Comparative Effects of Multimodal versus Single-Modality Sensory Stimulations on Swallowing Function in Patients with Post-Critical Illness Dysphagia

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Abstract

Background: Post-Critical Illness Dysphagia (PCID) is a common complication among Intensive Care Unit (ICU) patients. Early detection and appropriate sensory-based rehabilitation are essential to prevent aspiration, improve swallowing safety, and optimize functional recovery. **Purpose**: This study aimed to compare the effects of single-modality (thermal, tactile, gustatory) versus combined multimodal sensory stimulations on swallowing function in patients with PCID. **Design:** A quasi-experimental comparative design was used. **Sample:** A purposive sample of 120 adult ICU patients with PCID was divided systematically into four groups (n =30 each): tactile stimulation, thermal stimulation, gustatory stimulation, and combined multimodal sensory stimulation. **Setting:** Stroke and Trauma Intensive Care Units at Menoufia University Hospital, Egypt. **Instruments:** Data were collected using: (1) Demographic and Clinical Data Sheet; (2) Dysphagia Severity Rating Scale (DSRS); (3)The Fiberoptic Endoscopic Evaluation of Swallowing with the Penetration-Aspiration Scale (FEES-PAS); (4) Gugging Swallowing Screen (GUSS); (5) Functional Oral Intake Scale (FOIS); (6) Charlson Comorbidity Index (CCI); and (7) Simplified Acute Physiology Score II (SAPS II). **Results**: After the intervention, patients receiving combined multimodal sensory stimulation demonstrated significantly greater improvement across all swallowing outcomes compared with those receiving single-modality stimulation. Dysphagia severity was significantly reduced in the multimodal group compared to the tactile, thermal, and gustatory groups. Swallowing function improved significantly more in the multimodal stimulation group compared with all single-modality groups, indicating enhanced swallowing safety. Similarly, aspiration risk decreased significantly in the combined multimodal group compared with all single-modality groups. Additionally, patients receiving multimodal sensory stimulation had a significantly shorter ICU length of stay than those receiving tactile, thermal, or gustatory stimulation alone .**Conclusion**: Combined multimodal sensory stimulation is more effective than single-modality stimulation in improving swallowing function, reducing dysphagia severity and aspiration risk, enhancing oral intake, and shortening ICU stay among patients with PCID. **Recommendations**: Multimodal sensory stimulation should be incorporated into routine ICU dysphagia management protocols to enhance patient outcomes and reduce complications associated with PCID.

Keywords: Multimodal Sensory Stimulation, Post-Critical Illness Dysphagia, Swallowing Function.

Introduction

Post-Critical Illness Dysphagia (PCID) is a common and serious complication among critically ill patients, particularly those admitted to Intensive Care Units (ICUs). It often arises from a combination of factors such as prolonged mechanical ventilation, endotracheal intubation, neuromuscular weakness, reduced levels of consciousness, and critical illness-associated polyneuropathy or myopathy **(Ebihara & Naito, 2022; Renner et al., 2023)**. These physiological impairments disrupt the complex sensorimotor coordination required for safe swallowing, leading to delayed swallow initiation, reduced laryngeal elevation, impaired tongue propulsion, and an increased aspiration risk. Consequently, PCID is strongly associated with increased morbidity, aspiration pneumonia, malnutrition, dehydration, prolonged hospitalization, and higher healthcare costs **(Chen et al., 2024).**

Globally, dysphagia affects 30-50% of patients following extubation, and the prevalence rises to more than 60% among those mechanically ventilated for over 48-72 hours (Howard et al., 2023). In populations with ICU-acquired weakness, swallowing dysfunction is reported in up to 55% of cases **(Likar et al., 2024).** Regional studies in the Middle East indicate that approximately 20% of ICU patients develop dysphagia post-extubation, while more than half of ICU survivors experience long-term swallowing impairments. These statistics highlight the clinical significance of PCID and stress the necessity for early identification and management **(Coelho et al., 2024).**

Swallowing management has increasingly emphasized sensory-based techniques that stimulate the oropharyngeal region to augment sensory input, activate cortical swallowing centers, and improve reflexive swallowing responses **(Banda et al., 2023).** Tactile stimulation enhances proprioceptive feedback, thermal stimulation increases pharyngeal reflex sensitivity, and gustatory stimulation elevates cortical excitability. Emerging evidence suggests that combining these modalities may yield synergistic effects, potentially offering greater therapeutic benefit than single-modality interventions **(Marin et al., 2023).**

Critical care nurses play a crucial role in implementing these interventions, conducting early screening, administering sensory protocols, and monitoring patient responses **(Gatto et al., 2021).** However, despite the growing use of sensory stimulation, there remains a critical gap in comparative evidence regarding the relative effectiveness of different sensory modalities and whether multimodal stimulation provides superior outcomes. Furthermore, the processes of screening, implementing, and monitoring dysphagia management in the ICU underscore the need for clear, evidence-based protocols (**Leira et al., 2023; Chen et al., 2024).**

This study aims to address these gaps by comparing the effectiveness of thermal, tactile, gustatory, and combined multimodal sensory stimulations on swallowing function, dysphagia severity, aspiration risk, and functional oral intake among patients with PCID. The findings are expected to contribute to improved clinical decision-making and the development of effective dysphagia management strategies in critical care settings.

Significance of the Study

Post-Critical illness dysphagia (PCID) represents a major clinical challenge in intensive care settings, affecting 40%-70% of critically ill patients depending on their underlying condition and duration of mechanical ventilation **(Hongo et al., 2022; Abdelbaky et al., 2023).** Its impact extends far beyond impaired swallowing, as PCID is strongly associated with aspiration pneumonia, prolonged ICU and hospital stays, increased healthcare utilization, and higher short- and long-term mortality rates. Previous studies have reported a 9.2% increase in 90-day mortality and up to a 25% increase in one-year mortality among patients who develop PCID, highlighting the urgent need for effective, evidence-based interventions **(Cheng et al., 2022; Likar et al., 2024).** Additionally, swallowing dysfunction contributes to delays in transitioning to oral feeding, leading to malnutrition, dehydration, increased dependency on enteral feeding, and delayed rehabilitation **(Coleen et al., 2023).**

Sensory-based interventions such as tactile, thermal, and gustatory stimulation have emerged as promising non-pharmacological strategies for enhancing swallowing safety and efficiency. These modalities stimulate oral and pharyngeal sensory receptors, facilitate faster initiation of the swallowing reflex, and improve overall swallowing coordination **(Marin et al., 2023).** Evidence indicates that sensory stimulation can decrease pharyngeal delay time, reduce aspiration events, and enhance neural activation within swallowing pathways **(Labeit et al., 2023).**

However, despite these benefits, existing research has primarily focused on single-modality interventions, leaving a critical gap regarding the comparative effectiveness of different sensory techniques. Moreover, preliminary findings suggest that combining sensory modalities may produce synergistic effects, potentially accelerating recovery and improving key outcomes such as aspiration risk, functional oral intake, and ICU length of stay **(Cheng et al., 2022; Choy et al., 2023).** Yet, robust comparative studies in critically ill patients remain limited.

