ORIGINAL RESEARCH

Impact of Transcutaneous Electrical Acupoint Stimulation on Delayed Neurocognitive Recovery in Elderly Patients Following Bronchoscopy

YuFei Wang, MD; WenWen Du, MD; JunLu Wang, PhD

ABSTRACT

Background • Postoperative cognitive dysfunction (POCD) is a significant neurological issue after surgery, linked to increased mortality, extended hospital stays, higher costs, and workforce dropout. However, effective prevention methods for POCD remain elusive.
Objective • This study aims to investigate the impact of transcutaneous electrical acupoint stimulation (TEAS) on the cognitive function of elderly patients after bronchoscopy.
Design • The research team conducted a double-blind, randomized, controlled clinical trial.
Setting • The study was conducted at a university hospital in Wenzhou, China.
Participants • The study involved 80 patients who underwent bronchoscopy between December 2019 and September 2020.
Intervention • The participants were randomly assigned to two groups, each with 40 participants: the intervention and control groups. The intervention group received Transcutaneous Electrical Acupoint Stimulation (TEAS) for 30 minutes before anesthesia, while the control group had electrodes applied but did not receive stimulation.
Outcome Measures • Seven neuropsychological tests were administered before the operation and one day afterwards. Participants were also assessed via telephone after 7 days and one-month post-operation.
Results • The TEAS group exhibited a significant reduction in the incidence of delayed neurocognitive recovery (DNR) compared to the control group on the 7th-day post-operation, although no such difference was observed at 1 day and 30 days post-operation.
Conclusion • TEAS demonstrated positive effects in preventing cognitive decline in elderly patients undergoing bronchoscopy. (*Altern Ther Health Med.* 2023;29(8):48-53)

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INTRODUCTION

Postoperative cognitive dysfunction (POCD) represents a significant neurological complication following surgery, manifesting as cognitive impairment in the postoperative period. It affects a substantial portion of patients, with reported incidence rates ranging from 19% to 41% in individuals undergoing major non-cardiac surgical procedures.[1-3] Remarkably, findings from a clinical trial indicated that as many as 47% of patients continue to experience POCD even on the first day after outpatient surgery.[4] It suggests that the detrimental effects of POCD may extend well beyond the immediate postoperative phase. Recently, the term delayed neurocognitive recovery (DNR) has gained prominence as a more precise descriptor, particularly for cognitive dysfunction persisting within 30 days after surgery.[5]

POCD results from a complex relationship between numerous preoperative risk factors and perioperative predisposing factors.[1,6,7] Among these factors, age stands out as the most significant risk factor for developing POCD.[8-10] Therefore, the early identification and management of perioperative risk factors represent the most effective approach to addressing POCD.[11] Unfortunately, no effective preoperative interventions are currently available to prevent or treat this condition.

Previous research has highlighted the potential of Electroacupuncture (EA) to enhance cognitive function through various mechanisms, with neuroinflammation emerging as a crucial player in this context.[12] The impact of acupuncture on inflammation has been extensively investigated.[13] Clinical trials have consistently demonstrated that acupuncture can improve cognitive function by reducing the levels of proinflammatory cytokines, including IL-1β, interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α), induced by surgical procedures.[14-16] Similarly, animal studies have yielded consistent results.[17-19] Notably, Transcutaneous Electrical Acupoint Stimulation (TEAS) has demonstrated the potential to achieve similar effects, representing a simplified acupuncture technique. Intriguingly, within the existing literature, there exists a lack of studies that have concurrently investigated the impact of TEAS on cognitive function.

Therefore, this study aims to investigate the impact of TEAS on the cognitive function of elderly patients after bronchoscopy. The findings from this research will contribute to the theoretical foundation supporting TEAS use in clinical practice.

MATERIALS AND METHODS

Study Design

This trial constituted a prospective, randomized controlled study conducted at the First Affiliated Hospital of Wenzhou Medical University, involving patients undergoing bronchoscopy between December 2019 and September 2020. The Institutional Human Research Ethics Committee granted ethical approval for this study, and written informed consent was obtained from all participants.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) Eligible participants were individuals aged 60 years or older; (2) patients scheduled for bronchoscopy; and (3) patients with no contraindications for neuropsychological assessment. Exclusion criteria encompassed the following: (1) mini-mental state examination (MMSE) scores < 20; (2) conditions that might influence cognitive evaluation, such as language, visual or auditory impairments, pre-existing neurological disorders, severe depression, anxiety, or known or suspected misuse of analgesic drugs.

