



# THE EFFECTIVENESS OF TRANSCRANIAL MAGNETIC STIMULATION IN POST STROKE DYSPHAGIA, A CASE REPORT

Suska Lara Ginting<sup>1</sup>, Yetty Hambarsari<sup>2</sup>, Rivan Danuaji<sup>2</sup>, Baarid Luqman Hamidi<sup>2</sup>

Correspondence: [suskalaraginting@gmail.com](mailto:suskalaraginting@gmail.com)

<sup>1</sup>H Adam Malik General Hospital Medan

<sup>2</sup>Departement of Neurology, Faculty of Medicine, Universitas Sebelas Maret

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## ABSTRACT

**Background:** A 72-year-old male, experiencing dysphagia and left-sided weakness for six months post-stroke, encountered challenges such as coughing and choking during the consumption of liquids and soft foods, along with a prolonged meal-swallowing process. Bilateral thrombotic infarction and left lateralization were revealed through Magnetic Resonance Imaging (MRI).

**Case:** The Gugging Swallowing Screening Scale (GUSS) assessment demonstrated severe impairment with a total score of 7, persisting despite conventional physiotherapy attempts to improve swallowing function. Subsequently, repetitive transcranial magnetic stimulation (rTMS) was implemented, involving high-intensity stimulation in the ipsilesional hemisphere and low-intensity stimulation in the contralesional hemisphere. Remarkably, one month post-rTMS, the patient displayed significant progress, evidenced by an improved GUSS score of 15, indicating enhanced swallowing function.

**Discussion:** This case emphasizes the positive impact of bilateral rTMS hemispheric stimulation on post-stroke dysphagia. The strategic application of high-intensity ipsilesional and low-intensity contralesional stimulation emerged as an effective intervention for alleviating swallowing difficulties. These findings highlight the potential of rTMS as an innovative therapeutic approach for persistent dysphagia following a stroke.

**Keywords:** dysphagia, post-stroke, stimulation, TMS, transcranial magnetic stimulation



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## Introduction

Stroke is a cerebrovascular disease that often occurs with an incidence of one in four people suffering from a stroke during their lifetime. Stroke is also the second highest cause of death worldwide and the leading cause of disability in adults. Stroke is defined as an episode of neurological deficit caused by acute focal damage to the central nervous system (CNS), which may occur in the brain, retina, or spinal cord, due to vascular causes.<sup>1</sup>

Dysphagia comes from the Greek "phagein" which means to eat. Dysphagia is a disturbance in the swallowing process during bolus transportation from the oral cavity to the stomach. The swallowing process is divided into four stages, namely pre-oral, oral, pharyngeal and esophageal stages. Dysphagia can be classified into 4 types, namely oropharyngeal dysphagia, esophageal dysphagia, complex neuromuscular disorder dysphagia and functional

dysphagia.<sup>2</sup> Dysphagia is the most common complication of stroke, with a reported incidence of between 37% - 78%. Dysphagia is a complication of acute stroke that the symptoms can improve within the first few weeks of a stroke, but more than 50% of patients experience is persistent. Post-stroke dysphagia is associated with malnutrition, dehydration, aspiration pneumonia, prolonged hospital stay, and increased mortality. In stroke sufferers accompanied by dysphagia, the risk of aspiration pneumonia is three times higher and the mortality rate is 5.4 times higher than stroke without dysphagia. It is important to identify, diagnose early and treat appropriately these cases of dysphagia to improve functional status, quality of life, reduce morbidity and mortality in stroke patients.<sup>3,4</sup>

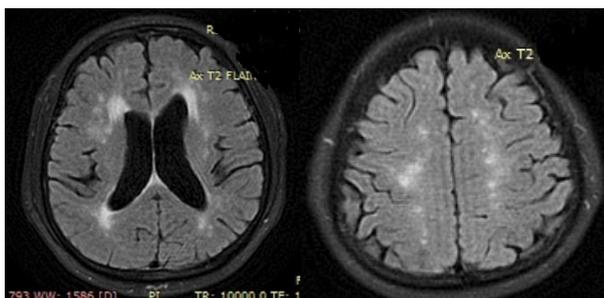
Studies show that the primary causes of post-stroke dysphagia include cortical or brainstem lesions, and peripheral causes include damage to the nerves or muscles involved in swallowing. Brainstem lesions are more

frequently associated with dysphagia. Treatment options for post-stroke dysphagia include behavioral therapy, oral care, pharmacology, neurostimulation, and dietary intervention. A variety of physical therapies and preventative measures can avoid dysphagia-related complication.<sup>5</sup>

