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Original Article

Effects of transcutaneous electrical acupoint stimulation on body temperature, hemodynamic responses, and recovery in patients undergoing open spinal surgery

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Abstract: Objective: To investigate the effects of transcutaneous electrical acupoint stimulation (TEAS) on intraoperative hypothermia, hemodynamic stability, stress responses, and postoperative recovery in patients undergoing open spinal surgery. Methods: Sixty-six patients scheduled for elective open spinal surgery under general anesthesia were randomly assigned to either the TEAS group (Group E) or the control group (Group C). TEAS was applied at Dazhui (GV14), unilateral Neiguan (PC6), Zusanli (ST36), and Taixi (KI3). Nasopharyngeal temperature, blood pressure (BP), heart rate (HR), cardiac output (CO), stroke volume variation (SVV), blood glucose (Glu), bispectral index (BIS), recovery time, incidence of postoperative shivering, incision infection, and deep vein thrombosis were recorded at six predefined time points: after entering the operating room (T0), during tracheal intubation (T1), at skin incision (T2), during pedicle screw insertion (T3), at the end of surgery (T4), and upon awakening (T5). Results: Six patients withdrew from the study, leaving 30 patients in each group for analysis. Compared with Group C, patients in Group E had significantly higher nasopharyngeal temperatures at T3-T5. Recovery time was significantly shorter, and the incidence of postoperative shivering was significantly lower in Group E. Heart rate was significantly lower in Group E at T2, whereas cardiac output was significantly higher at T3. Blood glucose levels were significantly lower at T2-T5, and BIS values were significantly higher at T5 in Group E. No significant differences were observed in postoperative incision infection or deep vein thrombosis between the two groups. Conclusion: TEAS effectively attenuated intraoperative hypothermia, reduced perioperative stress-induced hyperglycemia, improved hemodynamic stability, shortened recovery from general anesthesia, and decreased postoperative shivering in patients undergoing open spinal surgery. These findings suggest that TEAS is a safe and promising adjunctive strategy for perioperative management.

Keywords: Transcutaneous electrical acupoint stimulation, intraoperative hypothermia, open spinal surgery, hemodynamic stability, randomized controlled trial

Introduction

Intraoperative hypothermia is defined as a decrease in core body temperature to below 36°C during surgery and is primarily caused by redistribution of heat from the core to peripheral tissues and excessive heat loss exceeding metabolic heat production [1, 2]. Despite advances in temperature monitoring and warming strategies, the incidence of intraoperative hypothermia remains high, ranging from 50% to 70% [3]. Approximately 65% of patients experience perioperative hypothermia within the first hour of surgery [4]. Elderly patients are particularly susceptible due to impaired thermoregulatory function, poor nutritional status, reduced subcutaneous fat, and the presence of multiple underlying diseases, with the incidence of hypothermia reaching 51.08% in this population [5].

Various warming strategies, including warming blankets, forced-air warming systems, warmed intravenous fluids and irrigation solutions, and adjustment of operating room temperature, are commonly used to prevent intraoperative hypothermia. However, these approaches mainly rely on external heat supplementation and may be influenced by surgical duration, operative procedures, and the requirements of a ster-

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ile surgical environment. In addition, they are often applied as isolated interventions and may not provide sufficient or sustained temperature regulation. Therefore, strategies aimed at enhancing endogenous thermoregulatory capacity and maintaining perioperative temperature homeostasis require further investigation.

Transcutaneous electrical acupoint stimulation (TEAS), a noninvasive stimulation technique combining traditional acupuncture theory with modern electrical stimulation technology, has attracted increasing attention in perioperative medicine. Previous studies have demonstrated that TEAS can relieve pain, reduce opioid consumption, regulate gastrointestinal function, improve postoperative cognitive function, regulate bone metabolism in patients with fractures, and promote bone formation [6-8]. Through modulation of the autonomic nervous system and stress responses, TEAS may contribute to maintaining physiological stability during surgery.

However, whether TEAS can effectively prevent intraoperative hypothermia and improve perioperative physiological stability remains unclear. Therefore, this study aimed to investigate the effects of TEAS on body temperature regulation in elderly patients undergoing open spinal surgery under general anesthesia. In addition, we evaluated its effects on perioperative hemodynamic parameters, including heart rate (HR) and cardiac output (CO), blood glucose (Glu), and other clinical indicators, to explore its potential role in maintaining hemodynamic stability, reducing the stress response, and improving perioperative recovery.