This study is significant because it provides a comprehensive comparison of thermal, tactile, gustatory, and combined multimodal sensory stimulation among ICU patients with PCID. By identifying the most effective sensory intervention, the study offers essential evidence to guide clinical practice, enhance the role of critical care nurses in dysphagia management, reduce complications associated with unsafe swallowing, and ultimately improve the recovery trajectory of this vulnerable population.

Purpose of the Study

The purpose of this study was to compare the effects of single-modality (thermal, tactile, gustatory) versus combined multimodal sensory stimulations on swallowing function in patients with post-critical illness dysphagia.

Research Hypotheses:

- Patients with PCID who receive combined multimodal sensory stimulation will demonstrate a significantly greater reduction in dysphagia severity compared with those receiving any single sensory stimulation modality.
- Patients with PCID who receive combined multimodal sensory stimulation will exhibit significantly greater improvement in swallowing function than patients receiving single-modality stimulation.
- Patients with PCID who receive combined multimodal sensory stimulation will have a significantly shorter ICU length of stay than those receiving any single sensory stimulation modality.
- There will be a significant correlation between dysphagia severity and functional oral intake among patients with PCID.
- There will be a significant correlation between the severity of illness and dysphagia severity among patients with PCID
- There will be a significant correlation between swallowing function and functional oral intake among patients with PCID.

Methods

Research Design :

A quasi-experimental comparative research design was utilized to evaluate and compare the effects of thermal, tactile, gustatory, and combined multimodal sensory stimulation on swallowing function among patients with post-critical illness dysphagia (PCID). This design was appropriate as it allowed for a systematic comparison between intervention groups while maintaining clinical feasibility within the ICU environment.

Setting:

The study was conducted in the Stroke and Trauma Intensive Care Units and the Intermediate Neurological Care Unit at Menoufia University Hospital, Menoufia Governorate, Egypt. These units provide comprehensive care for critically ill patients requiring mechanical ventilation, advanced hemodynamic monitoring, and neurological assessment, making them suitable settings for examining dysphagia-related outcomes.

Sampling:

A purposive sample of 120 adult patients diagnosed with PCID was recruited based on predefined inclusion and exclusion criteria. Participants were systematically assigned into four equal groups (n = 30 each) using a quasi-random

alternating assignment method: Group I received tactile stimulation, Group II received thermal stimulation, Group III received gustatory stimulation, and Group IV received combined multimodal sensory stimulation (thermal + tactile + gustatory). Patients were eligible if they were 18-65 years old, had received invasive mechanical ventilation for more than 24 hours, had been extubated for more than 24 hours, and were hemodynamically stable (i.e., not requiring active resuscitation or high-dose vasoactive agents). Patients were excluded if they had a gastrostomy or gastrojejunostomy tube, any contraindication to oral feeding (e.g., recent gastrointestinal surgery), neuromuscular conditions known to cause dysphagia (e.g., amyotrophic lateral sclerosis, myasthenia gravis), prolonged dependence on high-level respiratory support (≥7 days post-extubation; e.g., >50% FiO_2, BiPAP, or HFNC), a Glasgow Coma Scale (GCS) score < 11, or were receiving active palliative care.

Sample Size Calculation:

The sample size was calculated using G*Power software to achieve 80% statistical power at a significance level of $\alpha = 0.05$ with a medium effect size ($f = 0.50$). The minimum required sample was 100 participants. To compensate for a potential attrition rate of 19%, an additional 20 participants were included, resulting in a final total sample size of 120 patients.

Instruments for Data Collection:

Seven validated instruments were utilized to collect data and assess swallowing-related outcomes among patients with post-critical illness dysphagia (PCID). These instruments were selected based on their reliability, validity, and suitability for critically ill patients.

Instrument (I) Demographic and Clinical Data Sheet:

A structured data sheet was developed by the researcher to collect baseline information, including age, gender, primary medical diagnosis, etiological factors contributing to PCID, duration of mechanical ventilation, and ICU length of stay. Additional clinical indices such as comorbidities and disease severity were also documented using standardized scoring tools. Data were extracted from patients' medical records upon enrollment.

.Instrument (II) Dysphagia Severity Rating Scale (DSRS):

Developed by **O'Neil et al., (1999),** the DSRS is a 7-point Likert scale that assesses the severity of dysphagia based on dietary and fluid modifications and the level of supervision required during feeding. Scores range from 0 (normal swallowing) to 12 (severe dysphagia), with scores ≥ 4 indicating unsafe swallowing requiring modification and clinical intervention. The DSRS has demonstrated strong test-retest reliability (r = 0.82-0.90) and acceptable sensitivity and specificity for detecting mild to moderate dysphagia **(O'Neil et al., 1999).**

Instrument (III) Fiberoptic Endoscopic Evaluation of Swallowing with the Penetration-Aspiration Scale (FEES-PAS):

FEES-PAS was used as the gold-standard instrumental assessment to objectively evaluate swallowing physiology and function, including swallowing safety. The procedure allows direct visualization of the pharyngeal and laryngeal structures during swallowing to detect impairments in timing, bolus clearance, and identify penetration and aspiration events. Patients were positioned in a sitting or semi-Fowler's position. A flexible fiberoptic endoscope was inserted transnasally, and different food and liquid consistencies, sometimes dyed with a food-grade colorant, were presented to evaluate swallowing function. Swallowing safety were scored using the Penetration-Aspiration Scale (PAS), which ranges from 1 (no penetration/aspiration) to 8 (severe aspiration). FEES-PAS has demonstrated high reliability and validity in directly assessing swallowing function and detecting aspiration **(Langmore, 2017).**

Instrument (IV) Gugging Swallowing Screen (GUSS):

Developed by **Trapl et al. (2007),** the GUSS is a validated bedside instrument for assessing oropharyngeal dysphagia and aspiration risk, especially in patients with neurological conditions. It includes one indirect assessment (consciousness level, voluntary coughing, saliva swallowing, and voice quality) and three direct swallowing trials (semisolids, liquids, and solids). Scores range from 0 to 20, with lower scores indicating higher aspiration risk. GUSS demonstrates high inter-rater reliability (r = 0.88) and internal consistency (Cronbach's $\alpha = 0.76$) and can be administered by

trained ICU staff in approximately 10-15 minutes **(Umay et al., 2019).**

Instrument (V) Functional Oral Intake Scale (FOIS):

Developed by **Crary et al. (2005),** FOIS assesses the level of functional oral intake in patients with dysphagia. Scores range from 1 to 7, where 1-3 represent non-oral feeding and 4-7 indicate varying degrees of oral intake. The scale reflects the patient's ability to consume different food consistencies and need for compensatory strategies. FOIS has demonstrated validity (81-98%) and inter-examiner reliability (0.86-0.91).