Repetitive transcranial magnetic stimulation is a non-invasive neuromodulation technique that can be used to treat post-stroke dysphagia. In general, according to the frequency rTMS can be divided into two treatment protocols, low frequency ( $\leq 1$  Hz) and high frequency ( $> 1$  Hz), low frequency inhibits cortical excitability, while high frequency activates cortical excitability. Many studies showed that rTMS were beneficial for overall dysphagia function, reducing the incidence of aspiration and improving the quality of life of post-stroke dysphagia patients. rTMS stimulation was found to be safe and no serious adverse effects were reported.<sup>6</sup>

## Case Report

72 years old male patient experienced difficulty in swallowing and sudden weakness on the left side of his body since 6 months ago. He coughed and choked when drinking water and ate foods with a liquid and soft consistency. The process of swallowing food took a long time and spilled from the corners of the mouth. So far, the patient has had a history of diabetes mellitus (DM) and hypertension controlled with medication. The patient underwent a Magnetic Resonance Imaging (MRI) examination with the impression of white matter infarction, bilateral periventricular (Figure 1). From the general examination, the Glasgow Coma Scale (GCS) level of consciousness was 15, fully conscious, cognitive function was within normal limits. There was facial and hypoglossus nerves weakness as well as motor weakness on both sides of the body with the impression of left lateralization. Swallowing function was assessed using GUSS with an indirect swallowing test score of 5 and a direct swallowing test of 3, the total GUSS score was 7 (normal score 20).<sup>10</sup>



**Figure 1.** Brain Magnetic Resonance Imaging

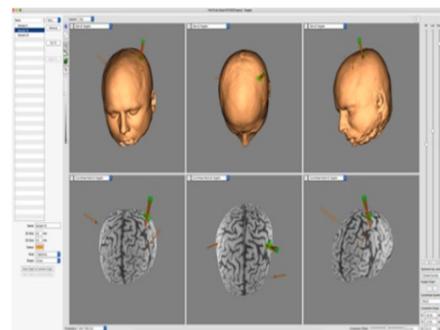
The MRI image was compatible with small vessel ischemic in white matter bilateral and bilateral lateral periventricular.

The patient was advised to have a nasogastric tube (NGT) installed but the patient refused. In the past six months, the patient routinely underwent conservative motor physiotherapy exercises and swallowing physiotherapy, his motor strength improved but not his swallowing function, so it was recommended that rTMS intracranial stimulation be carried out as additional therapy for his swallowing function, without abandoning conservative physiotherapy. Carrying

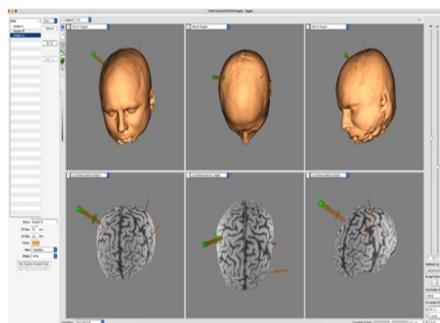
out single stimulation, the resting motor threshold at the stimulator output was 60%. rTMS therapy was carried out with figure-eight coil stimulation 90% resting motor threshold left hemisphere 1 Hz, 600 pulses/train at coordinates x -58.88, y -27.68 and z 28.23 according to the swallowing motor cortex or between C3/ T3 corresponds to 10-20 International system of electroencephalography electrode placement (Figure 2) and right hemisphere 10 Hz, 120 pulses/train, with a total of 1200 pulses, stimulation location at coordinates x 65.78, y -32.95 and z 18.80 or between C4/T4 (Figure 3). The stimulus was carried out in 5 sessions every day for 1 week for 20 minutes. One month after rTMS stimulation, the GUSS assessment was carried out again, an increase in the score was obtained, the indirect swallowing test score was 5 and the direct swallowing test was 10 with a total score of 15 (normal total score 20). The rTMS stimulation was repeated with the same protocol in addition to swallowing physiotherapy to obtain maximum results in improving swallowing function.