Sample Size Determination

A clinical study conducted by Rohan et al.[4] revealed that the incidence of POCD in elderly patients following a minor outpatient operation on the first day was approximately 47%. Assuming a 60% reduction in the incidence of DNR on the first day after surgery in the TEAS group, a sample size of 33 participants in each group would be required to detect a significant difference with a power of 0.80 at a significance level of 0.05. To account for potential attrition, we anticipated a 20% loss to follow-up and therefore recruited 80 participants.

In addition to the surgical patients, this study recruited 16 healthy volunteers from the local community to serve as a nonsurgical control group for assessing practice effects associated with repeated cognitive testing.[20] These volunteers were subject to the same inclusion and exclusion criteria as the successful aging after elective surgery sample and underwent identical neuropsychological testing at the same intervals as the surgical group. Patients were randomly assigned to either the control group or the TEAS group, with 40 patients in each group. The allocation was done using the random number table method, and the medical staff responsible for patient enrollment were blinded to the study.

Intervention Procedure

TEAS was administered 30 minutes before anesthesia. The chosen acupoints for POCD pretreatment were DU20 (Baihui) and PC6 (Neiguan) [12], based on traditional anatomical references. The detailed procedure was as follows: (1) The skin was cleansed with ethanol; (2) A conductive gel electrode was applied; (3) The Hwato electronic acupuncture therapy instrument (model SDZ-V, Suzhou Medical Instruments Co., Ltd.) was used for electrical stimulation of the acupoints; (4) Stimulation parameters included an intensity range of 6-9 mA and a frequency of 2/10 Hz, maintained for a duration of 30 minutes; (5) The intensity was adjusted to suit each individual's maximum tolerance, ensuring a slight twitching sensation in the local muscles, indicating appropriate stimulation. In the control group, patients had electrodes applied but received no stimulation.

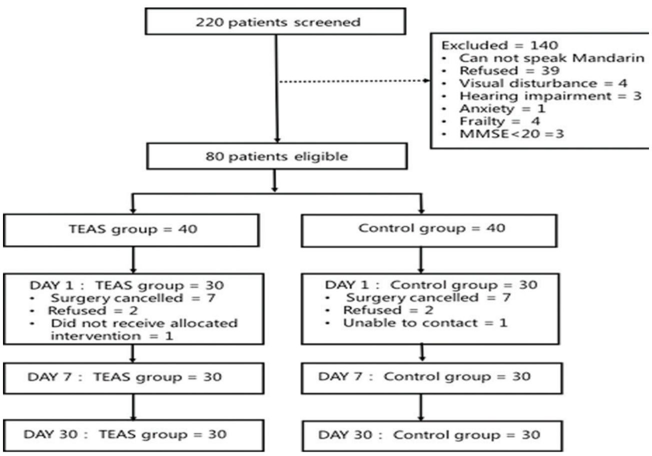
Observation Indicators

Preoperative Cognitive Assessments. We conducted cognitive assessments on the first day before the operation and during the initial postoperative day.

Neuropsychological Test Battery. A trained interviewer, who was blinded to the patient's anesthetic, administered a comprehensive battery of seven neuropsychological tests. This battery included the Auditory Verbal Learning Test (both immediate and delayed recall), the Sharp Trail Test (parts A and B), the Stroop Color-Word test[21] (measuring time and number of errors), and the Symbol Digit Modalities Test (assessing the number of correct answers). Further cognitive assessments were conducted via telephone at two additional time points: 7 days and 1 month following the operation.[22]

Evaluation of Postoperative Cognitive Dysfunction (POCD). To assess the incidence of POCD on the first day after the operation, we employed Jacobson and Truax's reliable change index (RCI).[23] We utilized the neuropsychological test results from the non-surgical control group to demonstrate the practical impact of repeated cognitive testing. The calculation process was as follows: (1) A z-score was computed for each test result. It was achieved by subtracting the baseline test score and the mean change on that test for the control group from the follow-up score. The result was then divided by the standard deviation of the change observed in the control group; (2) The composite RCI was calculated as the sum of the z-scores derived from different tests, divided by the standard deviation of this sum within the control group; (3) In individual patients, we defined postoperative cognitive dysfunction as an RCI ≤ -1.96 or a z-score ≤ -1.96 in at least two tests.[23]

Figure 1. Flowchart of Participant Recruitment and Study Progress



Note: This figure illustrates the flow of participant recruitment and the progression of the study. It outlines the enrollment process, group allocation, and the number of participants who completed neuropsychological tests and telephone assessments at various postoperative time points. The figure provides a visual representation of the study's participant flow, including the TEAS and control groups, highlighting the data collection and analysis stages.

