META-ANALYSIS

A Meta-analysis of the Effect of Noninvasive Brain Stimulation on Dysphagia in Patients with Cerebral Stroke

Jie Guo, BS; Chunying Chen, BS; Fei Xie, BS

ABSTRACT

The objective of this study is to assess the efficacy of non-invasive brain stimulation (NIBS) in preventing and treating dysphagia in patients who have experienced a cerebral stroke (CS). Both Chinese and international guidelines for the management of dysphagia resulting from CS mention various non-pharmacological treatments, such as acupuncture, mechanical myoelectric stimulation, and NIBS. However, due to limited evidence, these treatments are often suggested as measures rather than interventions. Therefore, this study assesses the impact of NIBS on the severity and improvement of dysphagia in CS patients. The researchers provide evidence-based recommendations for clinical practice by conducting a comprehensive literature review and meta-analysis.

The researchers analyze the impact of NIBS on the severity of dysphagia and its overall improvement in CS patients. Employing a systematic computer-based search, the researchers retrieved randomized controlled trials and cohort studies published between the inception of relevant databases and December 1, 2022, about the utilization of NIBS in managing dysphagia in CS patients. This effort included nine articles for meta-analysis, with sample sizes ranging from 14 to 59, allowing an assessment of the effectiveness of NIBS in CS patients.

The analysis revealed a mean difference (MD) score of 1.05 in the NIBS studies for the prevention and treatment of dysphagia severity in stroke patients, indicating a notable alleviation of dysphagia severity in CS patients through NIBS. The MD for the dysphagia score was also 1.05, and the MD for the functional dysphagia score was 1.78, suggesting that NIBS provided relief from dysphagia in CS patients.

In summary, this meta-analysis thoroughly evaluated NIBS efficacy in CS patients and provided evidence-based recommendations for clinical practice. Future research needs to collect additional indicators to elucidate the nuances of various interventions, contributing to a more robust theoretical foundation for clinical therapy. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Cerebral stroke (CS) is a disease that poses one of the most serious threats to human beings. Current research indicates that CS ranks among the top three causes of death for individuals over 60 years old worldwide, and it is also among the leading five causes of death for people aged 15-59. China has the highest incidence rate of CS globally. The latest global disease burden report reveals that in 2022, approximately 2.3 million people lost their lives due to stroke and stroke-related complications.[1,2]

In recent years, cerebrovascular disease has become the leading cause of death among nationals. Statistics show that the standardized prevalence rate of CS-type cerebrovascular diseases among the population aged 40 and above fluctuated around 4% from 2018 to 2022. Among these cases, nearly 50% of the patients were aged 40-64, indicating a concerning trend of CS occurring in younger individuals.[3]

CS is closely associated with factors such as hypertension, dyslipidemia, diabetes, smoking, physical inactivity, obesity, and atherosclerosis.[4] The significant disability, morbidity, and mortality rates associated with CS have made it a global public health and safety concern.[5] A critical issue that arises during the patient's poststroke recovery period is the frequent occurrence of the presence of dysphagia. After reviewing several, it was discovered that the probability of dysphagia occurring at different stages of patients' recovery after stroke is 37%-78%. Additionally, instrument-based assessments have revealed that complications from dysphagia account for 58%-78% of the incidence rate among stroke patients.[6]

Complications related to dysphagia caused by CS pertain to abnormal swallowing behavior. It is difficult for patients to

complete the swallowing process, and various factors contribute to the development of dysphagia. For patients with CS, complications such as dysphagia are characterized by the inability of the body to safely, stably, and effectively transport food or liquid into the oral cavity and the stomach when eating or drinking.[7] For example, difficulties in chewing or moving the tongue during the oral preparation stage are also considered forms of dysphagia. The process of swallowing is a complex physiological phenomenon that involves four stages: oral preparation, oral transit, the pharyngeal stage, and the esophageal stage.[8]

The initial phase of oral preparation involved the patient manipulating food or liquid in the mouth, using organs like the tongue and teeth to create a lump that can be swallowed comfortably in the pharynx. During the next step, the oral transit stage, the patient will push the appropriately sized and shaped food mass, prepared in the first stage, from the front to the rear of the mouth and ultimately into the pharynx. The third step is the pharyngeal stage, where the food mass continues its pharynx, starting from the back of the mouth. These first three stages are most affected and noticeable after a stroke. Additionally, conditions that may cause impaired swallowing function in patients include cognitive impairment resulting from post-stroke brain injury, such as attention deficits and facial nerve damage.[9] In summary, CS can result in varying levels of damage to many parts of the human brain. The damage disrupts patients' normal physiological functioning of the mouth and pharynx. Specifically, it can affect vital components such as the mandible, tongue, lips, soft palate tissue, throat, esophageal sphincter, and esophagus. As a consequence, patients can have difficulties and abnormalities when it comes to transporting food from mouth to stomach.