Instrument (VI) Simplified Acute Physiology Score (SAPS) II:

Developed by **Le Gall et al. (1993),** SAPS II predicts mortality risk in ICU patients within the first 24 hours of admission. It includes 17 variables, including 12 physiological parameters, age, admission type, and comorbidities. Scores range from 0 to 160, with higher scores indicating higher mortality risk (e.g., 29 = 10%, 40 = 25%, 52 = 50%, 64 = 75%, and 77 = 90%). SAPS II demonstrates high validity ($r = 0.873$) and internal consistency (Cronbach's $\alpha = 0.79$) in ICU settings **(Strand et al., 2010).**

Instrument (VII) Charlson Comorbidity Index (CCI):

The Charlson Comorbidity Index was designed by **Charlson et al., (1987)** to categorize comorbidities and predicts 10-year survival in patients with multiple conditions .It consists of 19 categories of comorbidity. Each condition is assigned a score from 0 to 6 depending on the risk of dying associated with that condition. A score of zero indicates that no comorbidities were found, and higher scores indicate greater comorbidity. Patients with a score of 5 or more have an estimated 100% risk of dying within one year. The scoring system of the scale is interpreted as: 0 points had 98% estimated 10-year survival, 1 point had 96%, 2 points had 90%, 3 points had 77%, 4 points had 53%, 5 points had 21%, 6 points had 2%, and 7 points or more had 0% estimated 10-year survival. The Charlson Comorbidity Index has well-established reliability and validity. The alpha coefficient for the internal consistency of the Charlson Comorbidity Index ranged from 0.86 to 0.95, indicating excellent reliability **(De Groot et al., 2003).** In the present study, test-retest reliability using internal consistency, yielded a Cronbach's alpha of 0.92 ($P < 0.001$).

Data Collection Procedure:

Following institutional and ethical approvals, a **pilot study** was conducted on 10% of the sample (n = 12) to evaluate the clarity, feasibility, and applicability of the data collection instruments and procedures. The pilot helped determine the average time required for assessment and identify any necessary modifications. Data from the pilot sample were excluded from the final analysis to prevent bias.

Data were collected over 15 months from the beginning of October 2023 to the end of December 2024 in the Stroke and Trauma Intensive Care Units of Menoufia University Hospital, with continuous follow-up in the Intermediate Care Unit. Eligible patients were screened within the first 24 hours post-extubation using the Dysphagia Severity Rating Scale (DSRS) and Fiberoptic Endoscopic Evaluation of Swallowing with the Penetration-Aspiration Scale (FEES-PAS).Those meeting inclusion criteria were enrolled after providing written informed consent. All groups were matched for age, sex, and baseline clinical characteristics to ensure homogeneity and minimize confounding variables.

The 120 adult patients with PCID were systematically allocated into four equal groups (n = 30 each), each receiving a distinct sensory stimulation therapy to enhance swallowing function: Study Group I received tactile stimulation, Study Group II received thermal stimulation, Study Group III received gustatory stimulation, and Study Group IV received combined sensory stimulation (tactile, thermal, and gustatory).

Baseline data included demographic and clinical characteristics (age, gender, medical diagnosis, etiological factors of PCID, ICU length of stay) and assessments of dysphagia severity using DSRS, swallowing function using FEES-PAS, aspiration risk using GUSS, functional oral intake using FOIS, comorbidities using CCI, and mortality risk using SAPS II. The dysphagia severity, swallowing function, aspiration risk, and functional oral intake were assessed at baseline and four weeks after the intervention.

All four intervention groups received the sensory stimulation program for 15 minutes, three times daily, for four weeks after the event onset. This was based on evidence suggesting that mild dysphagia often improves within the first week, while moderate to severe cases require longer intervention **(Jongprasitkul & Kitisomprayoonkul, 2020).**

Before the interventions, an educational session was held for ICU staff to introduce the protocol, clarify the intervention methods, and address patient safety concerns. A separate meeting with attending physicians ensured medical oversight and collaboration.

Study Group I: Tactile Stimulation:

Patients in group I received tactile stimulation using a sterile, gloved index finger or a cotton-tipped applicator soaked in sterile water. Gentle, repetitive stroking motions were applied to the anterior faucial arches, base of the tongue, and soft palate. The stimulation followed a standardized sequence, alternating between sides every 30 seconds, with each targeted area receiving three to five gentle strokes per minute. Each session lasted 15 minutes and was conducted three times daily for four weeks. Patients were positioned in a semi-Fowler's (30-45°) or full Fowler's (≥ 60°) position depending on their consciousness and respiratory condition. Vital signs were monitored before, during, and after each session.

Study Group II: Thermal Stimulation:

Patients in group II received thermal stimulation through a cold stimulus applied via a chilled metal laryngeal mirror (stored in ice for 5 minutes) or a medical swab dipped in ice water. The cold instrument was applied to the anterior faucial pillars and soft palate for 35 seconds per site, in three cycles per region, repeated throughout the 15-minute session. Sessions occurred three times daily for four weeks. Conscious patients were encouraged to perform a voluntary dry swallow.

Study Group III: Gustatory Stimulation:

Patients in group III received gustatory stimulation using high-flavor solutions, alternating between sweet (e.g., sugar syrup) and sour (e.g., lemon juice) stimuli. A sterile swab was dipped into the solution and applied to the anterior two-thirds of the tongue, hard and soft palate, and inner cheeks. Conscious patients who could safely swallow were encouraged to taste and perform a voluntary swallow after each application. Each session lasted 15 minutes, with taste stimuli rotated every 5 minutes, conducted three times daily for four weeks.