## Discussion

This patient has complaints of coughing when swallowing food, especially with a soft or liquid consistency. The time needed to swallow food is longer than usual, this has been experienced by patients since being diagnosed with ischemic stroke based on MRI. Dysphagia is a swallowing dysfunction that interferes with the optimal passage of fluids and/or food from the mouth to the stomach. Dysphagia can manifest in a series of signs and symptoms, such as food, liquid, or pills getting stuck in the throat, coughing or choking when eating or drinking, feeling such as a lump in the throat, feeling the sensation of food stuck behind the sternum, wet sounds, regurgitation, food or stomach acid that feels like it is rising into the throat, unexplained weight loss, and the occurrence of pneumonia aspiration.<sup>2,7</sup>



**Figure 2.** Location of Stimulation rTMS in the Left Hemisphere



**Figure 3.** Location of Stimulation rTMS in the Right Hemisphere

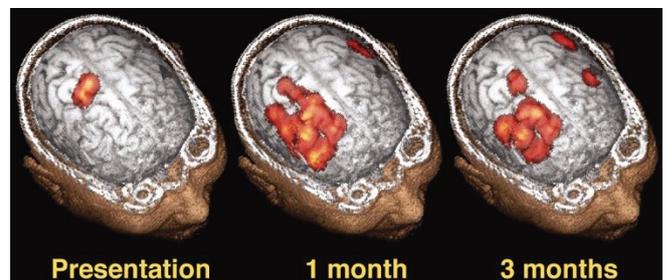
Previous studies have shown a significant relationship between diabetes mellitus (DM) and hypertension and dysphagia in ischemic stroke patients. This is due to the neuropathic element of DM which increases the incidence and severity of stroke, in addition to the effects of chronic diseases such as DM and hypertension affecting the patient's overall function, thereby increasing the risk of dysphagia. Age is also an important factor that influences the incidence of post-stroke dysphagia. The higher the age, the risk of dysphagia in stroke patients is also reported to increase. This is related to the gradual weakness of various body functions that occur with increasing age, including the maxillomandibular system (chewing, swallowing, breathing and vocal function) which can cause dysphagia. In addition, the possibility of degenerative processes in cranial nerve function and swallowing reflex function also increases in old age. Weakness of the transport capacity of the tongue muscles and atrophy of the tongue muscles in older patients causes the process to soften and the food bolus transport time to become longer in the swallowing process.<sup>8,9</sup>

The GUSS score in this patient before stimulation was 7 and it was recommended to install a nasogastric tube for food and drink entry, but the patient refused and 1 month of control after the rTMS stimulation procedure, the GUSS score was improved with a total score of 15 (from normal total score 20). The GUSS scale is a dysphagia assessment tool in acute stroke, it is easy, fast and non-invasive to apply and consists of direct and indirect examinations. Most post-stroke dysphagia involve difficulty swallowing food, especially liquid consistency. GUSS assesses swallowing function in 3 types of food consistency liquid, soft and solid. The study found that GUSS was accurately and validly used to identify dysphagia and the risk of aspiration in stroke patients with a sensitivity of between 77 - 90% and a specificity of 67.5% - 89%. The GUSS scale sensitively evaluates the oropharyngeal phase and is accompanied by recommendations for modifying the patient's diet to minimize the risk of aspiration. A total score of <9 (out of a total score of 20) indicates severe dysphagia with a high risk of aspiration, 10-14 moderate dysphagia and a moderate risk of aspiration, 15-19 mild dysphagia with a small risk of aspiration and a score of 20 indicates no/slight dysphagia with a minimal risk of aspiration. In this patient, there was an improvement in the degree of dysphagia based on the GUSS scale from a total score of 7 (severe degree with high risk of aspiration) to 15 (mild dysphagia with minimal risk of aspiration). The patient's diet recommendation after stimulation is a soft food dysphagia diet and slow consumption of liquid drinks.<sup>10,11</sup>