However, the complexity of the neurophysiological mechanism of swallowing and the complexity of the biological and mechanical principles involved make it challenging to establish standardized rehabilitation treatment for dysphagia. The primary concern in dysphagia rehabilitation is identifying an effective treatment for clinicians to treat patients with cerebrovascular accident (CVA) related dysphagia.[10] While mandatory exercise rehabilitation nursing can improve cerebral infarction patients' exercise and balance abilities, it is not the optimal overall treatment plan.[11]

Currently, there are various nondrug treatments for poststroke dysphagia, including behavioral intervention and noninvasive brain stimulation (NIBS), which encompasses transcranial magnetic and direct current stimulation and is an innovative therapeutic approach. Its underlying principles are based on the theories of "inhibition on the healthy side, excitement on the affected side" and the "hemispheric competition model," widely used in treating mental disorders or motor dysfunction after CS. NIBS has proven to be effective, non-invasive, and easy to administer.[12] Existing evidence suggests that NIBS can improve poststroke dysphagia and, to some extent, lower the risk of aspiration.[13] Clinical randomized controlled trials (RCTs) have demonstrated that high-frequency repetitive transcranial magnetic stimulation can significantly enhance patients' swallowing function compared to low-frequency stimulation.[14] Furthermore, a study has indicated that repetitive magnetic stimulation of the vagus nerve can effectively improve the swallowing function of patients after CS.[15]

Numerous alternative therapies, such as acupuncture, mechanical myoelectric stimulation, and NIBS, have been incorporated into both domestic and foreign guidelines for the rehabilitation of dysphagia in patients with CS. However, due to the lack of evidence, nondrug therapies are only recommended measures rather than interventions. Therefore, the purpose of this study was to gather global literature on the adoption of NIBS for the prevention and therapy of dysphagia in CS patients. By conducting a meta-analysis, the effectiveness of NIBS in improving the severity and dysphagia symptoms in CS patients was evaluated to establish a foundation for clinical therapy.

MATERIALS AND METHODOLOGIES

Document Retrieval

The researchers conducted computer-based searches using various databases, including PubMed, Embase, MEDLINE, Science Direct, The Cochrane Library, China National Knowledge Infrastructure (CNKI), Wanfang Database, Chinese science and technology journal databases, and Chinese biomedical literature databases (CBM). The purpose was to retrieve randomized controlled trials (RCTs) or cohort studies published from the inception of each database until December 1, 2022. The aim was to gather information on the use of non-invasive brain stimulation (NIBS) for the prevention and treatment of dysphagia in CS patients.

The search strategy employed was as follows. The English search terms included stroke, transcranial direct current stimulation, transcranial magnetic stimulation, NIBS, dysphagia, cerebral hemorrhage, cerebral infarction, cerebrovascular accident, and swallowing. Chinese search keywords included stroke, transcranial direct current stimulation, transcranial magnetic stimulation, NIBS, cerebral hemorrhage, cerebral infarction, cerebrovascular accident, dysphagia, and swallowing. The search strategies were carefully formulated based on multiple preliminary studies to ensure comprehensive retrieval. To avoid any omissions, professional journals were searched manually. Furthermore, only literature about human subjects was considered in the retrieval process. The search combined subject-specific keywords and free words to conduct multiple searches and obtain relevant references. Search engines were then utilized to locate each article. RevMan5.3 from the Cochrane Collaborative Network was employed to assess the quality of the articles.

Criteria for Inclusion and Exclusion of Literature

Tables 1 and 2 outline this study's inclusion and exclusion criteria to select relevant literature. A more detailed explanation of the criteria used for study inclusion and exclusion follows.

Table 1. Inclusion Criteria of Literature

No.	Criteria
1	Subjects were all dysphagia patients after CS.
2	Studies applied NIBS, such as transcranial direct current stimulation (tDCS) and repetitive transcranial magnetic stimulation (rTMS) as intervention methods.
3	Studies were considered if they had a control group that underwent a sham operation.
4	Only randomized controlled trials were included.
5	Studies were eligible if they reported efficacy or safety endpoints, such as comparing severity and dysphagia scores.
6	All patients had signed relevant informed consent documents and provided complete clinical data.