Study Group IV: Combined Sensory Stimulation:

Patients in Group IV received a structured intervention integrating tactile, thermal, and gustatory stimulations. Each 15-minute session was divided into three 5-minute phases: Tactile stimulation (as in Group I), Thermal stimulation (as in Group II), and Gustatory stimulation (as in Group III). The sequence was strictly followed in each session to allow progressive sensory priming. Patients were monitored for adverse responses such as gagging, coughing, oxygen desaturation, or bradycardia. Detailed documentation recorded alertness, tolerance, and observable swallowing attempts. Interventions were performed by the researcher or a trained ICU nurse following a standardized protocol to ensure consistency and safety. Each session lasted 15 minutes (5 minutes per modality), administered three times daily for four weeks. The severity of dysphagia, swallowing function, aspiration risk, and functional oral intake were assessed before and after the four-week intervention period.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing, Menoufia University (Approval No. 1061). Written informed consent was obtained from legal guardians after a full explanation of the study's purpose, procedures, potential benefits, and possible risks. Participation was voluntary, and participants retained the right to withdraw at any time without affecting the quality of medical care. Confidentiality and anonymity were ensured through coded data and secure storage of all documents. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

Data Analysis:

**Data were analyzed using IBM SPSS version 22. Descriptive statistics were used to summarize the data: means and standard deviations (Mean ± SD) for continuous variables, and frequencies and percentages (No. & %) for

categorical variables. The normality of continuous variables was assessed using the Shapiro–Wilk test and indicated approximate normal distribution. Between-group comparisons were conducted on post-intervention scores using one-way ANOVA, followed by Tukey's HSD post-hoc test to control for multiple comparisons.

Within-group comparisons between pre- and post-intervention measurements were conducted using paired t-tests. Categorical data were analyzed using Pearson's chi-square test. Relationships between variables were examined using Pearson correlation analysis, as data were approximately normally distributed. Multiple linear regression analysis was performed to identify independent predictors of swallowing outcomes, and model assumptions were checked with no significant violations detected. Statistical significance was set at $p \leq 0.05$, while $p \leq 0.001$ was considered highly statistically significant.

Results:

Table (1) illustrates that the mean age of participants in study group I, study group II, study group III, and the study group IV (Combined Group) were 55.8 ± 9.7, 56.4 ± 8.8, 55.9 ± 9.3, and 56.2 ± 8.9 years, respectively. Regarding gender, more than half of the participants in each group were males (56.7%, 53.3%, 50.0%, and 60.0%, respectively). The primary reason for ICU admission and subsequent development of PCID was stroke (73.3%, 70.0%, 76.7%, and 73.3%) in Groups I, II, III, and IV, respectively. The mean CCI scores were 13.55 ± 0.71, 13.63 ± 0.68, 13.58 ± 0.74, and 13.51 ± 0.69, while the mean SAPS II scores were 36.4 ± 9.5, 37.1 ± 9.2, 35.8 ± 9.1, and 36.0 ± 9.6 for Groups I, II, III, and IV, respectively, indicating a relatively low mortality risk (approximately 36%). No statistically significant differences were found among the groups regarding demographic characteristics or baseline clinical data ($p > 0.05$), confirming group homogeneity.

Table (2) demonstrates that prolonged mechanical ventilation (>48 hours) was prevalent across all groups (93.3%, 90.0%, 96.7%, 90.0%), with 100% of participants having a history of endotracheal intubation. Neuromuscular weakness (83.3%, 80.0%, 86.7%, 83.3%), sedation use (86.7%, 83.3%, 90.0%, 80.0%), and critical illness polyneuropathy (60.0%, 56.7%, 63.3%, 60.0%) were also common. No statistically significant differences were observed among groups for any etiological factor ($p>0.05$), indicating comparability regarding underlying causes of dysphagia.

Table (3) shows that all groups experienced significant reductions in DSRS scores post-intervention (t-test: $p<0.001$). The Combined Group achieved the lowest score (best) post intervention (2.80 ± 0.90) compared to Tactile (4.20 ± 1.10), Thermal (4.00 ± 1.00), and Gustatory (4.10 ± 1.20) groups ($F = 11.16$, $p<0.001$). These findings indicate that combined multimodal sensory stimulation was more effective in reducing dysphagia severity than single-modality interventions.

Table (4) indicates a significant improvement in swallowing function across all groups post-intervention (t-test: $p<0.001$). The Combined Group showed the lowest FEES-PAS score (2.46 ± 1.35), followed by Tactile (3.56 ± 1.45), Thermal (3.70 ± 1.71), and Gustatory (3.83 ± 1.15) groups ($F = 9.01$, $p<0.001$). These results suggest that multimodal sensory stimulation provided superior enhancement of swallowing function and safety.

Table (5) demonstrates significant increases in GUSS scores for all groups post-intervention (t-test: $p<0.001$). The Combined Group attained the highest mean score (18.7 ± 1.8), compared to Tactile (15.2 ± 2.1), Thermal (15.9 ± 2.0), and Gustatory (15.6 ± 2.2) groups ($F = 11.09$, $p<0.001$), indicating that multimodal sensory stimulation more effectively reduced aspiration risk.

Table (6) shows a significant increase in FOIS scores across all groups (t-test: $p<0.001$). The Combined Group achieved the highest mean post-intervention (6.10 ± 0.77), followed by Gustatory (5.72 ± 0.50), Tactile (5.60 ± 0.50), and Thermal (5.17 ± 0.49) groups ($F = 3.40$, $p = 0.02$), demonstrating the superior effect of multimodal sensory stimulation on oral intake.

Table (7) reveals that combined multimodal stimulation group demonstrated significantly better swallowing outcomes compared with all single-modality groups in post-hoc pairwise comparisons across severity of dysphagia (DSRS), swallowing function (FEES-PAS), aspiration risk (GUSS) and functional oral feeding (FOIS) ($p<0.001$). No significant differences were observed among the single-modality groups for DSRS,FEES-PAS or

GUSS, except for small differences in FOIS between the Tactile and Thermal Groups ($p = 0.035$) and between the Thermal and Gustatory Groups ($p = 0.025$).This indicates that multimodal sensory stimulation had the strongest effect on swallowing recovery.

Table (8): Multiple linear regression analysis of predictors of swallowing outcomes (N = 120). Predictors included Intervention Type (dummy coded, with the tactile intervention as the reference), Age, baseline SAPS II, Charlson Comorbidity Index, and duration of mechanical ventilation (MV Days). β-coefficients indicate the direction and magnitude of each predictor's effect. Intervention Type $\beta = 0.42$, SE = 0.08, $p < 0.001$, 95% CI 0.28–0.56; Age $\beta = -0.15$, SE = 0.06, $p = 0.02$, 95% CI –0.26 to –0.04; SAPS II $\beta = -0.28$, SE = 0.09, $p = 0.003$, 95% CI –0.45 to –0.11; Charlson Index $\beta = -0.19$, SE = 0.07, $p = 0.01$, 95% CI –0.32 to –0.06; MV Days $\beta = -0.23$, SE = 0.08, $p = 0.006$, 95% CI –0.38 to –0.08. Model assumptions were checked, and no significant violations were detected.