Materials and methods

General materials

A total of 60 elderly patients who underwent elective open spinal surgery under general anesthesia at Dongzhimen Hospital, Beijing University of Chinese Medicine, between January 2024 and December 2025 were enrolled in this study (**Figure 1**). The study protocol was approved by the Ethics Committee of Dongzhimen Hospital, Beijing University of Chinese Medicine (Approval No. 2022DZMEC-410-02), and was conducted in accordance with the principles of the Declaration of Helsinki.

Methods

Sample size assessment, randomization, and blinding: Due to the exploratory nature of this study and the practical limitations associated with recruiting elderly patients undergoing open spinal surgery, a target sample size of 60 participants was initially planned. Assuming a dropout rate of approximately 10%, the final sample size was increased to 66 participants, with 33 patients allocated to each group.

This study was designed as a randomized controlled trial. Before participant enrollment, a randomization sequence was generated using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). The randomization list was prepared, coded, and maintained by an independent third party who was not involved in patient recruitment, treatment administration, outcome assessment, or data analysis.

A total of 66 participants were randomly assigned in a 1:1 ratio to either the TEAS group (Group E, n = 33) or the control group (Group C, n = 33). Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes. Upon enrollment, each participant was assigned to a study group according to the next envelope in the predetermined randomization sequence.

Patients, surgeons, and outcome assessors were blinded to group allocation throughout the study period. Group assignments were disclosed only after completion of data collection and statistical analysis.

TEAS group (Group E): In Group E, TEAS was administered by a trained investigator using a standardized protocol. The selected acupoints included Dazhui (GV14), unilateral Neiguan (PC6), Zusanli (ST36), and Taixi (KI3). After patients entered the operating room, electrode pads were placed at the designated acupoints and connected to an electronic acupuncture stimulation device. TEAS was delivered using a dilatational wave with alternating frequencies of 2/100 Hz. The stimulation intensity was adjusted individually to the maximum level tolerated by each patient without causing discomfort. Stimulation was initiated 30 minutes before the induction of anesthesia and continued until the completion of surgery. To minimize the influence of environmental factors on body temperature, the operating room