Table 1. Characteristics and Intra-operative Variables for 80 Participants

Factors	TEAS	Controls	*P* value
Number	n = 40	n = 40	
Age (year)	66.20 (4.22)	66.32 (5.83)	.92
Sex (male/female)	30 (75%)	35 (88%)	.25
Education level			.53
Junior School	1 (2%)	2 (5%)	
Primary School	32 (80%)	28 (70%)	
Illiteracy	4 (10%)	3 (8%)	
High School	3 (8%)	7 (18%)	
MMSE	26.83 (2.31)	26.10 (2.31)	.16
BMI, kg/m²	23.61 (3.70)	22.29 (3.35)	.10
ASA			.62
1 or 2	20 (50%)	17 (42%)	
3	18 (45%)	22 (55%)	
4	2 (5%)	1 (2%)	
Cancer	23 (57%)	29 (74%)	.16
Smoke	21 (52%)	21 (54%)	1.00
Drink	11 (28%)	16 (41%)	.24
Hypertension	17 (42%)	12 (31%)	.35
Diabetes	11 (28%)	5 (13%)	.16
Coronary Artery Disease	4 (10%)	3 (8%)	1.00
History of Arrhythmia	6 (15%)	5 (13%)	1.00
COPD	1 (2%)	4 (10%)	.20
Asthma	2 (5%)	0 (0%)	.49
History of Stroke	6 (15%)	2 (5%)	.26
Surgical Time (Min)	29.50 (22.00, 41.00)	22.00 (15.00, 43.00)	.40
Anesthetic Time (Min)	33.00 (25.00, 44.50)	27.00 (19.00, 45.00)	.32

Note: Data presented as mean (SD), median [interquartile range (IQR)], or number (%).

Abbreviations: ASA: ASA physical status; COPD: chronic obstructive pulmonary disease; MMSE: mini-mental state examination.

Table 2. Rates of Delayed Neurocognitive Recovery (DNR) in Two Groups at 1, 7, and 30 Days After Operation

	Postoperative Day 1				Postoperative Day 7				Postoperative Day 30			
	TEAS (n = 30) [(%)]	**Controls (n = 30) [n(%)]**	χ^2	***P* value**	**TEAS (n = 30) [(%)]**	**Controls (n = 30) [n(%)]**	χ^2	***P* value**	**TEAS (n = 27) [(%)]**	**Controls (n = 30) [n(%)]**	χ^2	***P* value**
DNR	12 (40%)	14 (47%)	0.27	.60	4 (13%)	12 (40%)	5.45	.02	1(4%)	6 (20%)	2.15	.14
No DNR	18 (60%)	16 (53%)			26 (87%)	18 (60%)			26 (96%))	24 (80%)		

Note: Data are reported as the number of patients and the percentage within each group. χ^2 values and *P* -values indicate the significance of differences between the two groups at each time point, with $P < .05$ considered statistically significant. DNR is an 'RCI' ≤ -1.96 or a z-score ≤ -1.96 in at least two neuropsychological tests.

Statistical Analysis

Continuous variables are presented as either mean ± standard deviation ($\overline{x} \pm s$) or median [interquartile range (IQR)], while categorical variables are expressed as frequencies and percentages (%). A normality test was conducted to assess the distribution of the sample. To compare continuous variables, we utilized either Student's unpaired *t* tests or Mann–Whitney U-tests, as appropriate. Depending on the context, categorical variables were analyzed using either Pearson's Chi-squared test or Fisher's exact test. All data underwent statistical analysis using Stata SE 15.1. Two-sided *P* values were reported, and the statistical significance was set at $P < .05$.