Table (9): shows a significant reduction in ICU length of stay for the Combined Group (30.11 ± 5.36 days) compared to Tactile (35.00 ± 5.31), Thermal (37.32 ± 5.59), and Gustatory (40.10 ± 6.53) groups ($F = 3.452$, $p = 0.03$), highlighting the clinical benefit of multimodal sensory stimulation.

Table (10): demonstrates a highly significant negative correlation between dysphagia severity and both swallowing function and functional oral intake across all groups post-intervention (r = -0.655, -0.557, -0.595, -0.697; r = -0.597, -0.567, -0.563, -0.697; $p = 0.001$). This indicates that higher dysphagia severity is associated with poorer swallowing function and reduced oral intake.

Table (11): shows a highly significant positive correlation between dysphagia severity and both mortality risk and comorbidities across all groups post-intervention (r = 0.399, 0.410, 0.450, 0.401; r = 0.391, 0.375, 0.463, 0.397; $p = 0.001$). This suggests that patients with more severe dysphagia also have more severe underlying illness and higher comorbidity burden.

Table (12): demonstrates a highly significant positive correlation between swallowing function and functional oral intake across all groups (r = 0.732, 0.725, 0.747, 0.727; $p = 0.001$). Additionally, swallowing function was negatively correlated with mortality risk and comorbidities (r = -0.411, -0.432, -0.441, -0.421; r = -0.395, -0.387, -0.367, -0.391; $p = 0.001$). These results indicate that better swallowing function is associated with improved oral intake and lower mortality risk and comorbidity burden.

Table (1): Demographic and Clinical Data of the Studied Sample (N = 120)

Demographic and Clinical Data	Study Group I (Tactile) (n=30)		Study Group II (Thermal) (n=30)		Study Group III (Gustatory) (n=30)		Study Group IV (Combined) (n=30)		Test Statistic χ^2 / F	p-value
Age (years)									F = 0.11	0.955 ns
• **Mean ± SD**	55.8 ± 9.7		56.4 ± 8.8		55.9 ± 9.3		56.2 ± 8.9			
Sex	**No.**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	χ^2 = 0.56	0.905 ns
• **Male**	17	56.7	16	53.3	15	50.0	18	60.0		
• **Female**	13	43.3	14	46.7	15	50.0	12	40.0		
Primary Reason for ICU Admission										
• **Stroke**	22	73.3	21	70.0	23	76.7	22	73.3	χ^2 = 1.22	0.942 ns
• **TBI**	4	13.3	5	16.7	3	10.0	3	10.0		
• **Guillain-Barré Syndrome**	4	13.3	4	13.3	4	13.3	5	16.7		
Baseline CCI (Mean ± SD)	13.55 ± 0.71		13.63 ± 0.68		13.58 ± 0.74		13.51 ± 0.69		F = 0.18	0.910 ns
Baseline SAPS II (Mean ± SD)	36.4 ± 9.5		37.1 ± 9.2		35.8 ± 9.1		36.0 ± 9.6		F = 0.12	0.946 ns

Data are presented as mean ± SD for continuous variables and number (%) for categorical variables.
Note: (ns): not significant p value>0.05 χ2: Chi-square test; t: independent t-test.

Table 2: Distribution of the Etiological Factors for PCID among Studied Groups (N = 120).

Etiological Factor	Study Group I (Tactile) (n=30)		Study Group II (Thermal) (n=30)		Study Group III (Gustatory) (n=30)		Study Group IV (Combined) (n=30)		Test Statistic χ^2 / F	p-value
	No.	**%**	**No**	**%**	**No**	**%**	**No**	**%**		
• **Prolonged MV>48 hours**	28	93.3%	27	90.0%	29	96.7%	27	90.0%	χ^2 = 1.25	0.741 ns
• **Endotracheal intubation**	30	100%	30	100%	30	100%	30	100%	χ^2 = 0.32	0.823 ns
• **Neuromuscular weakness**	25	83.3%	24	80.0%	26	86.7%	25	83.3%	χ^2 = 0.58	0.901 ns
• **Sedation use**	26	86.7%	25	83.3%	27	90.0%	24	80.0%	χ^2 = 0.57	0.903 ns
• **Critical illness as polyneuropathy**	18	60%	17	56.7%	19	63.3%	18	60.0%	χ^2 = 0.29	0.961 ns
• **Days on ventilation (Mean ± SD)**	6.20 ± 2. 1		6.50 ± 2.3		6. 80 ± 2.4		6.51 ± 2.2		F = 0.16	0.619 ns

Note: (ns): not significant p value>0.05

Table (3): Effect of Interventions on Severity of Dysphagia among Studied Sample Post Intervention (N=120).

Severity of Dysphagia (DSRS)	Study Group I (Tactile) (n=30)	Study Group II (Thermal) (n=30)	Study Group III (Gustatory) (n=30)	Study Group IV(Combined) (n=30)	Test Statistic (F)	p-value
Pre-Intervention	8.75 ± 1.32	7.84 ± 1.41	7.64 ± 1.52	8.45 ± 1.33	F (3,116) =1.11	0.23
Post-Intervention	4.20 ± 1.10	4.00 ± 1.00	4.10 ± 1.20	2.80 ± 0.90	F(3,116) =11.16	<0.001HS
t-test **p-value**	t(29) =21.96 <0.001	t(29) =16.38 <0.001	t(29) =17.02 <0.001	t(29) = 19.66 <0.001	-	-

Note: **DSRS:** Dysphagia Severity Rating Scale**.** HS: highly statistically significant (p ≤0.001) . t: paired t-tes.

Table (4): Effect of Interventions on Swallowing Function among Studied Sample Post Intervention (N=120).

Swallowing Function (FEES-PAS)	Study Group I (Tactile) (n=30)	Study Group II (Thermal) (n=30)	Study Group III (Gustatory) (n=30)	Study Group IV (Combined) (n=30)	Test Statistic (F)	p-value
Pre-Intervention	5.25 ± 1.58	5.63 ± 1.78	6.60 ± 1.88	5.78 ± 1.88	F (3,116) = 1.02	0.12
Post-Intervention	3.5 6 ± 1.45	3.70 ±.1.71	3.83 ± 1.15	2.46 ± 1.35	F (3,116) = 9.01	<0.001HS
t-test **p-value**	t(29) =18.62 <0.001	t(29) =16.75 <0.001	t(29) =19.41 <0.001	t(29) = 22.54 <0.001	-	-

Note **FEES:** Fiberoptic Endoscopic Evaluation of Swallowing **; PAS:** Penetration-Aspiration Scale. HS: highly statistically significant (p ≤0.001). t: paired t-test

Table (5): Effect of Interventions on Aspiration Risk among Studied Sample Post Intervention (N=120).