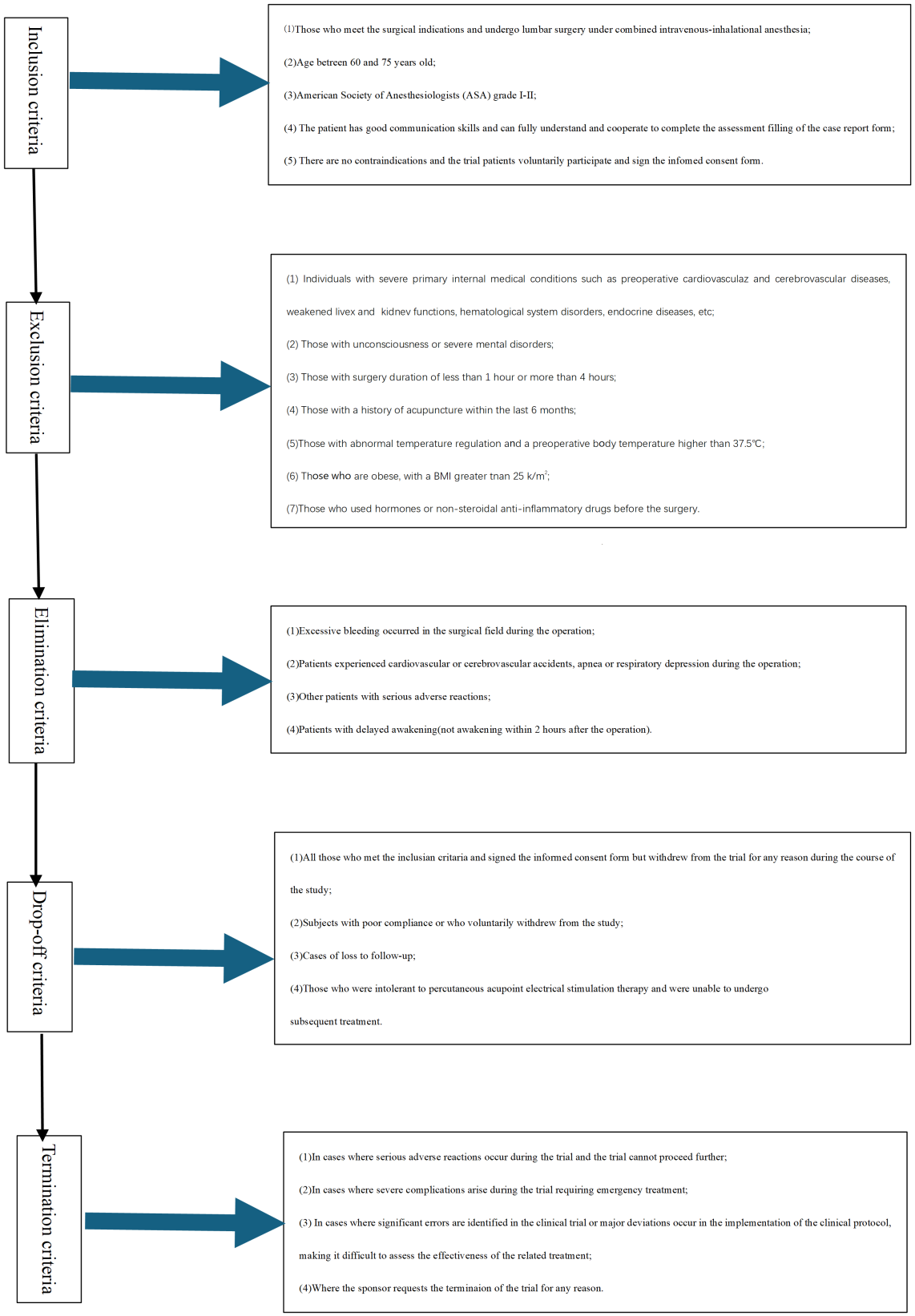

Figure 1. The inclusion criteria, exclusion criteria, elimination criteria, drop-off criteria and termination criteria of the patients.

temperature was maintained at 26°C upon patient arrival and at 25°C after the start of surgery.

Control group (Group C): Patients in Group C received sham TEAS using the same acupoints, electrode placement, stimulation device, and treatment duration as those in Group E. The stimulation intensity was set at 1 mA, which was sufficient to maintain the appearance of treatment while minimizing the physiological effects of electrical stimulation. Patients were unable to distinguish the sham intervention from active TEAS based on sensory perception. All other perioperative management procedures, including anesthesia protocol, operating room temperature, and intraoperative monitoring, were identical to those in Group E.

Outcome measures

Primary outcome: Nasopharyngeal temperature: Nasopharyngeal temperature was used as an indicator of core body temperature. After each patient entered the operating room, a nasopharyngeal temperature probe was inserted into the posterior nasopharynx and connected to the patient monitor for continuous intraoperative temperature monitoring. Core body temperature was recorded throughout the surgical procedure. Intraoperative hypothermia was defined as a core body temperature of < 36.0°C at any time during the perioperative period.

Secondary outcomes: The secondary outcomes included intraoperative and postoperative clinical parameters, including systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), cardiac output (CO), stroke volume variation (SVV), blood glucose (Glu), bispectral index (BIS), intraoperative urine output, intraoperative blood loss, recovery time from general anesthesia, the incidence and severity of postoperative shivering, and the incidence of surgical site infection and deep vein thrombosis (DVT) within 30 days after surgery.

Assessment of postoperative shivering

The severity of postoperative shivering was evaluated according to the classification proposed by DeWitte et al.: Grade 0: No shivering; Grade 1: Mild fasciculation or tremor limited to the face or neck; Grade 2: Visible muscular activity involving the head, neck, or upper extremities; Grade 3: Generalized muscular tremors involving the entire body.