RESULTS

Basic Characteristics of Participant

A total of 80 participants were recruited from an initial pool of 220 individuals. These participants were evenly divided, with 40 assigned to the TEAS group and 40 to the control group (see Figure 1). Among them, 60 participants (75%) completed the neuropsychological test one day after the operation, and the same number completed the telephone assessments at both 7- and 30-days post-operation. Recruitment was slow due to language and medical exclusions. Notably, there were no evident differences in patient characteristics and medical histories between the two groups ($P > .05$) (see Table 1).

Incidence of Delayed Neurocognitive Recovery (DNR)

The rate of DNR seven days after the operation was significantly reduced in the TEAS group ($P = .02$). However, this reduction was not observed at 1 day or 30 days post-operation, refer to Table 2.

Normalized Postoperative Changes in Neuropsychological Tests

The normalized postoperative changes in neuropsychological tests on the first postoperative day are detailed in Table 3. While TEAS did not decrease the rate of DNR on the first postoperative day, it had a notable effect on the changes in the Sharp Trail Test B ($P = .046$), refer to Table 4. This change suggests that TEAS positively influences postoperative recovery in terms of a patient's cognitive performance.

TICS-m Score Comparison

The TICS-m score of patients in the TEAS group was significantly superior to that of the control group (7 days

Table 3. Cognitive Scores of Participants 1 Day Before Surgery And on The First Postoperative Days.

	Pre-Operative		Postoperative Day 1	
Tests	**TEAS (n = 40)**	**controls (n = 40)**	**TEAS (n = 30)**	**controls (n = 3)**
AVLT-I, (n)	16 ± 5	15.± 5.	25.± 6	23.± 6
AVLT-D, (n)	5.7.± 2.3	4.8.± 2.6	8.2.± 2.5	7.0.± 2.8
STT-A, (s)	81.5(61, 103)	83 (48, 104)	76 (57, 105)	86 (53, 99)
STT-B, (s)	239.5 (169, 303)	218. (154, 271)	236.5 (166, 281)	221 (161, 304)
SDMT, (n)	21 (15.5, 26.5)	22 (13, 30)	25 (19, 31)	26 (18, 33)
SCWT (s)	98.5 (78, 123.5)	98 (85.5, 135.5)	79.5 (71, 119)	101 (79, 117.)
SCWT, (n)	5 (2, 10)	4.5 (2, 13)	2.5 (0, 5)	4 (1, 8)

Note: This table displays participants' cognitive scores before surgery and on the first postoperative day. The values are mean with standard deviation (SD) or median with interquartile range (IQR). Tests are AVLT(I and D): Auditory Verbal Learning Test (immediate and delayed recall); STT: Sharp Trail Test (parts A and B); SCMT: Stroop Color-Word test (time and number of errors); SDMT: Symbol Digit Modalities Test.

Table 4. Normalized Postoperative Changes In Neuropsychological Tests Between Two Groups.

	TEAS	Controls	
Tests	**n = 30**	**n = 30**	***P* value**
AVLT-I, (n)	0.01 ± 0.63	-0.17 ± 0.62	.25
AVLT-D, (n)	0.08 ± 0.83	0.00 ± 0.78	.71
STT-A, (s)	-0.58 (-1.11, -0.02)	-0.60 (-0.98, -0.33)	.99
STT-B, (s)	-0.26 (0.82)	-0.68 (0.76)	.046
SDMT, (n)	-0.02 (1.15)	-0.02 (1.10)	1.00
SCWT (s)	0.25 (-0.80, 1.06)	0.10 (-0.56, 1.30)	.85
SCWT, (n)	-0.31 (-0.72, 0.92)	-0.31 (-0.72, 0.51)	.79

Note: This table presents the normalized postoperative changes in neuropsychological test scores between the TEAS and control groups. Data are reported as mean with standard deviation (SD) or median with interquartile range (IQR). Tests are AVLT (I and D): Auditory Verbal Learning Test (immediate and delayed recall); STT: Sharp Trail Test (parts A and B); SCMT: Stroop Color-Word test (time and number of errors); SDMT: Symbol Digit Modalities Test.

