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Assessment of swallowing and its disorders—A dynamic MRI study

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ABSTRACT

Magnetic resonance imaging overcomes the limitations of videofluoroscopy in assessing without radiation exposure. The clinical utility of dynamic MRI for swallowing disorders is not well documented. This study demonstrates the feasibility of using dynamic MRI in assessment of swallowing disorders. Ten normal and three brainstem lesion patients participated in this study. GE Signa HDxt 1.5 Tesla MRI scanner with head-and-neck coil as a receiver and fast imaging employing steady state acquisition sequence was used. The swallow was analyzed in terms of symmetry and amplitude of movements of velum, faucial pillars, tongue, epiglottis and cricopharyngeous and images from the sagittal, coronal and axial planes. In sagittal plane posterior movement of tongue and its compression on velum, elevation of hyoid bone, elevation of larynx and lid action of epiglottis, in the coronal view the symmetrical movements of the faucial pillars and pharyngeal constrictor muscles and in axial plane three anatomical landmarks were targeted based on their role in swallowing, viz. velum, epiglottis and cricopharyngeous were studied. In brainstem lesion individuals, posterior movement of tongue, and elevation of larynx were not seen. Asymmetrical movements of faucial pillars and cricopharyngeous muscle were appreciated in the dynamic MRI. This demonstrates that, dynamic MRI is an efficient tool to understand the swallowing physiology and helps the speech language pathologist in modifying the swallowing maneuvers. Dynamic MRI is an effective tool in assessing swallowing and its disorders. This muscle specific information is not appreciated in videofluoroscopy and this information is necessary to modify the therapy maneuvers.

1. Introduction

Assessment of dysphagia always had demanded multi disciplinary involvement, viz. neurologist, radiologist, gastroenterologist, speech language pathologist, etc. For the evaluation of swallowing, radiological assessment is very crucial. It allows evaluation of both structure and functions of the organs involved in swallowing. Radiologically, swallowing can be described in terms of displacement of a defined anatomic structure and bolus movement. Moreover, there is a close relationship among the oral and pharyngeal components of swallow. Therefore, all patients with dysphagia symptoms should undergo a complete radiological evaluation of swallow. Other important indicators for radiological evaluation in subjects with dysphagia are recurrent pneumonia, aspiration and unintentional weight loss.

Videofluoroscopy (VFS) is considered to be the "Gold standard" among imaging modalities has been used to evaluate swallowing. This procedure however has several disadvantages including radiation exposure and limitations in detection of soft tissues. On the other hand, magnetic resonance (MR) imaging offers excellent contrast resolution in head and neck soft tissues without radiation exposure. Advanced MR technology allows imaging of soft-tissue motion with almost real-time resolution, and has been used to evaluate swallowing disorders. Foucart et al. [1] reported that kinetic MRI could be applied to the study of the oropharyngeal apparatus. Anagnostara et al. [2] reported that high-speed kinetic MRI allowed direct soft-tissue imaging at close to the real-time resolution offered by videofluoroscopy. Hartl et al. [3] demonstrated that dynamic MRI with single-shot fast spin echo provided clear images of oral and pharyngeal surfaces as well as deep tissue structures.

Study done by Ohkubo et al. [4] revealed that the conjunctional use of cine-MR imaging and high-quality static MR images offers a new method for clinically evaluating swallowing disorders. High speed MRI, has allowed a dynamic analysis of the pharyngeal phase of swallowing that was impossible using conventional MRI. The oral, pharyngeal cavities and the laryngeal musculatures can be evaluated during motion, allowing the assessment of swallowing mechanism. Dynamic MRI has the advantage of not involving

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exposure to radiation. However, the temporal and spatial resolution of dynamic MRI is inferior to videofluoroscopy. But with recent advances in techniques, the issue of resolution can be overcome.

Although, dynamic MR imaging for swallowing disorders has been reported, it remains to be clinically validated. This new technique offers a new method for evaluation of swallowing disorders. And thus the aim of this experimental study is to find the feasibility of using dynamic MRI with advanced technology in assessment of swallow, which will enable the speech, language pathologist (SLP) to alter and tailor make the treatment strategies according to the muscle involvement.

2. Methods

2.1. Subject details

Thirteen subjects participated in this present study in 2 groups, viz. experimental and control group. Experimental group included three male subjects with brainstem infarct with the mean age 61 years (SD: 6.43) with 1 month, 1.5 month and 3 months post-onset, respectively. Subjects in the experimental group were diagnosed to have brainstem infarct using MRI. Ten subjects (7 males and 3 females) in the age range of 9–83 years with the mean age of 42 years (SD: 2.66) were randomly selected for the study in control group. The subjects who consented to participate were included in the study. The wide age range for control group was considered to find the feasibility of using dynamic MRI in swallowing assessment across age group (pediatric, adult and geriatric). The subjects in control group were included based on following criteria:

- No complaint or history of any difficulty in swallowing.
- No history of any neurological conditions/symptoms.
- No history of speech, language or cognitive deficits.