Table 2. Exclusion Criteria for References

No.	Criteria
1	In conjunction with other therapeutic interventions
2	Such as self-controlled, cohort studies, case-control studies, cross-sectional studies, and other non-RCTs
3	It involved people with severe aphasia or cognitive impairment.
4	Studies with incomparable baselines or those not reporting baseline information were excluded.
5	If outcome data extraction was not possible or the full text could not be obtained after contacting the author, the study was excluded.
6	Studies with poor design or incorrect statistical methods were excluded.
7	Studies lacking well-defined diagnostic criteria and intervention duration were not included.
8	Excluded were case reports, protocols, conference abstracts, animal experiments, and reviews

Data Collection

Two professionals utilized a Microsoft Excel spreadsheet (Microsoft, USA) to screen the literature, extract data, and carefully examine the inclusion and exclusion criteria, cross-checking their findings to ensure accuracy. Discrepancies were resolved through discussion. The extracted data included basic information (title, first author, publication date, country, journal name, and literature source, general characteristics of the subject (age, sample size of both the test and control groups), duration of intervention, therapeutic effects and critical elements of bias risk assessment (randomization method, blinding, allocation concealment). Additionally, outcome measures and measures of interest were also documented.

Literature Evaluation Standard

The Cochrane Collaborative Network's criteria for assessing the risk of bias were applied to the randomized controlled trials. These criteria included the following components:

1) Random Allocation Method
   a) "Correct" If the study employed computer-generated random sequences, random number tables, coin toss, dice, or number shaking.
   b) "Incorrect" If a method that did not meet the "Correct" criteria was employed.
   c) "Unclear" When there was insufficient information to determine the randomization method.
2) Allocation Concealment
   a) "Yes" (Perfect) If the study employed central conceal methods, such as sealed envelopes monitored by phone, network, or pharmacy.
   b) "No" (Imperfect) If the allocation concealment did not meet the "Perfect" criteria.
   c) "Unclear" When there was insufficient information to determine whether allocation concealment was implemented.
3) Blinding
   a) "Yes" (Correct) If patients, doctors, or individuals responsible for outcome measurement or statistical analysis were appropriately blinded, or if blinding did not affect the measurement of outcome indicators or introduce bias.
   b) "No" (Incorrect) If the blinding method was not implemented or if it was easily compromised, and could result in outcome measurement bias.
   c) "Unclear" When there was insufficient information to determine the adequacy of blinding.
4) Completeness of Result Data (Determining whether result data was complete involved assessing if there were any issues with missing data or if the authenticity of outcome measures was compromised.)
   a) "Yes" If no issues or missing data did not affect the measurement of result indicators or introduce bias.
   b) "No" If there were significant issues with missing data or if the authenticity of outcome measures was compromised, affecting the prediction of outcome measures.
   c) "Unclear" In cases with insufficient information to support the judgment.
5) Selectivity in Reporting Results (The researchers examined whether the study reported all pre-designed measures).
   a) "Yes" All measures were reported.
   b) "No" (Partial Reporting) If not all pre-designed measures were reported
   c) "Unclear" When there was insufficient information to determine the extent of result reporting.
6) Other Sources of Bias
   a) "Yes" (Absent) If there were no other sources of bias.
   b) "No" (Present) If other sources of bias were identified.
   c) "Unclear" When the presence or absence of other sources of bias could not be definitively determined.

For each of these criteria, the assessments were categorized as "low risk," "high risk," or "unclear risk." The specific quality of research evidence was then graded from A (strong) to C (weak) based on the overall assessment of these components. Determining whether the resulting data was complete involved assessing any issues with missing data or if the authenticity of outcome measures was compromised.

Statistical Methods

RevMan5.3 and Stata were utilized for the study. The mean difference (MD) was used as an effect measure for the continuous variable. Each effect metric was presented with point estimates and 95% confidence intervals. Heterogeneity among the results was assessed using a χ^2 test level at a significance level of a=0.1 and quantified by I^2. If $P \geq 0$ and $I^2 \leq 50\%$, then no marked heterogeneity was suggested between the studies, and the fixed-effect model (FEM) was adopted. If $P < .05$ and $I^2>50\%$, it indicated considerable heterogeneity between studies. In such cases, random effects models were used, and subgroup analyses were conducted to find possible sources of heterogeneity. The significance level for the meta-analysis test level was $\alpha=0.05$. A forest map and summary receiver operating characteristic (SROC) curves, and an asymmetric linear regression funnel plot were drawn. The