Adverse events

All adverse events occurring during the study period were recorded and evaluated with respect to their severity and potential relationship to the TEAS intervention. TEAS was administered by experienced acupuncturists using a standardized protocol. If a patient experienced discomfort or pain due to electrical stimulation, the stimulation intensity was immediately reduced to a tolerable level. Appropriate precautions were taken throughout the study to minimize TEAS-related risks. Any adverse events were documented and managed according to standard clinical practice.

Statistical analysis

Statistical analyses were performed using SPSS Version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (X±SD) for normally distributed data or as median with interquartile range [M (P25, P75)] for non-normally distributed data. Normality of data distribution was assessed before statistical analysis. Comparisons between two independent groups were performed using the independent-samples t-test for normally distributed variables and the Wilcoxon rank-sum test for non-normally distributed variables. Categorical variables were expressed as frequencies and percentages and were analyzed using the χ^2 test or Fisher's exact test, as appropriate. Repeated measures obtained at different perioperative time points were analyzed using repeated-measures analysis of variance (RM-ANOVA). When significant main effects or interactions were detected, post hoc multiple comparisons were performed with appropriate correction methods. All statistical tests were two-sided, and a P value < 0.05 was considered statistically significant.

Results

Baseline characteristics

A total of 66 patients were enrolled and randomized in this study. During the study period, three patients withdrew due to intolerance to TEAS, two patients declined further participa-

Table 1. General data comparison ($\bar{X}$±S)/M (P_{25}, P_{75})

Variable	Group E	Group C	*P*
Age (years)	69.80±5.84	68.29±4.09	0.224
Height (cm)	163.00±7.23	163.40±8.50	0.845
Weight (kg)	63.06±6.85	63.20±7.43	0.943
BMI	24.13 (22.45, 24.84)	24.19 (23.88, 24.63)	0.877
Gender (Male/Female)	10/20	12/18	0.425
Surgical duration (min)	148.5 (125.75, 166)	137.5 (120.75, 155.5)	0.120
Anesthesia duration (min)	183 (161, 205.25)	172 (157, 193.25)	0.412
Infusion volume (ml)	2050 (1575, 2100)	1650 (1575, 2100)	0.520
Urine volume (ml)	200 (300, 525)	300 (450, 600)	0.202

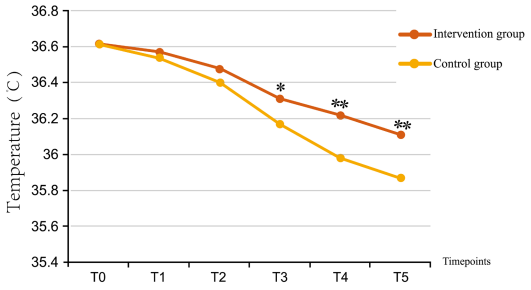

Figure 2. Comparison of nasopharyngeal temperatures between the two groups at different time points. **P* < 0.05; and ***P* < 0.01 versus Group C.

Table 2. Comparison of the nasopharyngeal temperatures

	Group E	Group C	Group E	Group C
			P	*P*
T_0	T_1	T_1	0.320	0.147
	T_2	T_2	0.005**	< 0.001**
	T_3	T_3	< 0.001**	< 0.001**
	T_4	T_4	< 0.001**	< 0.001**
	T_5	T_5	< 0.001*	< 0.001**

* Compared with T0, P < 0.05; ** Compared with T0, P < 0.01.

tion after randomization, and one patient was excluded because of incomplete data. Consequently, 60 patients completed the study, with 30 patients in each group. Baseline demographic and perioperative characteristics were comparable between the two groups, and no statistically significant differences were observed in any characteristics (all P > 0.05; **Table 1**).

Primary outcome

Comparison of nasopharyngeal temperature: An intention-to-treat (ITT) analysis was performed for the primary outcome, namely nasopharyngeal temperature. In both groups, nasopharyngeal temperatures gradually decreased during surgery. Although the nasopharyngeal temperature in Group E was consistently higher than that in Group C throughout the observation period, no statistically significant differences were observed between the groups at T0-T2 (all P > 0.05). However, from T3 to T5, nasopharyngeal temperatures were significantly higher in Group E than in Group C (P < 0.05) (**Figure 2**).