Aspiration Risk (GUSS Score)	Study Group I (Tactile) (n=30)	Study Group II (Thermal) (n=30)	Study Group III (Gustatory) (n=30)	Study Group IV (Combined) (n=30)	Test Statistic (F)	p-value
Pre-Intervention	7. 5 ± 1. 2	7. 4 ± 1.4	7.6 ± *1.5*	8.4 ± 1.1	F(3,116) = 0.931	0.42ns
Post-Intervention	15.2 ± 2.1	15.9 ± 2.0	15.6 ± 2.2	18.7 ± 1.8	F(3,116) = 11.09	<0.001 HS
t-test **p-value**	t(29) =19.45 <0.001	t(29) =17.24 <0.001	t(29) =16.12 <0.001	t(29) = 21.36 <0.001	-	-

Note: **GUSS:** Gugging Swallowing Screen**.** HS: highly statistically significant (p ≤0.001); ns: not significant (p value>0.05) .

Table (6): Effect of Intervention on Functional Oral Intake among Studied Sample Post Intervention (N=120).

Functional Oral Intake Measure(FOIS)	Study Group I (Tactile) (n=30)	Study Group II (Thermal) (n=30)	Study Group III (Gustatory) (n=30)	Study Group IV (Combined) (n=30)	Test Statistic (F)	p-value
Pre-Intervention	4.00 ± 0.90	4.00 ± 0.80	3.90 ± 0.90	4.10 ± 0.70	F(3,116) =1.14	0.13
Post-Intervention	5.60 ± 0.50	5.17 ± 0.49	5.72 ± 0.50	6.10 ± 0.77	F(3,116) = 3.40	0.02*
t-test	t(29) =16.43	t(29) =15.04	t(29) =17.38	t(29) =14.90	-	-
p-value	<0.001**	<0.001**	<0.001**	<0.001**		

Note: FOIS: Functional Oral Intake Scale. *Statistically significant (p value<0.05); **Highly statistically significant (p<0.001) .

Table (7): Post-hoc Pairwise Comparisons of Swallowing Outcomes between Studied Groups (N=120)

Comparison	Severity of Dysphagia (DSRS Score)		Swallowing Function (FEES-PAS)		Aspiration Risk (GUSS Score)		Functional Oral Feeding (FOIS)	
	Mean Difference	p-value	Mean Difference	p-value	Mean Difference	p-value	Mean Difference	p-value
Combined vs Tactile	-1.40	<0.001**	-1.10	<0.001**	+3.47	<0.001**	+0.50	<0.001**
Combined vs Thermal	-1.17	<0.001**	-1.24	<0.001**	+2.90	<0.001**	+0.93	<0.001**
Combined vs Gustatory	-1.33	<0.001**	-1.37	<0.001**	+3.14	<0.001**	+0.38	<0.001**
Tactile vs Thermal	+0.23	0.245	+0.14	0.367	-0.57	0.089	+0.43	0.035*
Tactile vs Gustatory	+0.07	0.642	+0.27	0.154	-0.33	0.312	-0.12	0.421
Thermal vs Gustatory	-0.16	0.421	+0.13	0.395	+0.24	0.458	-0.55	0.025*

*Statistically significant (p value<0.05); **Highly statistically significant (p<0.001) .

Table (8): Multiple Regression Analysis of Predictors of Swallowing Outcomes (N=120)

Predictor Variable	β-coefficient	Standard Error	P- value	95% Confidence Interval
Interventions Type	0.42	0.08	<0.001**	0.28-0.56
Age	-0.15	0.06	0.02*	-0.26- -0.04
Baseline SAPS II	-0.28	0.09	0.003*	-0.45- -0.11
Charlson Index	-0.19	0.07	0.01*	-0.32- -0.06
MV Days	-0.23	0.08	0.006*	-0.38- -0.08

* Statistically significant ($p \leq 0.05$); ** Highly statistically significant ($p \leq 0.001$)

Table (9): Effect of Intervention on the Length of ICU Stay among Studied Sample (N=120).

Item	Study Group I (Tactile) (n=30)	Study Group II (Thermal) (n=30)	Study Group III (Gustatory) (n=30)	Study Group IV (Combined) (n=30)	Test Statistic (F)	p-value
Length of ICU Stay (days) **Mean ± SD**	35.00 ± 5.31	37.32 ± 5.59	40.10 ± 6.53	30.11± 5.36	F = 3.452	0.03*

* Statistically significant ($p \leq 0.05$)

Table (10): Relationship between Severity of Dysphagia, Swallowing Function and Functional Oral Intake among Studied Samples Post Intervention (N=120).

Items	Severity of Dysphagia							
	Study Group (Tactile) (n=30)		Study Group II (Thermal) (n=30)		Study Group III (Gustatory) (n=30)		Study Group IV (Combined) (n=30)	
	r	p. value	r	p. value	r	p. value	r	p. value
Swallowing Function (FEES-PAS)	-.655**	0.001	-.557**	0.001	-.595**	0.001	-.697**	0.001
Functional Oral Intake (FOIS)	-0.597**	0.001	-0.567**	0.001	-0.563**	0.001	-0.697**	0.001

Pearson correlation coefficients (r) * statistically significant at $p \leq 0.05$ (two-tailed)
** Highly statistically significant at $p \leq 0.001$(two-tailed)

Table (11): Relationship between Severity of Dysphagia and Mortality Risk and Comorbidities among Studied Sample (N=120).

Items	Severity of Dysphagia							
	Study Group I (Tactile) (n=30)		Study Group II (Thermal) (n=30)		Study Group III (Gustatory) (n=30)		Study Group IV (Combined)(n=30)	
	r	p. value	r	p. value	r	p. value	r	p. value
Mortality Risk (SAPS II)	0.399**	0.001	0.410**	0.001	0.450**	0.001	0.401**	0.001
Comorbidities (CCI)	0.391**	0.001	0.375**	0.001	0.463**	0.001	0.397**	0.001

Pearson correlation coefficients (r) * statistically significant at $p \leq 0.05$ (two-tailed);
** Highly statistically significant at $p \leq 0.001$(two-tailed)

Table (12): Relationship between Swallowing Function, Functional Oral Intake , Mortality Risk and Comorbidities among Studied Sample (N=120).