Table 3. Basic Information Data Included in the Literature

Author	Year	Duration (h/d/w/m)		Case		Age	
		Experimental	Control	Experimental	Control	Experimental	Control
Kumar[16]	2011	80.29 ± 39.17 (h)	96.71 ± 42.52 (h)	7	7	79.71±9.45	70.00±11.07
Lim[17]	2014	30.30 ± 14.80 (d)	34.40 ± 10.10 (d)	14	15	59.80±11.80	62.50±8.20
Park[18]	2013	59.90 ± 16.30 (d)	63.90 ± 26.80 (d)	9	9	73.70±3.80	68.90±9.30
Pingue[19]	2018	2 (m)	2 (m)	8	12	64.53±18.54	67.77±9.22
Shigematsu[20]	2013	12.90 ± 7.80 (w)	12.10±9.00 (w)	10	10	66.90 ± 6.30	64.70±8.90
Suntrup[21]	2018	116.3 ± 98.9 (h)	116.8 ± 64.9 (h)	29	30	68.9 ± 11.5	67.2 ± 14.5
Ünlüer[22]	2019	105.93 ± 49.02 (d)	101.38 ± 42.06 (d)	15	13	67.80±11.88	69.31±12.89
Wang[23]	2020	66.79 ± 38.62 (d)	67.50 ± 47.62 (d)	14	14	61.43 ± 11.24	62.00 ± 10.46
Yang[24]	2012	25.2 ± 11.5 (d)	26.9 ± 7.8 (d)	9	7	70.44 ± 12.59	70.57 ± 8.46

Figure 1. Flow Chart of Literature Retrieval

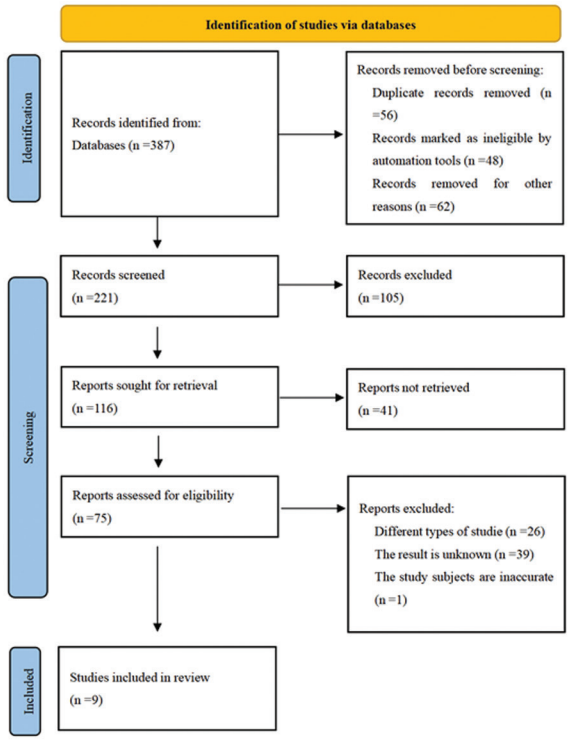
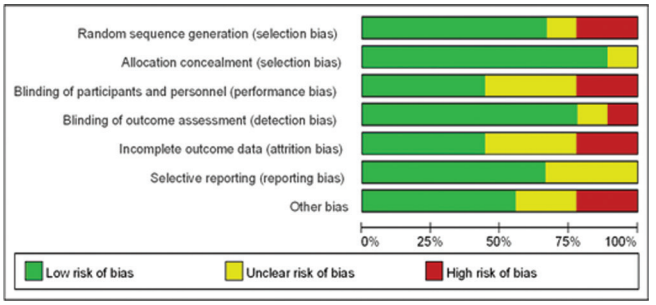


Figure 2. Reference Risk Bias Assessment Map Generated by RevMan5.3, Judgments About Each Risk of Bias Item Presented Across All Included Trials



funnel plots of the various treatment indexes were plotted to test the potential publication bias and analyze it.