Table 3. The cases with hypothermia

Timepoints	Group E	Group C	χ^2	*P*
T_0			-	-
T_1	0	0	-	-
T_2	1/30	2/30	0.351	0.554
T_3	2/30	5/30	1.456	0.228
T_4	4/30	12/30	4.356	0.037*
T_5	8/30	17/30	5.554	0.018*

* Compared with Group C, P < 0.05.

Comparison of nasopharyngeal temperatures within groups: In both groups, nasopharyngeal temperatures at all measured time points (T1-T5) were lower than those at baseline (T0). Compared with T0, nasopharyngeal temperatures decreased significantly at T2-T5 in both groups (P < 0.05) (**Table 2**).

Comparison of the incidence of hypothermia: No patients developed hypothermia at T0 or T1. Hypothermia occurred in both groups at T2 and T3. Although the incidence of hypothermia was lower in Group E than in Group C during this period, the difference was not statistically significant (P > 0.05). At T4 and T5, the incidence of hypothermia in Group E was significantly lower than that in Group C (P < 0.05) (**Table 3**).

Table 4. Comparison of the recovery time and the shivering

Group	Recovery time	*P*	Shivering case	Grade1	Grade2	Grade3	*P*
Group E	6.63±1.80	0.001**	7	4	2	1	0.017*
Group C	9.40±2.21		17	5	6	6	

* Compared with Group C, P < 0.05; ** Compared with Group C, P < 0.01.

Table 5. Comparison of the incision infection rates [n (%)]

Group	Incision infection		χ^2	*P*
	Yes	No		
Group E	1	29	0.351	0.554
Group C	2	28		

Secondary outcome indicators

Comparison of recovery time and post-awakening shivering between the two groups: The recovery time in Group E was significantly shorter than that in Group C (P < 0.05). The incidence of post-awakening shivering was 23.33% (7/30) in Group E and 56.67% (17/30) in Group C. The incidence of post-awakening shivering was significantly lower in Group E than in Group C (P < 0.05) (**Table 4**).

Comparison of the incision infection rates: There was no significant statistical difference between the two groups for the incision infection rates (P > 0.05) (**Table 5**).

Comparison of non-invasive hemodynamic parameters: Heart rate (HR) was significantly lower in Group E than in Group C at T2 (P < 0.05). No significant differences were observed between the two groups in systolic blood pressure (SBP), diastolic blood pressure (DBP), or mean arterial pressure (MAP) at any time point (all *P* > 0.05) (**Figure 3**).

Comparison of invasive hemodynamic parameters: Cardiac output (CO) in both groups initially decreased and then increased over time, reaching its lowest value at T3. At T3, the CO in Group E was significantly higher than that in Group C (P < 0.05). No significant differences in stroke volume variation (SVV) were observed between Group E and Group C at any time point (all P > 0.05) (**Table 6**).

Comparison of blood glucose (Glu) levels: Blood glucose (Glu) levels were lowest at T0 and gradually increased, reaching their highest values at T5. The Glu levels in Group E were significantly lower than those in Group C from T2 to T5 (P < 0.05) (**Figure 4**).

The incidence of hyperglycemia in Group E was significantly lower than that in Group C at T3-T5 (P < 0.05) (**Table 7**).

Comparison of bispectral index (BIS): The BIS value in Group E was significantly higher than that in Group C at T5 (P < 0.05) (**Table 8**).

Comparison of postoperative deep vein thrombosis after surgery: No cases of deep vein thrombosis were observed during the postoperative follow-up period.

Discussion

The present study evaluated the effects of transcutaneous electrical acupoint stimulation (TEAS) on perioperative hypothermia and physiological responses in elderly patients undergoing open spinal surgery under general anesthesia. The findings demonstrated that TEAS helped maintain intraoperative core temperature, reduced the incidence of hypothermia and postoperative shivering, shortened recovery time, and improved perioperative glucose regulation. In contrast, although several hemodynamic parameters showed favorable trends, no significant differences were observed between groups. These results suggest that TEAS may serve as a safe adjunctive intervention for improving perioperative physiological stability.

