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REVIEW ARTICLE

Swallowing Difficulties with Tracheostomy: A Neuro-Rehabilitation Perspective

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ABSTRACT

Swallowing and breathing are complex and highly coordinated functions. These functions depend on well-coordinated work of many organs with larynx and nervous system playing a critical role. Disturbance in one of these functions negatively affects the other. Surgical airways like tracheostomies are required in a number of situations, including but not limited to major head and neck procedures, cases with decreased lung function, excessive bronchial secretions and cases requiring neuro-rehabilitation when prolonged airway is required for mechanical ventilation. Extensive neuro-rehabilitation is required since patients with surgical airway may develop swallowing difficulties including dysphagia and/or aspiration with a very high prevalence, which can pose a threat to life. This article reviews the current status of the diagnostic and therapeutic modalities for swallowing difficulties with special emphasis on current neuro-rehabilitative strategies. Electronic databases including Medline, Web-of-science, Cochrane Library, and Google scholar were used for literature search. Downloaded articles were subsequently assessed independently by two researchers to determine suitability for inclusion in the study.

Key words: Neurorehabilitation, Tracheostomy, Transcranial direct current stimulation, Transcranial magnetic stimulation, swallowing difficulty

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Introduction

Breathing and swallowing are essential and highly coordinated functions. These functions depend on well-coordinated work of many organs with larynx and nervous system playing a critical role. Disturbance in one of these functions negatively affects the other. Swallowing being a complex neurological process plays an essential part in food digestion. Its main role is lower respiratory tract (LRT) protection, demanding precise coordination between the essential functions of breathing and swallowing. This is mediated through a swallowing reflex. Any pathological or physiological deficiency or impairment of central nervous, neuromuscular, musculoskeletal or cardiopulmonary system may modulate the swallow reflex arc and lead to a potential delay, deficiency or disorder in swallowing function.[1]

Surgical airways like tracheostomies are required in a number of situations including but not limited to major head and neck procedures, in cases with decreased lung function, excessive bronchial secretions and cases requiring neuro-rehabilitation when prolonged airway is required for mechanical ventilation. According to Loss et al. a large percentage (41.5%) of patients requiring intensive unit care, require mechanical ventilation (MV) with 9.9% requiring MV for prolonged period.[2] Of these critically ill survivors, many face dysphagia and in these cases tracheostomy is an important risk factor.[3] Thus, in the intensive care units (ICU) mechanical ventilation after tracheostomy may lead to loss of pulmonary protection or swallowing abnormality.[4] The prevalence of swallowing disorders in critical tracheostomized patients who are on MV ranges from 50 to 83%.[5] Regardless of the presence or absence of neuromuscular issues it has been reported to be 3 to 62% in another study,[3] nevertheless its real incidence is not yet established. The swallowing reflex can be modulated by pathological as well as some physiological conditions.[1] The placement of tracheostomy disturbs the normal vertical hyoid and laryngeal movements essential for normal swallowing.[6] Tracheostomy also reduces the sensitivity of the larynx,[7] and the cuff of tracheostomy tube may alter the stimulation of the pressure receptors in the subglottic area,[8] which can result in aspiration. Hernandez et al. have claimed that deflation of tracheostomy tube cuff in these patients shorten the weaning thus reducing the respiratory infections and improving swallowing.[9] Hence tracheostomy tube results in difficulty in verbal communication and reduction in laryngeal movement results in further compromise in swallowing.[10] Also tracheostomy has been noted as an independent risk factor for development of aspiration and dysphagia.[4] Extensive neuro-rehabilitation is required since patients with surgical airway may develop swallowing difficulties including dysphagia and / or aspiration with a very high prevalence, which can pose a threat to life.

This paper attempts to review the current status of therapeutic modalities for swallowing difficulties with special emphasis on current neuro-rehabilitative strategies. This has significance since such cases are neglected and result in morbidity and mortality. Literature search was conducted using electronic databases including Medline, Web-of-science, Cochrane Library, and Google scholar for articles published between 2000 to 2018 using keywords like "Neurorehabilitation", "Tracheostomy", "Transcranial direct current stimulation", "Transcranial magnetic stimulation", "Swallowing difficulty" and a combination of these words. Downloaded articles were subsequently assessed independently by two researchers to determine suitability for inclusion in the study.