Pathological processes that cause dysphagia can peripheral or central disorders (corticobulbar tract) cause disorders of the cranial nerves that innervate the swallowing muscles, limited tongue movement, paralysis of the soft palate. As a result, intraoral and pharyngeal pressure cannot be fully increased, the movement of food from the oral cavity to the pharynx and esophagus is weak, and the transit time is significantly prolonged. Retention causes hyperreflexia or spasm of the sphincter and cricopharyngeal muscles at the esophageal inlet of patients with supraglomerular lesions (pseudobulbar palsy) and uncoordinated swallowing muscle movements, resulting in inadvertent ingestion of food into

trachea leading to aspiration. There is clinical evidence that TMS can induce changes in the excitability of the cerebral cortex that cause accelerated neural plasticity, control neurotransmitter release and improve dysphagia by regulating neuroplasticity.<sup>12</sup>

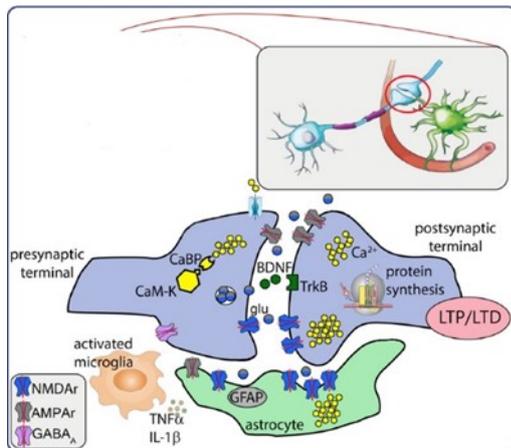
High frequency of the brain TMS is an alternative method of treating dysphagia through modulating neuroplasticity. A strong current is applied through a TMS coil placed on the scalp, creating a magnetic field that penetrates the skull to a depth of approximately 1.5–2 cm and induces a strong electric field to depolarize surface axons and activate the cortical network. The electromyographic response or motor contraction of the target muscle that arises is called a motor-evoked potential. High frequency stimuli ( $\geq 1$  Hz) increase cortical excitability, whereas low frequencies are inhibitory, suppressing cortical excitability. The recovery process of post-stroke dysphagia is associated with an increase in cortical representation for functional swallowing in the healthy hemisphere. The hemisphere on the side of the lesion innervates projection neurons to the brainstem that control the motor function of the swallowing muscles of dysphagia patients. TMS stimulation in post-stroke dysphagia sufferers aims to modulate the cortical reorganization. TMS follow-up data at one and three months indicated that subjects who recovered swallowing function had significantly greater pharyngeal representation in the unaffected hemisphere as compared to baseline. These findings suggest that re-organization in the contralesional hemisphere is key in swallowing recovery, as illustrated in (Figure 4).<sup>12,13</sup>



**Figure 4.** Expansion of pharyngeal motor cortex on unlesioned hemisphere during swallowing recovery after stroke. Magnetic resonance image with co-registered topographic data from transcranial magnetic stimulation at baseline, one month, and three months after enrolment<sup>(13)</sup>

rTMS stimulation can induce changes in synaptic plasticity such as long-term potentiation (LTP) or long-term depression (LTD) that increase or decrease synaptic strength. The mechanism is thought to be N-methyl-D-aspartate (NMDA) receptor mediated. Transcranial stimulation induces an increase in the intracellular  $Ca^{2+}$  ions and activation of presynaptic  $Ca^{2+}$  dependent enzymes (CaMK). This mechanism results in the release of glutamate and activates AMPA / NMDA receptors, modulates the release of Brain-derived Neurotrophic Factor (BDNF) and interactions with receptor tyrosine kinase B (TrKB) which is related to the process of intracellular protein synthesis. Apart from that, this stimulation can also modulate astrocyte activation and neuroinflammatory responses which together are related to the LTP/LTD process. Long-term potentiation

and LTD as an after effect of transcranial stimulation and are associated with clinical improvements in swallowing function in dysphagia patients (Figure 5).<sup>12,14</sup>



**Figure 5.** Neurobiological After Effects Scheme Transcranial Electrical Stimulation<sup>(14)</sup>

According to Zhong, 2021 rTMS stimulation of 3 Hz and 10 Hz in the motor cortex representing the ipsilateral esophageal cortex or mylohyoid cortex, as well as 1 Hz and 5 Hz stimulation in the contralateral showed improvements in swallowing function compared with sham stimulation. rTMS stimulation in the mylohyoid cortical area of the ipsilesional, contralesional and cerebellar hemispheres is useful in improving swallowing function in patients with post-stroke dysphagia. Coil placement approximately 2-4 cm anterior and 4-6 cm lateral to the vertex is the location of the mylohyoid cortex, and 4.3 cm lateral and 2.4 cm below the vertex is the location of the representation of the mylohyoid cortex in the cerebellum.<sup>15</sup>