Potential mechanisms of TEAS in temperature regulation

According to traditional Chinese medicine (TCM), normal body temperature is maintained through the balance of Yin and Yang and the warming function of Yang Qi. Hypothermia is considered to result from insufficient Yang Qi and impaired circulation of Qi and Blood. Based on these principles, Dazhui (GV14), Neiguan (PC6), Zusanli (ST36), and Taixi (KI3) were

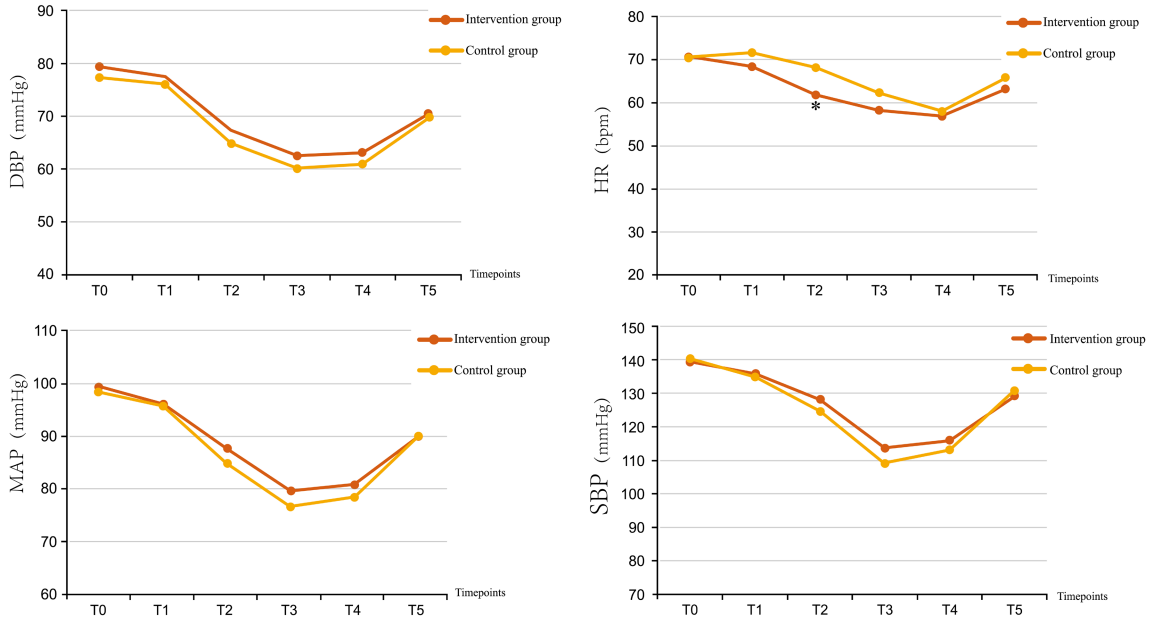

Figure 3. Comparison of changes in non-invasive hemodynamic parameters at different timepoints between the two groups. *P < 0.05 versus Group C.

Table 6. Comparison of the invasive hemodynamics ($\bar{X}$±S)/M (P_{25}, P_{75})

Timepoints	CO		*P*	SVV		*P*
	Group E	Group C		Group E	Group C	
T_0	5 (4.6, 5.6)	5 (4.5, 6)	0.549	10 (8, 11)	9 (7, 11.25)	0.434
T_1	4 (3.5, 5.28)	5 (3.6, 6)	0.520	10 (8.75, 11.25)	8.5 (5, 15)	0.608
T_2	3.82±0.65	3.81±0.82	0.972	10.20±3.13	10.63±3.63	0.623
T_3	3.26±0.59	2.86±0.79	0.030*	12.40±2.99	12.83±3.89	0.630
T_4	3.79±0.52	3.62±0.81	0.338	10 (8, 13)	11 (9, 13)	0.292
T_5	4.78±0.91	4.53±0.98	0.039	9.5 (8.75, 12)	9.5 (5, 14.25)	0.513

* Compared with Group C, P < 0.05.

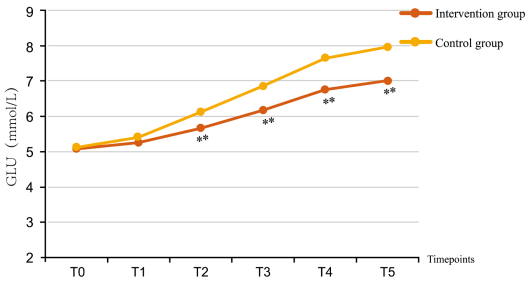

Figure 4. Comparison of changes of the Glu levels at different timepoints between the two groups. **P < 0.01 versus Group C.

selected because they are traditionally used to regulate Yang Qi, promote Qi and blood circulation, and maintain physiological balance.