Discussion

Tracheostomy is a common airway procedure associated with complications of swallowing difficulties as well as airway protection abnormalities. These complications demands a multidisciplinary team approach, with good coordination between its team members, for evaluation and rehabilitation to ensure the safety and quality care of these patients.[10,11] In a study, Mah et al. concluded that, "the introduction of care bundle for post tracheostomy care to the multidisciplinary tracheostomy service significantly improve oral diet intake as well as de-cannulation".[12] Thus restoration of function of respiration, phonation, feeding and swallowing demands a strict integration and participation among different members of the multidisciplinary rehabilitation team. A number of strategies are used conventionally to facilitate swallowing and prevent aspiration easing de-cannulation including digital occlusion of tracheostomy during swallowing, use of one-way valves, adjustment of tidal volume and timing of swallow with expiratory

cycle for patients on MV. These strategies, increase subglottic pressure and prevents aspiration, with partial or complete cuff deflation as the case may be, allowing deglutition and phonation system rehabilitation. Also, the tracheostomy cannula should preferably not fill more than two-third to three-fourths of the tracheal lumen, since it will make rehabilitation difficult.[9]

Evaluation is usually carried out using existing simple screening tools like 3-oz water tests as well as specific assessment tools. These include Video fluoroscopy, Modified barium swallows, Fiber-optic Endoscopic Evaluation of Swallowing (FEES) with the validated grading measures. The grading measures include Modified Barium Swallow Impairment Profile (MBSImP) and Penetration-Aspiration Scale. MBSImP provides a standardized protocol to interpret and communicate swallowing impairment in an accurate and objective manner with 17 components grouped in three functional domains each to access Oral Impairment, Pharyngeal Impairment, and Esophageal Impairment.[13] Knowledge is incomplete for using these tools to assess post extubation dysphagia. FEES being the method of first choice is easy to use, with bedside evaluation, and can help remove misjudgment in dysphagia diagnosis and help revise diet in around 70% cases.[14]

To assess swallowing reflex, the integrity of the Oropharyngeal-cortical afferent pathways can be assessed by electroencephalography (EEG) while generating sensory-evoked potentials by pharyngeal electrical stimulation and the Cortical-pharyngeal efferent pathways can be considered by electromyography through motor-evoked potentials by transcranial magnetic stimulation.[15]

When tracheostomy tube is in place, swallowing can be assessed by oral motor and vocal cord assessment with adduction of vocal cord by phonation and strength of cough reflex and Pharyngeal assessment with per oral trials. Air Leak around Tracheostomy Tube can be assessed by occluding tracheostomy tube by a finger during exhalation with instruction to phonate while feeling for pressure on finger and listening for air movement and phonation. Good air leak is indicated by clear phonation, no pressure on finger and no pressure release when finger is removed. Poor air leak is indicated by none or strangled phonation, pressure on finger and air pressure release when finger is removed. However, if the cuff cannot be fully deflated a minimal leak technique can be considered. Due to risk of silent aspiration, cuff manometry is a better option.[16] Chronic MV patients who require full cuff inflation can be assessed by FEES. If the air leak is good then the tracheostomy tube is capped to observe oxygen saturation, respiratory rate, difficulty in clearing secretions and signs of breathing difficulty. If all remains fine orders can be obtained to leave cap as tolerated. De-Cannulation can be done if the patient tolerates 48 hours of capping without need of deep suction; however different centers follow different criteria.

Most guidelines regarding the management of swallowing disorders in these patients basically aim to prevent complications,[17] with conventional compensatory strategies like modification in diet including changes in consistency; bolus presentation i.e. amount, frequency and placement; other strategies like non oral options (no straw), liquid by spoon, moisten mouth before swallow; and other safe swallowing techniques like digital occlusion during swallow etc.[18] Changes in posture involve Chin Tuck, Head Turn, Head Tilt and Head Back. Other facilitation technique includes Effortful Swallow, Mendelshon Maneuver, Supra-glottic swallow and Super-supra-glottic swallow maneuver along with Laryngeal Closure Exercises.

Table I: Summary of conventional and neurorehabilitation interventions for dysphagia		
Class	**Type**	**Technique**

Conventional Compensatory Strategies [18,19]	Modification in Diet	• Consistency
		• Bolus Presentation
		  • Amount
		  • Frequency
		  • Placement