Items	Swallowing Function							
	Study Group I (Tactile) (n=30)		Study Group II (Thermal) (n=30)		Study Group III (Gustatory) (n=30)		Study Group IV (Combined) (n=30)	
	r	p. value	r	p. value	r	p. value	r	p. value
Functional Oral Intake (FOIS)	0.732 **	0.001	0.725 **	0.001	0.747 **	0.001	0.727 **	0.001
Mortality Risk (SAPS II)	-.411**	0.001	-.432**	0.001	-.441**	0.001	-.421**	0.001
Comorbidities (CCI)	-0.395**	0.001	-0.387**	0.001	-0.367**	0.001	-0.391**	0.001

Pearson correlation coefficients (r) * statistically significant at ≤ 0.05 (two-tailed)
** Highly statistically significant at p ≤ 0.001(two-tailed)

Discussion

Post-critical illness dysphagia (PCID) is a significant complication in critically ill patients, particularly those admitted to the ICU after prolonged mechanical ventilation or neurological events such as stroke **(McIntyre et al., 2021).** It leads to malnutrition, dehydration, aspiration, and aspiration pneumonia due to impaired swallowing mechanisms, contributing to extended ICU stay, increased rehospitalization rates, and higher mortality **(Marin et al., 2023).** Therefore, early intervention aimed at improving swallowing function is essential to enhance patient outcomes and reduce healthcare burdens.

Regarding **demographic characteristics,** The findings of the current study indicated that the mean age of patients in tactile (Group I), thermal (Group II), gustatory (Group III), and the combined (Group IV) groups were 55.8 ± 9.7, 56.4 ± 8.8, 55.9 ± 9.3, and 56.2 ± 8.9 years, respectively, This may be explained by the increased incidence rates of PCID among older adults. This finding was corroborated by **Murphy et al. (2020),** who indicated that older adults face a higher risk of PCID compared to younger adults, noting that age is a significant contributor to PCID risk, with incidence doubling for each decade after the age of 55 years. This aligns with **Yousef et al. (2020),** who reported that over fifty percent of both groups were aged over 50 years. This may be connected to the increased prevalence of PCID with advancing age.

Furthermore, over fifty percent of the patients in all studied groups were male. These findings align with **Gamal et al. (2020),** who reported that over half of the participants in their study were male. Consistent with **Magdy et al. (2021),** who revealed that the majority of participants were male. Also, **Battaglini et al. (2023),** who indicated no significant differences between the examined patients in terms of age or gender and the majority of the participants, were male. Conversely, the findings of **Kharbach et al. (2020)** indicated that the majority of their study sample consisted of females, suggesting that gender distribution may vary across different population and clinical setting.

Effect of Multimodal Sensory Stimulation on Severity of Dysphagia:

Multimodal sensory stimulation involves applying different types of sensory stimuli. This approach can significantly impact cortical and behavioral processes, thereby enhancing swallowing motor functions in patients with PCID **(Zuercher et al., 2022).** The present study

hypothesized that patients with PCID who receive combined multimodal sensory stimulation would demonstrate a significantly greater reduction in dysphagia severity compared to those receiving any single sensory stimulation modality. The findings of the present study support the hypothesis and illustrated that all groups exhibited a significant reduction in dysphagia severity post-intervention. However, the combined multimodal sensory stimulation group achieved the greatest reduction in DSRS scores compared to Tactile, Thermal and Gustatory groups ($F = 11.16$, $p<0.001$), with post-hoc comparisons confirming the significant superiority of multimodal stimulation over each single modality ($p<0.001$). These findings align with prior studies demonstrating that combined sensory stimulation enhances cortical activation and neuroplasticity, facilitating motor control of swallowing **(Siao et al., 2023 ;Yang et al., 2023).** Similary, **Rivelsrud et al. (2023) and Ravinder et al. (2024)** reported similar improvements in dysphagia severity with multimodal interventions compared to tactile-only stimulation. Moreover, **Zuercher et al. (2022),** highlighted that the synergistic effects of tactile, thermal, and gustatory inputs accelerate swallowing recovery, consistent with the current study's results.

Effect of Multimodal Sensory Stimulation on Swallowing Function:

Multimodal sensory stimulation has been shown to improve pharyngeal swallowing function by decreasing oral phase time, pharyngeal swallow initiation time, and pharyngeal phase duration, thereby reducing the risk of aspiration **(Liu et al., 2025).** The current study hypothesized that patients with PCID who receive combined multimodal sensory stimulation would exhibit significantly greater improvement in swallowing function than those receiving single-modality stimulation. Despite the relatively small subgroup sample size, the consistency and strength of the observed effects support the robustness of the findings. The findings of the current study showed that swallowing function, as assessed by FEES-PAS, improved significantly across all groups post-intervention. However, the combined group showed the lowest mean FEES-PAS score, indicating the greatest improvement in swallowing function and a reduced risk of aspiration, compared to the tactile, thermal, and gustatory groups ($F = 9.01$, $p < 0.001$). These results are consistent with **Siao et al. (2023) and Coelho et al. (2024),** who found that combined multi-sensory stimulation significantly improved pharyngeal swallow function and decreased aspiration risk in post-critical illness patients. Additionally, **Cola et al. (2021) and Ravinder et al. (2024)** demonstrated that a comprehensive program including oral-motor exercises, thermal and tactile stimulation, and swallowing education enhanced pharyngeal swallowing efficiency and reduced aspiration. These studies support the notion that multimodal sensory interventions provide superior functional recovery compared to single-modality therapies.

Effect of Multimodal Sensory Stimulation on Aspiration Risk score:

Multimodal sensory stimulation has been shown to improve the pharyngeal swallowing process, by decreasing oral phase time, pharyngeal swallow initiation time, pharyngeal phase time, leading to decreased risk of aspiration **(Liu et al., 2025).** The present study findings showed that aspiration risk scores (GUSS) were significantly improved in the combined group compared to tactile, thermal, and gustatory post-intervention ($F=11.09$, $p<0.001$). This confirms that multimodal stimulation is more effective in mitigating aspiration risk. These results are compatible with what was reported by **Zuercher et al. (2022); Renner et al. (2023),** who demonstrated significant reductions in aspiration risk score with multi-sensory stimulation, emphasizing its protective effect on airway safety.

Effect of Multimodal Sensory Stimulation on Functional Oral Intake:

Multimodal sensory stimulation enhances oral sensation, which may lead to increased ability to perceive oral bolus and improve swallowing function and oral intake **(Assoratgoon et al., 2023).**The present study findings found the combined group achieved the highest FOIS score , indicating improved oral intake, versus tactile , thermal , and gustatory , groups post-intervention ($F = 3.40$, $p = 0.02$). Similar findings have been

reported by **Hafez &Abo-Baker (2023); El Nahas et al. (2024),** who found that multimodal sensory stimulation enhances oral bolus perception and coordination of swallowing, resulting in improved oral intake. Similarly, **Siao et al. (2023); Rivelsrud et al. (2023),** reported significant gains in functional oral feeding with combined sensory programs.