Among these acupoints, Dazhui (GV14), located on the Du Meridian, is regarded as a principal acupoint for regulating Yang Qi and strengthening defensive functions. Previous studies have shown that stimulation of Dazhui (GV14) can reduce postoperative shivering [9], while thermal stimulation of this acupoint may alleviate surgery-induced Yang Qi deficiency and support thermoregulation [10]. Neiguan (PC6), located on the Pericardium Meridian, has been widely used to regulate circulation and autonomic function. Previous studies have reported that stimulation of Neiguan (PC6) reduces postoperative shivering, and Shoar et al. [11] demonstrated that combined stimulation of Neiguan (PC6) and Hegu (LI4) alleviated postoperative shivering. Zusanli (ST36) and Taixi (KI3) are tra-

Table 7. Comparison of hyperglycemia [n (%)]

Timepoints	Group E	Group C	χ^2	*P*
T_0	0 (0.00)	0 (0.00)	-	-
T_1	2 (6.67)	5 (16.67)	1.456	0.228
T_2	6 (20.00)	10 (33.33)	1.364	0.243
T_3	10 (33.33)	19 (63.33)	5.406	0.020*
T_4	16 (53.33)	25 (83.33)	6.239	0.012*
T_5	19 (63.33)	28 (93.33)	7.954	0.005**

* Compared with Group C, P < 0.05; ** Compared with Group C, P < 0.01.

Table 8. Comparison of BIS ($\bar{X}$±S)/M (P_{25}, P_{75})

Timepoints	Group E	Group C	Z/t	*P*
T_0	92.10±3.81	92.27±3.98	-0.166	0.869
T_1	48.17±4.50	48.77±5.59	-0.458	0.649
T_2	49 (43, 58.25)	51.5 (45.5, 59)	-0.637	0.524
T_3	45.5 (43.75, 52.25)	46 (41.75, 51.75)	-0.119	0.906
T_4	61.43±3.86	59.60±6.31	1.358	0.18
T_5	88.23±2.28	86.80±2.57	2.603	0.012*

* Compared with Group C, P < 0.05.

ditionally associated with regulation of Qi and blood circulation and maintenance of Yin-Yang balance, providing a theoretical basis for their use in perioperative temperature management.

Perioperative hypothermia is a common consequence of general anesthesia and major surgery. Anesthetic agents impair central thermoregulation, inhibit metabolic heat production, and promote redistribution of core heat to peripheral tissues, while surgical exposure and environmental heat loss further accelerate the decline in core temperature. Consistent with these mechanisms, nasopharyngeal temperature gradually decreased throughout surgery in both groups. However, patients receiving TEAS maintained significantly higher temperatures during the later stages of surgery and experienced a lower incidence of intraoperative hypothermia. These findings suggest that TEAS may partially counteract anesthesia-induced thermoregulatory impairment and contribute to maintaining perioperative temperature homeostasis.

Effects of TEAS on recovery and postoperative shivering

Delayed emergence from general anesthesia is associated with prolonged surgery, blood loss, and intraoperative hypothermia and may adversely affect postoperative recovery [12]. In the present study, recovery time was significantly shorter in the TEAS group, consistent with previous reports demonstrating that TEAS facilitates postoperative recovery [13]. Although the underlying mechanisms remain unclear, improved temperature regulation and attenuation of the physiological stress response may contribute to faster emergence from anesthesia.

Postoperative shivering is a frequent complication following anesthesia. Although hypothermia is the primary cause, postoperative pain and opioid withdrawal may also contribute to its development. In this study, both the overall incidence and severity of postoperative shivering were significantly lower in the TEAS group than in the control group. This finding is likely attributable, at least in part, to improved maintenance of intraoperative temperature. In addition, previous studies have shown that TEAS provides analgesic effects and reduces perioperative analgesic requirements [14], which may further contribute to the reduction in moderate and severe postoperative shivering.