RESULTS

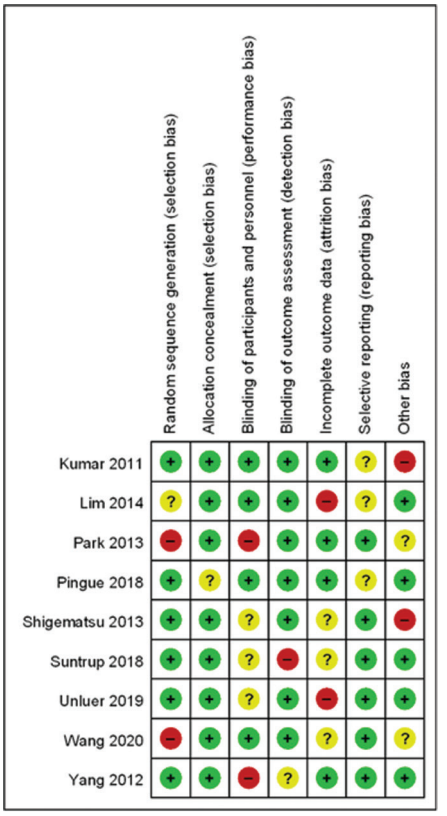
Search Results and Basic Information

A total of 387 articles were harvested by database retrieval. Initially, 56 duplicate articles were removed, followed by the exclusion of 48 articles with nonconformities and 62 articles for other reasons. The remaining 221 articles were preliminarily selected. After reading the abstracts and topics, 105 articles were further excluded. The remaining articles numbered 116. Forty-one research reports and review articles were excluded, resulting in a final selection of 75 articles. Then, the full texts of all these remaining articles were read; 26 articles with incorrect research types were excluded. Additionally, 39 articles were excluded due to incomplete or unavailable required treatment results. One article that did not target human subjects was excluded. Eventually, nine articles were finally included.[16-24] Figure 1 visually represents the document retrieval process.

The sample size ranged from 14 to 59 in the nine articles included (Table 3). All nine articles focused on the prevention and treatment of dysphagia in CS patients using NIBS. These articles documented the changes in patients before and after receiving treatment.

The quality evaluation of the nine articles included in the study was carried out. The results indicated that four articles (44.4%) were rated as A, four articles (44.4%) were rated as B, and one article (11.1%) was rated as C. Figures 2 and 3 depict the evaluation plots for bias in the references as well as a summary map illustrating the risk bias in the references.

Figure 3. Risk of Bias Summary: Judgments About Each Risk of Bias Item for Each Included Trial by Revman5.3.Note: "+" Low Risk, "-" High Risk, and "?" Unclear



Heterogeneity Evaluation Results

The researchers evaluated the variability in treatment effectiveness across the studies. They found no variation in the use of NIBS for the severity score of dysphagia prevention and treatment in CS patients ($I^2 = 0.00\%$). Similarly, there was no variation in the use of NIBS for poststroke dysphagia (PSD) scoring in patients across the studies ($I^2 = 0.00\%$). However, when it came to the functional dysphagia score for dysphagia prevention in CS patients, there was a high level of variation between the studies ($I^2 = 93.00\%$). To confirm the differences in treatment indicators and assess the heterogeneity of NIBS data for dysphagia prevention and treatment in CS patients, a REM analysis was conducted along with a funnel plot to evaluate the overall fit.

Meta-analysis of Severity

When considering the clinical outcome indicator, MD (shown in Figure 4), the scores for MD about the application of NIBS for preventing and treating dysphagia severity in CS patients were found to be 1.05, with a 95% CI (0.48, 1.61) $P = .46$, and $I^2 = 0.00\%$. The MD values indicated no significant variations between the studies and no heterogeneity in severe cases. The lowest MD was 0.26, with a 95% CI (-1.35, 1.87), and the highest MD was 1.34, with a 95% CI (0.55, 2.13).

The posttreatment severity scores were comprehensively analyzed to assess the effect of treatment. Figure 5 is a heterogeneity test chart of the severity scores, which set the heterogeneity among the studies and the potential abnormal values. The heterogeneity difference among the studies was minimal and highly accurate. Figure 6 presents the funnel plot of the severity score, indicating no bias in any studies and a low risk of bias. Based on these results, it can be concluded that NIBS effectively alleviated dysphagia severity in patients with CS.

Meta-analysis of Dysphagia After CS

Using the MD as the clinical outcome index (Figure 7), the four articles examined the impact of NIBS on the PSD score of patients. The MD value was 1.05, with a 95% CI (0.49, 1.61), $P = .89$, and $I^2 = 0.00\%$. The MD values showed no significant differences or heterogeneity in PSD scores across the studies. The lowest MD recorded was 0.49, with a 95% CI (-1.38, 2.36), while the highest MD was 1.18, with a 95% CI (-0.73, 3.09).

A comprehensive analysis of the PSD score was conducted to assess the effectiveness of treatment. Figure 8 illustrates a test chart of the heterogeneity of the PSD score, which showed no significant heterogeneity difference among the studies when evaluating heterogeneity and potential abnormal values. Figure 9 presents the funnel plot of the dysphagia score after CS. The risks of bias in the various studies were minimal, indicating no study bias. Based on these findings, NIBS provided relief for dysphagia in patients with CS.