Table 5. TICS-m Scores of Two Groups 7 and 30 Days After Operation

Assessment	**Postoperative Day 7**		***P* value**	**Postoperative Day 30**		***P* value**
Groups	TEAS (n = 30)	Controls (n = 30)		TEAS (n=30)	Controls (n=30)	
TICS-m	34 (32, 36)	32 (30, 35)	.034	35 (34, 39)	33.5 (32, 36)	.015
Orientation	9 (8, 9)	9 (8, 9)	.74	9 (8, 9)	8.5 (8, 9)	.42
Memory	5 (3, 6)	3 (2, 5)	.036	6 (5, 8)	4.5 (3, 6)	.01
Language And Attention	16 (15, 18)	16 (14, 19)	.82	16.5 (15, 18)	16 (14, 18)	.72

Note: Data are reported as mean with standard deviation (SD) or median with interquartile range (IQR). TICS-m, modified telephone interview for cognitive status.

after operation: $P = .034$; 30 days after procedure: $P = .015$). This difference was primarily observed in the memory domain (7 days after operation: $P = .036$; 30 days after operation: $P = .01$); refer to Table 5.

DISCUSSION

In this study, we observed that TEAS effectively decreased the incidence of DNR in patients aged 60 years or older, particularly notable at the 7-day mark following bronchoscopy. Furthermore, compared to the control group, patients in the TEAS group demonstrated significantly better Tics-M scores at both 7- and 30-days post-operation. It is worth noting that the rate of DNR on the first postoperative day in this study aligns with findings from previous research.

Many studies have reported that acupuncture can reduce the incidence of POCD, particularly within 3 days[24,25] or 7 days[25] after an operation. However, its long-term effects have remained less explored, with only a limited number of studies conducting follow-ups extending beyond two weeks. Nonetheless, it is essential to note that some research suggests that cognitive decline one month after surgery may be an intrinsic characteristic of surgical populations and may present challenges for intervention.[26,27] Similarly, our findings did not reveal significant positive effects of TEAS on cognitive function one month after surgery.

We did not observe a positive effect of TEAS on DNR on the first postoperative day. However, a significant difference between the two groups was identified in the standardized Sharp Trail Test B, suggesting that TEAS can accelerate the recovery of a patient's functional ability. Similarly, no notable decrease in the rate of DNR was observed 30 days after the operation. Nonetheless, the TICS-M scores of the TEAS group showed significant improvement compared to the control group, particularly in the memory domain. There is limited research investigating the potential relationship between postoperative cognition and the recovery of other functions.

Furthermore, few studies have concurrently examined the cognitive function and the assessment of instrumental activities of daily living. Price et al.[28] demonstrated that patients with cognitive dysfunction experience the most pronounced decline in selective memory and executive function. Our findings align with previous research in this regard. In a single-center prospective cohort study, postoperative neurocognitive impairment was found to be closely associated with the level of independence in daily living three months after surgery.[29] Notably, these impairments affected various aspects of everyday life, including meal preparation, social activity planning, item location within the home, appointment recall, shopping, laundry, transportation, and appliance usage.[27-29]

In our study, TEAS appeared to accelerate the recovery of executive function and memory. These improvements suggest the potential for TEAS to have a more substantial impact on independent daily activities following surgery. Conversely, it is important to note that our cognitive ability assessment was based on the summation of individual test variables within a comprehensive set of cognitive tests (battery).

There are a couple of factors to consider. Firstly, it is possible that the set of cognitive tests used could dilute and obscure sensitive indicators of postoperative cognitive dysfunction, potentially diminishing the observed positive effect of TEAS on DNR. Secondly, it is known that patients with higher baseline cognitive scores are generally more likely to experience cognitive recovery after surgery. In contrast, a substantial proportion of the patients included in this study (90%) had received only a primary school education or had lower educational backgrounds. Additionally, 78% of patients in the control group fell into this category. These findings suggest that these patients might face more significant challenges in recovering from DNR, which could potentially reduce the active impact of TEAS.

Reducing the severity and incidence of DNR remains a significant challenge in anesthesiology, with no established anesthetic or surgical strategies for effectively mitigating cognitive decline. Most studies have focused on descriptive aspects, attempting to establish relationships with DNR rather than exploring methods to enhance cognitive function. Several studies have indicated that the type of anesthesia does not significantly influence the incidence of DNR. Among these, a substantial trial involving 428 patients found no significant difference in the incidence of POCD between those who received general anesthesia and those who underwent regional anesthesia.[30] Notably, 37% of patients in the regional anesthesia group received intravenous propofol sedation.

Additionally, research by Silbert et al.[31] has demonstrated that POCD can occur in older patients following Extracorporeal Shock Wave Lithotripsy (ESWL), even in the absence of centrally acting drugs. These findings support that DNR may result from healthcare interventions unrelated to centrally acting anesthetic agents. Similarly, in elderly patients, the choice of anesthesia techniques appears to have a limited impact on DNR and recovery.