Effects of TEAS on postoperative incision infection

Perioperative hypothermia is a recognized risk factor for surgical-site infection because hypothermia-induced vasoconstriction reduces tissue perfusion and oxygen delivery, thereby impairing wound healing and immune function [15, 16]. Although the incidence of postoperative incision infection was numerically lower in the TEAS group than in the control group, the difference was not statistically significant. This finding is likely attributable to the relatively small sample size and the routine administration of prophylactic antibiotics. Larger studies are required to determine whether improved perioperative temperature control with TEAS translates into a meaningful reduction in postoperative infectious complications.

Effects of TEAS on intraoperative hemodynamics

Maintenance of hemodynamic stability is particularly important in elderly patients, who are more vulnerable to cardiovascular fluctuations during major surgery [17]. Previous studies have shown that stimulation of Neiguan (PC6) may reduce blood pressure and heart rate [18, 19]. Experimental evidence further suggests that acupuncture exerts antihypertensive effects by attenuating oxidative stress within the lateral medulla oblongata [20]. In addition, electroacupuncture at Neiguan (PC6) has been shown to regulate autonomic nervous system activity and promote endogenous opioid release, thereby suppressing sympathetic excitation and reducing the incidence of hypertension, myocardial ischemia, and arrhythmia [21, 22]. TEAS has also been reported to enhance autonomic cardiovascular protection and attenuate the adverse cardiovascular effects associated with surgical stress [23-25].

In the present study, systolic, diastolic, and mean arterial pressures showed similar trends in both groups, and no significant intergroup differences were observed. These findings are consistent with previous reports demonstrating that TEAS may improve perioperative cardiovascular regulation without producing marked differences in conventional blood pressure measurements [26-28]. Likewise, cardiac output and stroke volume variation tended to be more favorable in the TEAS group but did not differ significantly between groups. These findings suggest that TEAS may provide modest cardiovascular benefits while preserving overall hemodynamic stability, although larger studies are needed to confirm these effects.

Effects of TEAS on perioperative glucose regulation

Perioperative hyperglycemia is a common manifestation of the physiological stress response to surgery and is associated with an increased risk of postoperative complications [29, 30]. Elevated blood glucose levels have been linked to a higher incidence of surgical-site infection, whereas maintaining glucose levels below 8.3 mmol/L may reduce this risk [31, 32]. Previous studies have suggested that TEAS attenuates the surgical stress response by suppressing the excessive release of stress-related hormones, including adrenocorticotropic hormone, cortisol, and epinephrine [33].

In the present study, blood glucose levels increased progressively during surgery in both groups, reflecting the metabolic response to surgical trauma. However, patients receiving TEAS exhibited significantly lower glucose levels than those in the control group from T2 to T5, together with a lower incidence of intraoperative hyperglycemia. These findings suggest that TEAS may attenuate the perioperative stress response and contribute to improved glucose homeostasis. Because insulin secretion and insulin resistance were not evaluated in this study, the underlying mechanisms remain uncertain. Nevertheless, our findings are consistent with previous reports demonstrating beneficial effects of TEAS on perioperative glucose regulation and stress modulation [34, 35].

Limitations

This study has several limitations. First, it was conducted at a single-center with a relatively small sample size, which may have limited the ability to detect differences in relatively infrequent postoperative outcomes, such as surgical-site infection and deep vein thrombosis. Second, only short-term perioperative outcomes were assessed, and the long-term effects of TEAS on postoperative recovery and functional outcomes remain unknown. Larger multicenter studies with extended follow-up are warranted to further validate the clinical benefits of TEAS and investigate its underlying mechanisms.

Conclusion

In conclusion, TEAS applied at Dazhui (GV14), Neiguan (PC6), Zusanli (ST36), and Taixi (KI3) helped maintain intraoperative core temperature, reduced the incidence of hypothermia and postoperative shivering, shortened recovery time, and improved perioperative glucose regulation in elderly patients undergoing open spinal surgery under general anesthesia. Although no significant improvements in intraoperative hemodynamic parameters were observed, the overall findings support TEAS as a safe and promising adjunctive strategy for perioperative management. Further multicenter studies are needed to confirm these findings and clarify the underlying mechanisms.

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Disclosure of conflict of interest

None.

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