Meta-analysis of Functional Dysphagia

Using MD as the clinical outcome index (Figure 10), four studies were analyzed regarding the application of NIBS

Figure 4. Forest Plots of Severity Scores

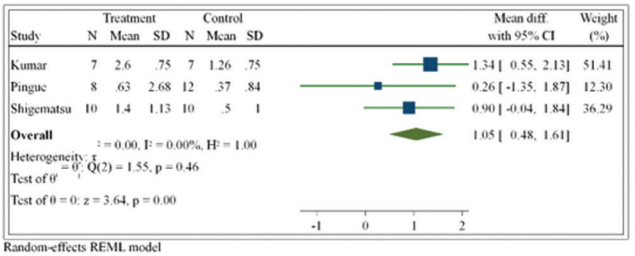


Figure 5. Galbraith Heterogeneity Test for Severity Scores

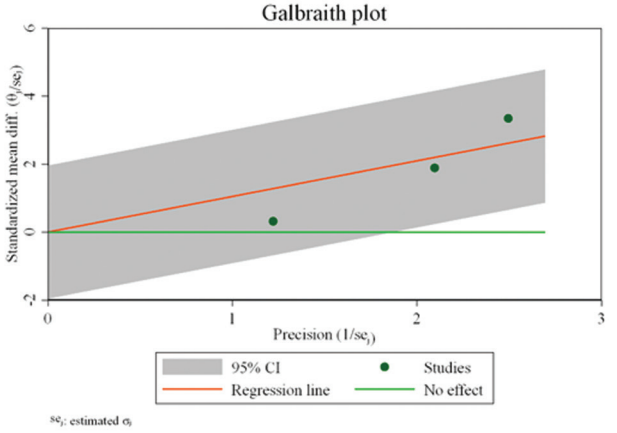


Figure 6. Funnel Plot of Severity Score

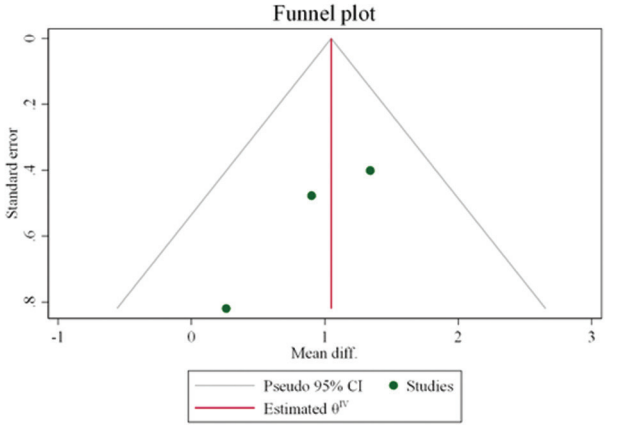


Figure 7. Forest Plot of Dysphagia Score After CS

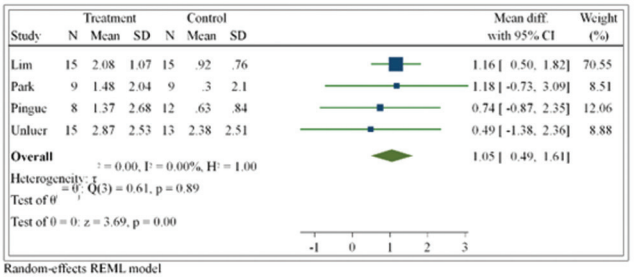


Figure 8. Galbraith Heterogeneity Test Diagram of Dysphagia Score After CS

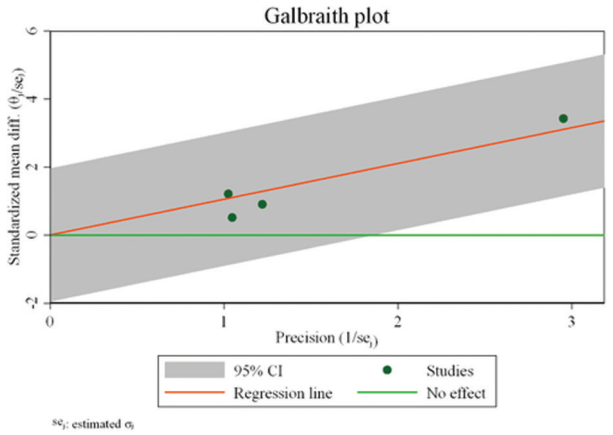


Figure 9. Funnel Plot of Dysphagia Score After CS

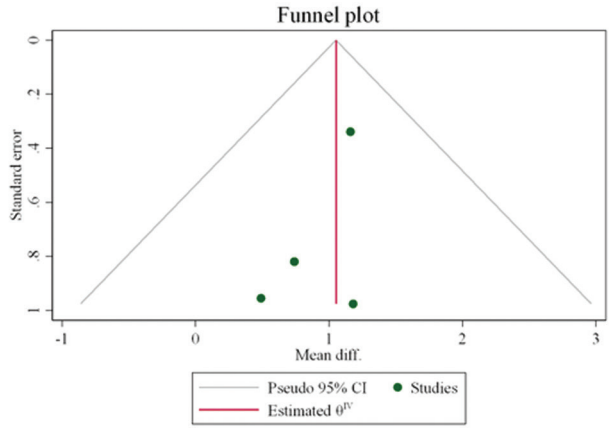
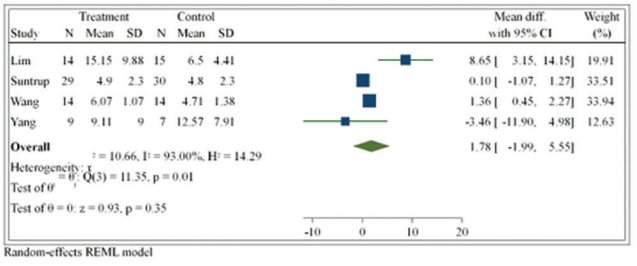


Figure 10. Forest Map of Functional Dysphagia Scores



for the treatment and prevention of dysphagia CS patients. The MD for the functional dysphagia score was -1.78, with a 95% CI (-1.99, 5.55), P=0.01, and I^2=93.00%. The MD values indicated significant differences and high heterogeneity in functional dysphagia scores across the studies. The lowest MD was -3.46, with a 95% CI (-11.90, 4.98), while the highest MD was 8.65, with a 95% CI (3.15, 14.15).