Similarly, the choice of anesthesia techniques appears to have a limited impact on DNR and recovery in elderly patients. While animal studies have demonstrated that blocking the inflammatory process can enhance postoperative cognition[32] these findings have not been consistently replicated in clinical studies. Several clinical investigations have explored the potential neuroprotective effects of various drugs during cardiac surgery, targeting various mechanisms, including the attenuation of the inflammatory response. However, none of these drugs has demonstrated significant efficacy.[33-36] The impact of neuroprotective agents on DNR also appears to be restricted. The absence of effective pharmacological interventions for reducing DNR leaves few options for improving perioperative prognosis. Therefore, TEAS emerges as a promising and potentially valuable intervention.

In addition to our study's results, it is noteworthy that the Perioperative Cognition Nomenclature Working Group has recently recommended transitioning from the term "Postoperative Cognitive Dysfunction (POCD)" to "delayed neurocognitive recovery" and mild or major Neurocognitive Disorder (NCD).[5] This revised diagnosis aligns with the three critical aspects outlined in the Diagnostic and Statistical Manual for Mental Disorders, fifth edition (DSM-5): subjective complaint, objective impairment, and functional decline.[37] However, it should be considered that the DSM-5 does not specify particular neuropsychological tests or the quantity required for diagnosis. Furthermore, cognitive decline measured solely through neuropsychological testing may not always correlate with clinically meaningful cognitive decline. Therefore, evaluating postoperative neurocognitive disorders has long been a complex challenge. Our study contributes to this ongoing discourse by highlighting the potential benefits of TEAS in mitigating cognitive decline in elderly patients undergoing bronchoscopy, further emphasizing the need for comprehensive and precise assessments of postoperative cognitive function.

Study Limitations

Several limitations of our study should be acknowledged. Firstly, our sample size calculation was based on the rate of DNR on the first postoperative day. The absence of significant results at other time points may, in part, be attributed to insufficient sample size, limiting our ability to assess the long-term effects of TEAS comprehensively. Secondly, losing one-fifth of the participants on the first day after the operation raises the possibility of differences between this subgroup and the remaining participants, which could have influenced the results. Thirdly, we did not collect data on changes in serum proinflammatory factors before and after painless bronchoscopy in patients, which could have mechanistically demonstrated how TEAS may reduce the incidence of DNR by mitigating neuroinflammation. Fourthly, this study did not gather data regarding the independence and functional limitations in the daily living of DNR patients after hospital discharge. Consequently, we were unable to assess the impact of TEAS on the independence of daily living for patients experiencing cognitive decline.

Future Directions and Considerations

Future studies should aim for larger sample sizes to provide a more comprehensive investigation into the impact of TEAS on DNR and to enhance our ability to improve the long-term prognosis of patients. Mechanistic insights into how TEAS enhances cognition should be refined by collecting additional data, particularly related to inflammatory markers. Furthermore, cognitive decline measured solely through neuropsychological testing may not always correlate with clinically meaningful cognitive decline. It is essential to consider factors such as age, preoperative cognitive ability, occupational status, and psychosocial support levels. Even a minor cognitive decline from the presurgical baseline can have significant functional consequences. Therefore, future investigations may benefit from focusing on assessing independence in daily living and functional limitations to define the protective effects of TEAS more precisely on cognition.

CONCLUSION

In conclusion, our study provides valuable insights into the potential role of TEAS in addressing the challenges of postoperative cognitive dysfunction. We observed that TEAS exhibited a positive effect in reducing the incidence of delayed neurocognitive recovery in elderly patients undergoing bronchoscopy. Furthermore, our findings highlighted improvements in specific cognitive domains, particularly memory and executive function, in the TEAS group compared to the control group. Our study also underscores the complexities inherent in assessing postoperative neurocognitive function. The recent recommendations emphasize subjective complaints, objective impairment, and functional decline, reflecting the multifaceted nature of cognitive assessment. Our research suggests that TEAS holds promise as a potential intervention to mitigate cognitive decline in elderly surgical patients. Future investigations with larger sample sizes and more extended follow-up periods are warranted to explain further TEAS's long-term effects and mechanistic underpinnings, particularly in modulating neuroinflammation.

DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon request.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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