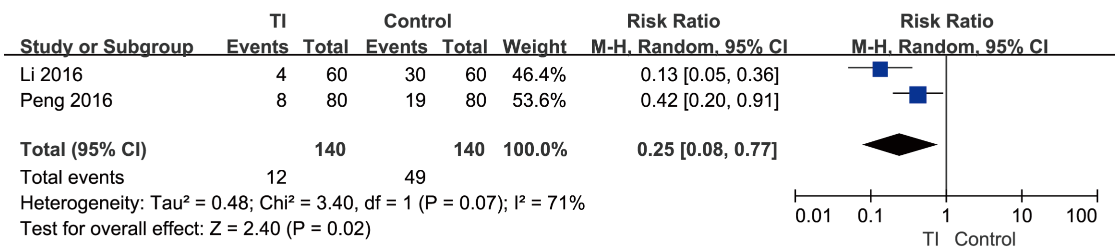

Figure 6 Forest plot for shivering rate between patients with TI and controls. TI, thermal insulation.

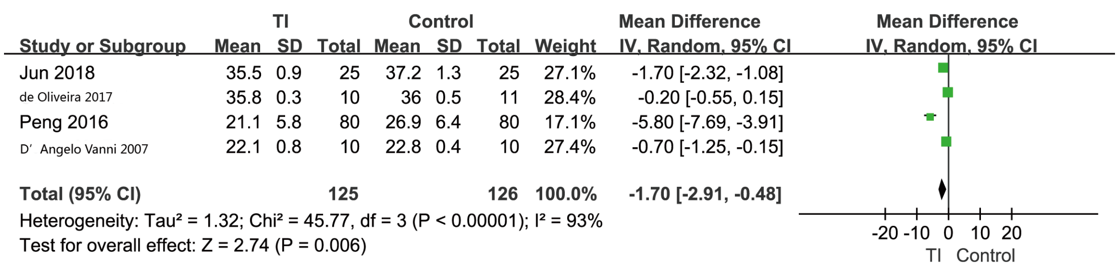

Figure 7 Forest plot of sensitivity analysis of awakening time after anesthesia among patients with TI and controls. TI, thermal insulation.

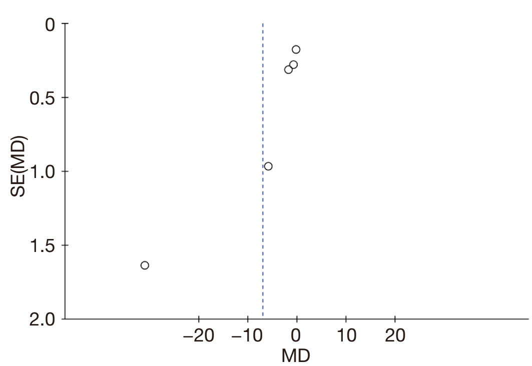

Figure 8 Funnel plot of publication bias. SE, standard error; MD, mean difference.

during the perioperative period is vitally important to both improve the quality of anesthesia and reduce adverse reactions of patients.

This meta-analysis showed significant differences in awakening time after anesthesia and length of stay in PACU among patients in the TI group and the control group, which suggested that TI can reduce both awakening time and length of stay in PACU, and further promote the patient's recovery. Our results concurred with Torossian's research that TI is an effective measure during convalescence of anesthesia (17).

With regard to the shivering rate, the difference between the TI and control groups was also significant. Xiao *et al.*

stated that TI could reduce the incidence of complications after anesthesia, which is consistent with our results (30). In order to avoid postoperative stroke, we should also avoid hypotension, low blood oxygen, hypoglycemia or hyperglycemia and preventive treatment with drugs can be conducted when necessary (29,30).

The normal value of central body temperature is about 37.5 ℃. Every 1 ℃ increase or decrease in temperature will have a great impact on the body. The central temperature below 36 ℃ is called hypothermia. Hypothermia is a common phenomenon after surgery, especially after some long-time and traumatic surgery, the incidence can reach 50–70%. The loss of body temperature mainly occurs in every link before, during and after operation through conduction, convection and radiation. Therefore, we should intervene in controllable risk factors. Comprehensive heat preservation nursing measures start from many aspects. They use more humanized measures and more accurate and easy-to-operate equipment to achieve the purpose of heat preservation and temperature increase. In particular, using a variable temperature blanket can quickly increase the body surface temperature to achieve the purpose of heat preservation and temperature increase (28-30).

In conclusion, our meta-analysis showed that the application of TI during the recovery period of anesthesia is safe and effective, and the results were consistent with those of other studies. The heterogeneity of the meta-analysis was low, and according to both the funnel chart and the Berger test, there was no publication bias, which better supports our conclusion. The main limitation of this study is that more parameters of the TI and control groups need to be analyzed and evaluated in the future. We intend to carry out further study to elucidate this issue.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the PRISMA reporting checklist. Available at https://dx.doi.org/10.21037/apm-21-2716

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://dx.doi.org/10.21037/apm-21-2716). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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(English Language Editor: K. Brown)

Cite this article as: Chen S, Qian W, Feng J, Yu X, Zhang P. Thermal insulation during recovery from anesthesia: a systematic review and meta-analysis. Ann Palliat Med 2021;10(11):11394-11402. doi: 10.21037/apm-21-2716