A comprehensive analysis was conducted on the functional dysphagia score after treatment to assess the effect of treatment. Figure 11 shows the heterogeneity test diagram for the available dysphagia score across the studies. A

Figure 11. Galbraith Heterogeneity Test Diagram of the Functional Dysphagia Score

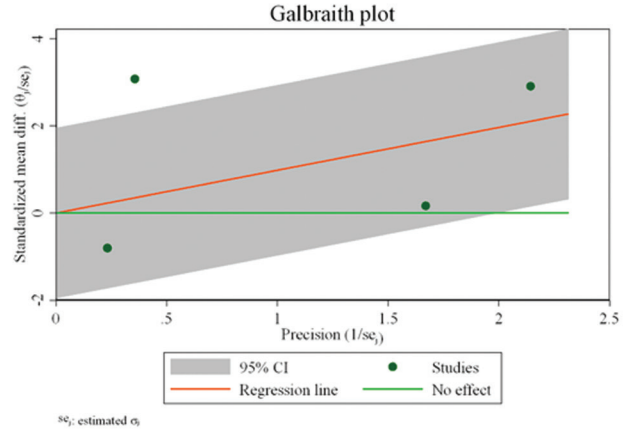
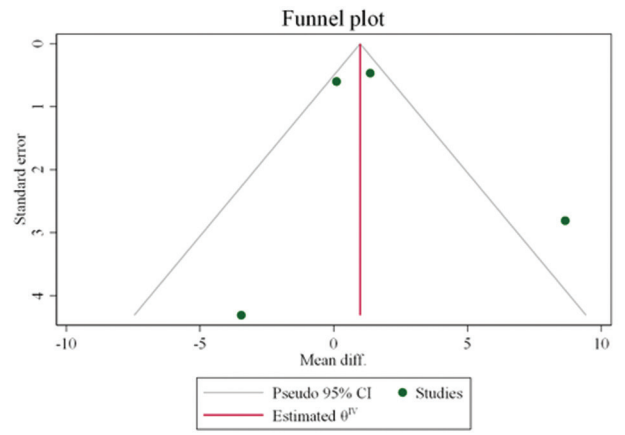


Figure 12. Funnel Plot of Functional Dysphagia Score



random-effects model was used to evaluate the studies' heterogeneity and potential abnormal values. Figure 12 shows the funnel plot of the functional dysphagia score, indicating minimal risk of bias in all studies except for one that deviated. Based on these findings, NIBS shows promise in alleviating functional dysphagia in CS patients.

Reliability Analysis

The sensitivity analysis was conducted by changing the analysis models. Meta-analysis indicated no significant alteration in the findings when different analysis models were used, indicating that the included articles were stable. Model analysis, including funnel asymmetric linear regression analysis, also demonstrated consistent and reliable verification.