Effect of Multimodal Sensory Stimulation on ICU Length of Stay:

Patients receiving multimodal stimulation had the shortest ICU stay compared to Tactile, Thermal, and Gustatory, groups ($F = 3.452$, $p = 0.03$). This findings support the study hypotheses that patients with PCID who receive combined multimodal sensory stimulation would have a significantly shorter ICU length of stay than those receiving any single sensory stimulation modality. This finding aligns with **Choy et al. (2023),** who reported that enhancing swallowing function through multimodal interventions facilitates earlier recovery of nutritional and respiratory status, thereby shortening ICU stay.

Relationship between Severity of Dysphagia and Mortality Risk

Dysphagia risk factors also include a high APACHE II or SOFA score, gender and other coexisting conditions, such as arterial hypertension, renal disorders, diabetes mellitus, COPD, MI, heart failure, and addiction of nicotine (**Doeltgen, 2023).** The recent study findings showed a positive association between severity of dysphagia and the mortality risk among studied groups post intervention. Patients with higher severity of dysphagia were at greater mortality risk, highlighting the critical need for effective intervention to manage dysphagia in ICU patients. These results are in line with **Silva et al. (2023); Mélotte et al. (2023); Song et al. (2024); Shen et al. (2024),** who examined the relationship between severity of dysphagia and mortality risk and found that dysphagia is a primary predisposing factor for higher mortality in patients with critical illness. The severity of dysphagia can reflect the overall health status and prognosis of critically ill patients, influencing their chance of survival.

Relationship between Dysphagia Severity and Swallowing Function

Dysphagia is not always noticeable to patients, and silent aspiration may occur without evident clinical signs **(Labeit et al., 2023).** While impaired swallowing function is easier to identify, often causing coughing, voice changes, shortness of breath, and, in severe cases, choking silent aspiration presents a greater challenge, as it lacks clear symptoms but can lead to unexplained fever and pulmonary infections **(Yan et al., 2024).**Patients with dysphagia are at an increased risk of pneumonia, with the severity of dysphagia playing a significant role in this risk. This is particularly dangerous as the likelihood of aspiration pneumonia is even higher in patients experiencing silent aspiration **(Tian et al., 2023).**

The findings of the present study revealed a significant negative correlation between dysphagia severity and swallowing function. Patients with more severe dysphagia had more impaired swallowing function, emphasizing the urgent need for effective management strategies. These results align with what was reported **by Labeit et al. (2023); Yan et al. (2024),** who found that increased dysphagia severity is an independent risk factor for a higher aspiration risk in critically ill patients.

Relationship between Dysphagia Severity and Functional Oral Intake

The relationship between dysphagia severity and functional oral intake is a critical concern in clinical practice. Dysphagia severity reflects the extent of swallowing difficulty a patient experiences, while functional oral intake refers to the ability to consume food and liquids by mouth safely and sufficiently **(Lee , 2023).** As dysphagia becomes more severe, patients often face greater challenges in maintaining adequate oral intake, which may require modified diets or complete reliance on alternative feeding methods **(Banda et al., 2023).**

The present study revealed a significant negative correlation between dysphagia severity and functional oral intake. This finding suggests that patients with more severe dysphagia exhibit reduced functional oral intake, further highlighting the critical impact of dysphagia on nutritional status and overall health. These results are consistent with what was reported by **Spronk et al. (2022); Siao et al. (2023)**, who found that

increased dysphagia severity is a key factor contributing to reduced oral intake among critically ill patients.

Regression Analysis of Predictors of Swallowing Outcomes:

Multiple linear regression identified intervention type as the strongest independent predictor of improved swallowing outcomes ($\beta = 0.42$, $p<0.001$), followed age, baseline SAPS II, Charlson Comorbidity Index, days on mechanical ventilation which were negative predictors. These results indicate that while clinical factors influence swallowing outcomes, the intervention itself had the largest positive effect, confirming the causal benefit of multimodal sensory stimulation. This is in line with **Banda et al. (2023); Shen et al. (2024),** who similarly demonstrated the independent effect of combined sensory interventions on swallowing recovery after controlling for comorbidities and age.

Limitation of the study

- The generalizability of these findings is limited due to the use of small sample size.
- Moreover, as the study was conducted at a single healthcare facility, caution should be exercised when applying these results to other settings or populations.

Conclusion

The findings of the present study provide strong evidence that multimodal sensory stimulation, incorporating tactile, thermal, and gustatory modalities, is a safe, effective, and feasible nursing intervention for patients with post–critical illness dysphagia. In line with the study hypotheses, patients who received multimodal stimulation demonstrated a significantly greater reduction in dysphagia severity as measured by DSRS scores compared with those receiving single-modality stimulation.

Furthermore, multimodal sensory stimulation resulted in significantly superior improvement in swallowing function, as assessed by FEES–PAS scores, indicating enhanced airway protection and swallowing safety. Functional oral intake, evaluated using FOIS, also improved significantly more in the multimodal group, supporting the hypothesis that combined sensory input facilitates earlier and safer progression toward oral feeding. In addition, patients receiving multimodal stimulation experienced a significantly shorter length of ICU stay, confirming its positive impact on clinical recovery outcomes.

Regression analysis revealed that multimodal sensory stimulation was the strongest independent predictor of improved swallowing outcomes, even after controlling for demographic and clinical variables such as age, comorbidity burden, disease severity (SAPS II), and duration of mechanical ventilation. This finding confirms that the observed improvements were primarily attributable to the intervention itself rather than to patient-related characteristics. Moreover, significant associations were identified between dysphagia severity, swallowing function, functional oral intake, comorbidity burden, and disease severity, thereby supporting the correlational hypotheses of the study.

Recommendations :

Based on the finding of the present study, the following recommendations are proposed:

Recommendations for Clinical Practice in ICUs

- Integrate multimodal sensory stimulation into standardized ICU protocols for dysphagia management as a first-line rehabilitation intervention for patients with post-critical illness dysphagia.
- Implement routine dysphagia screening using validated tools such as the Gugging swallowing Screen (GUSS) within 24 hours post-extubation to facilitate early identification and timely intervention

Recommendations for Nursing Education and Training:

- Develop and mandate continuing education programs and hands-on workshops for critical care nurses to ensure safe, standardized, consistent application of multimodal sensory stimulation .
- Provide procedural manuals,visual aids, and competency checklists to promote high-fidelity implementation across shifts and practitioners.

Recommendations for Future Research

- Conduct multi-center randomized controlled trials with larger and more diverse samples to validate these findings and enhance generalizability

- Examine the long-term effects of multimodal sensory stimulation on swallowing recovery , nutritional status, quality of life,and healthcare utilization following ICU discharge.
- Explore the role of telehealth approaches and objective diagnostic tools in dysphagia assessment and monitoring to support early detection and continuity of care in critical care settings.

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Conflict of interest:

No potential conflicts of interest

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