	Non-Oral Options	• Liquid by Spoon • Moisten Mouth before Swallow
	Other Safe swallowing Techniques	• Digital occlusion during swallow
	Changes in Posture	• Chin Tuck • Head Turn • Head Tilt • Head Back
	Other Facilitation Techniques	• Effortful Swallow • Mendelsohn maneuver • Supra-glottic swallow • Super-supra-glottic swallow maneuver • Laryngeal closure exercises
Conventional Therapeutic Techniques [20]	Oral Exercises	• Oral Motor exercises
	Pharyngeal Exercises	• Tongue Base exercises • Pharyngeal exercises (Masako)
	Laryngeal Exercises	• Laryngeal elevation and closure exercises
	Thermal Tactile Stimulation	
	Swallow Exercises	• Sour Bolus exercises
Neurorehabilitation Treatment [19,20,21]	Peripheral Non-invasive Stimulation	• Neuromuscular Electrical Stimulation • Oro/facial Electrical Stimulation • Deep Pharyngeal Neuromuscular Stimulation • Pharyngeal Electrical Stimulation–For Neuroplasticity [23] • Palatal Electrical Stimulation [24] • Functional Magnetic Stimulation [25]
	Central Non-invasive Brain Stimulation [15, 26,27,28]	• Repetitive Transcranial Direct Current Stimulation • Paired Associative Stimulation • Transcranial Magnetic Stimulation

Focus of these strategies being compensation rather than physiological restoration of function.[19] The therapeutic techniques commonly used include Oral Motor Exercises, Tongue Base Exercises, Pharyngeal Exercises (Masako), Laryngeal Elevation and Laryngeal Closure Exercises, Thermal Tactile Stimulation and Sour Bolus Swallow. [20]

Oropharyngeal dysphagia still lacks specific neurorehabilitation treatment with current advances including peripheral and central non-invasive stimulation.[21] According to Cabib et al., rehabilitation strategies are shifting from compensatory techniques to promotion of brain plasticity with the aims of recovering swallow function as well as swallow dysfunction caused by neurological damage.[21] Electrical and magnetic stimulation has gained momentum in the treatment of dysphagia to improve physiological restoration of swallowing with a number of therapeutic interventions gaining interest.

VitalStim Therapy (VST) also known as Neuro-muscular electrical stimulation (NMES) has been used for neuromuscular re-education in cases with oropharyngeal dysphagia.[19,20] The oral/facial electrical stimulation is applied to restore muscle function and Deep Pharyngeal Neuromuscular

Stimulation (DPNS) for restoring reflexes within the pharynx. FDA (USA) protocol for dysphagia recommends use of electrode positioning on submental musculature. Humbert et al.[22] noted significant results especially for muscle strengthening in cases with oropharyngeal dysphagia. Pharyngeal electrical stimulation (PES), using a catheter-electrode placed intra-luminal in the pharynx and attached to stimulator unit to generate the required stimulus has been explored for exploitation of neuroplasticity in motor cortex and has been found to be of benefit as it results in less aspiration and dysphagia.[23] Palatal electrical stimulation has also been used by some researchers to initiate sensory feedback, so as to get swallow reflex involuntarily, with controversial results.[24]

Momosaki et al.[25] used Functional Magnetic Stimulation (FMS) and noted a statistically significant improvement in swallowing function, both in terms of capacity and speed of swallowing. In this noninvasive method instead of electrodes, parabolic coil is used to deliver FMS at 30 Hz to suprahyoid muscles in a 20 second train for 10 minutes and total 1200 pulses were given. It is said to reach a greater depth compared to electrical stimulation without causing discomfort.[26]

Recent neurorehabilitation development includes Non-Invasive Brain Stimulation (NIBS) comprising of transcranial magnetic stimulation (TMS) as well as transcranial direct current stimulation (TDCS) and paired associative stimulation (PAS), with a number of studies suggesting promising results.[15,26,27] Simons et al found mixed results when used for management of neurogenic dysphagia and pointed out controversies that exist regarding treatment with this modality. These controversies include the appropriate site of stimulation, strength and the time duration of the stimulus for producing the most beneficial effect.[26] Kim et al found repetitive (r) TMS to be useful for recovery of swallow function in cases with brain injury and dysphagia, with superior results compared to conventional interventions,[26] while Dionisiio et al.[28] in a systematic review found rTMS to be a useful tool in rehabilitation of stroke cases. Lee et al., studied the effect of rTMS according to site of stimulation and reported that stimulation of the area of brain cortex which generated motor evoked potentials (MEP) from suprahyoid muscles caused maximum improvement in swallowing function when compared to that over the interconnected site.[29] Different researchers have also studied reorganization of intact hemisphere for the purpose of recovery from post-stroke dysphagia (PSD). Significant results have been reported in connection with the use of NIBS on the contra-lateral side of the brain as a therapeutic potential for PSD rehabilitation in different studies.[27]

Conclusion

The complications of tracheostomy and swallowing impairment decree an accurate assessment using modern methodologies like FEES with MBSImP and Penetration aspiration scale. Individualized treatments including most recent neuro-rehabilitation with DCS and TCS is of utmost significance.

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