DISCUSSION

Stroke is a widespread disease that affects people worldwide, causing death and severe disabilities. It is often accompanied by various complications, leading to extended hospital stays and expensive medical treatments.[25] Post-stroke dysphagia is a common functional disorder that can manifest as the first symptom or occur several days after a

stroke. Patients with PSD experience clinical symptoms such as excessive salivation, coughing, difficulty in eating, asphyxia, and recurrent fever. These symptoms increase the risk of dehydration, pneumonia, malnutrition, and other complications. Swallowing difficulties have emerged as a significant factor contributing to the mortality and disability rate among stroke patients in middle- and late-stage stroke.[26] While most patients with CS dysphagia recover on their own, 11-50% of patients still experience dysphagia six months after CS. Swallowing difficulties can have a profound impact on patients and their families. Therefore, it is imperative to expedite the process of swallowing rehabilitation and address the swallowing issues in PSD patients as soon as possible.[27,28]

Based on an analysis that examined different types of stimuli studied, it was determined that both rTMS and tDCS show effectiveness, with rTMS demonstrating better therapeutic outcomes. At present, the primary focus of clinical treatment guidelines for patients with dysphagia is to prevent complications through compensatory strategies or postural adjustments.[29] Several studies have suggested that individuals with PSD may achieve swallowing recovery by compensatory recombination of swallowing function in the uninjured hemisphere rather than by compensatory recombination of the injured hemisphere function.[30] Some researchers have used this model as a theoretical basis for designing their research plans.[31]

Transcranial magnetic stimulation as a routine diagnostic technique has been widely used in neurophysiological research. RTMS, a form of repetitive transcranial magnetic stimulation, is a safe and noninvasive treatment technique. A sizeable current pulse generator is employed to release a current that is thousands of amperes greater than the current flowing through the coil. As a result, it produces short magnetic pulses of a few terawatts in strength. Depending on the frequency of stimulation, RTMS can alter cortical excitability, either increasing it with high frequencies (≥1 Hz) or decreasing it with low frequencies (≤1 Hz). When using rTMS to treat patients with PSD, the optimal site for stimulation (healthy, affected, or bilateral) has not yet been determined. In terms of safety, severe adverse reactions caused by rTMS, such as epileptic seizures, have a frequency below 0.1%.[32-34] While nerve damage may slightly increase the risk of rTMS-induced seizures, none of the subjects in this meta-analysis reported experiencing seizures.

In contrast, tDCS, another form of NIBS, utilizes two electrodes and its own power supply battery devices, along with control software to regulate the output of stimulus.[35] It is noninvasive and utilizes constant and low-intensity direct current to affect neuron activity in the cerebral cortex. Unlike rTMS, tDCS only affects active neurons and does not release dormant neurons.[36] By intervening in the brain over a long period, TDCS enhances cerebral blood flow and local cortical metabolism, reorganizing the brain's functional network.[37] Although both tDCS and rTMS use electrical current to stimulate specific nerve sites, tDCS only reaches a depth of approximately 1 cm, whereas rTMS can penetrate 6 cm. H-coils can stimulate the deep nuclei of the brain. In a systematic review and meta-analysis of NIBS, the treatment group showed significant improvement in the severity of dysphagia compared to the sham stimulation group. Nevertheless, when discussing specific treatments, only the rTMS group demonstrated notable improvement over the sham stimulation group. The tDCS group showed no significant improvement compared to the pseudostimulus group.[38]

This study rigorously evaluated the effectiveness of NIBS in patients with CS. By utilizing a comprehensive meta-analysis approach, the researchers examined the impact of NIBS on the severity and dysphagia in CS patients. The results were compelling.

The intervention of NIBS in preventing and treating dysphagia in stroke patients yielded a significant reduction in severity, as indicated by an MD score of 1.05. Moreover, the MD of the dysphagia score was also 1.05, while the MD score for functional dysphagia score was 1.78. These findings highlight the potential of NIBS to relieve dysphagia in CS patients.

These findings hold substantial clinical significance. The minimal heterogeneity among the studies and the concentration of research data strengthen the reliability of these results, providing valuable insights for healthcare practitioners. It suggests that NIBS holds promise as an approach to improve dysphagia outcomes and decrease the incidence of aspiration in CS patients.

In summary, this meta-analysis provides evidence-based recommendations for clinical practice, offering a new avenue for managing dysphagia in CS patients. Future studies will further explore the field, expanding the collection of additional indicators and conducting detailed comparisons of various interventions to contribute to a more robust theoretical framework for clinical treatment.

CONCLUSION

This study demonstrates that non-invasive brain stimulation significantly impacts the severity score, PSD score, and functional dysphagia score in patients after a CS. This suggests that NIBS is an effective intervention for improving dysphagia outcomes and reducing the risk of aspiration in this population. It is worth noting that the slight variations between the studies and the focused research data strengthen the reliability of the study's results, underlining their practical significance.

Future research endeavors will collect a broader range of indicators and conduct more detailed comparisons of various interventions. These efforts will further contribute to developing a solid theoretical foundation for clinical therapy. In the meantime, this study's findings provide valuable insights for clinicians seeking evidence-based strategies to enhance the management of dysphagia in patients following a stroke.

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