Stroke causes an imbalance of activity between the two hemispheres due to increased transcallosal inhibition. Stroke causes a decrease in neuronal activity on the side of the lesion and also an abnormal increase in the excitability of the contralesional hemisphere inhibiting the ipsilesional hemisphere. rTMS stimulation plays a role in restoring the balance between these hemispheres. High-intensity stimulation increases neuronal excitability and neuroplasticity. This cortical excitability increases stimulation to motor neurons of the corticobulbar and corticospinal tracts, subsequently improving the synaptic innervation of mylohyoid muscle projections which is associated with improved swallowing function. This study shows that rTMS stimulation in “hot spots” in both hemispheres is more effective than unilateral stimulation in patients with acute and chronic onset dysphagia.<sup>6,15</sup>

In this patient, bilateral rTMS stimulation was performed with a low frequency of 1 Hz in the left hemisphere (contralesion) and a high frequency of 10 Hz in the right hemisphere (ipsilesion), with 90% resting motor threshold, total pulse 1200, 5 sessions in 1 week for 20 minutes. In the lesioned hemisphere there is a decrease in excitatory activity while in the contralesional hemisphere there is an excessive inhibitory response to the ipsilesional hemisphere which causes various functional disorders. Low frequency stimulation in the contralesional hemisphere

provides an LTD effect and high frequency stimulation in the ipsilesional hemisphere has an LTP effect, so that balance is achieved between the two hemispheres again. The LTP effect of high frequency stimulation in the ipsilesional hemisphere brings unbalanced cortical excitability back into balance, leading to improved swallowing function.<sup>6</sup>

Assessment of swallowing function 1 month after stimulation showed an increase in the total GUSS value but had not yet reached the normal value which indicates optimal swallowing function. According to a study by Liu et al, in 2022 there are several prognostic factors that can influence the cure rate for post-stroke dysphagia, including stroke severity, dysphagia severity, age, malnutrition, interventions carried out at an early or late stage, bilateral hemisphere lesions, brain stem lesions. Severe stroke severity and bilateral hemisphere lesions as seen in this patient are associated with a poor prognosis and minimal response to therapy. More extensive and bilateral lesions are associated with more severe dysphagia symptoms, possibly involving bilateral brainstem-cortical tracts and primary motor cortex function for swallowing is more impaired in more extensive lesions. Age over 70 years has been found to be significantly associated with a poor prognosis in post-stroke dysphagia because muscle volume (sarcopenia) and the ability of facial and pharyngeal muscle contractility have decreased, nerve and musculoskeletal regeneration decreases with increasing age. The state of malnutrition caused by a lack of nutritional intake in dysphagia can be related to a decrease in cell repair ability. Malnutrition is also said to be associated with an increased incidence of pneumonia in post-stroke dysphagia.<sup>16</sup>

## Conclusion

Dysphagia is a disturbance in the swallowing process during bolus transportation from the oral cavity to the stomach. Dysphagia is a frequent post-stroke complication and is associated with malnutrition, dehydration, aspiration pneumonia, prolonged length of stay in hospital, and increased mortality rates in stroke sufferers. Dysphagia needs to be identified and get appropriate and fast treatment.

Besides conservative swallowing physiotherapy, rTMS, which is a non-invasive neuromodulation technique, is used in the treatment of post-stroke dysphagia. High frequency rTMS stimulation (> 1 Hz) plays a role in increasing cortical excitability, whereas low frequency stimulation (≤ 1 Hz) suppresses cortical excitability. High frequency stimulation is given in the mylohyoid representative area in the ipsilesional hemisphere to increase the excitability of neurons that are still intact and low frequency stimulation in the contra-lesion hemisphere to suppress increased excitability due to contralateral hemisphere compensation so that interhemispheric balance is achieved and this stimulation is proven to be effective in improving swallowing function in post-stroke dysphagia patients.

Apart from the rTMS protocol factors given to patients, there are several prognostic factors that influence the recovery rate of post-stroke dysphagia, including stroke severity, dysphagia severity, age, malnutrition, interventions

carried out at an early or late stage, bihemispheric lesions, brainstem lesions.

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