All participants in the control group were subjected to radiological evaluation (MRI of brain) before the assessment of swallowing to rule out neurological lesions.

2.2. Instrumentation

The instrument used in this study was GE Signa, HDxt 1.5 Tesla MRI scanner, with a head-and-neck coil as a receiver. Fast imaging employing steady state acquisition (FIESTA) sequence was used to obtain imaging data because of its increased SNR which would give better resolution. MRI was obtained in the sagittal, coronal and axial planes keeping faucial pillars, velum, hyoid bone, epiglottis and cricopharyngeous muscle as reference. In sagittal plane, the posterior superior movement of velum toward the velo pharyngeal wall closing the velo pharyngeal port, number of swallow trials (deciphered with the help of tongue movement), elevation larynx and hyoid bone and lid action of epiglottis closing the larynx were studied. In the axial plane, symmetrical closure of velum, epiglottis and the cricopharyngeous were studied. And in the coronal view symmetrical movement of faucial pillars and pharyngeal constrictors muscles were studied (Figs. 1–5).

2.3. Instruction to the subjects

The subjects were asked to lie in a supine position on the MRI table and were instructed to swallow dry air and saliva when the dynamic images were taken. At any point of discomfort they were also instructed to inform the radiologist to terminate the procedure.

The movement of velum, epiglottis, hyoid bone and cricopharyngeous muscle were appreciated in dry air swallow and the same physiology was also studied when the participants swallowed saliva. The dynamic MRI was done by a radiologist in the presence of a speech pathologist. The radiologist analyzed the dynamic MRI in terms of any structural abnormality and the speech pathologist studied the swallowing physiology of the participants. Consensus on visual perception of symmetry and amplitude of movement of velum, faucial pillars, tongue, epiglottis and cricopharyngeous was arrived by a radiologist in conjunction with speech pathologist was arrived.

3. Results

Since it is a descriptive study and comparison of dynamic MRI with the “Gold standard” assessment using videofluoroscopy was not done, no statistical results were drawn.

3.1. Findings of control group during saliva and dry air swallow

The motion of the tongue, velum, hyoid bone and larynx, during swallowing was visible in each image. The saliva appeared to be white in color on the dynamic MRI.

In the sagittal plane, the movement of tongue posteriorly and its compression on velum was very evident. The movement of velum toward the posterior pharyngeal wall closing the velo pharyngeal port was very evident. The hyoid bone moved in anterosuperior direction, the elevation of larynx and lid action of the epiglottis were also seen.

In the coronal view the symmetrical movements of the faucial pillars and pharyngeal constrictor muscles were appreciated. In the axial plane three anatomical landmarks were targeted based on their role in swallowing, viz. velum, epiglottis and cricopharyngeous. The approximation of velum toward the posterior pharyngeal wall, the lid action of the epiglottis and the contraction and relaxation of the cricopharyngeous were appreciated in terms of the symmetrical movement.

On the saliva swallow the above mentioned movements were appreciated in the respective planes. The saliva appeared to be white and resembled CSF.

3.2. Findings of experimental group during dry air swallow and swallow

In brainstem infarct individuals, posterior movement of tongue, elevation of larynx were not seen. It was also noted that these individuals also had multiple swallow trials. Asymmetrical movements of faucial pillars and cricopharyngeous muscle were also seen in the dynamic MRI assessment of swallowing.

On assessing the swallowing physiology during dry air swallow, in sagittal plane, it was noted that in all three individuals, multiple swallow trials was observed. The movement of velum toward posterior pharyngeal wall closing the velo pharyngeal port was observed in these subjects. The elevation of hyoid bone antero superiorly and elevation of larynx were diminished in all three subject. The lid action of epiglottis was also observed to be sluggish. On assessing the swallow physiology in sagittal plane during saliva swallow, similar findings were noted. In addition to this, mild pooling of saliva in the pyriform fossa was also observed in two out of three subjects.

On assessing the swallowing physiology in axial plane during dry air swallow, complete closure of velo pharyngeal port by velum was observed in two out of three subjects. In the third subject though the velum approximation was noted, asymmetry was observed. At the level of epiglottis complete closure of larynx was not seen leaving a small gap for the subjects, which facilitated mild pooling of saliva on the pyriform fossa. Asymmetrical movement of the cricopharyngeous muscle was also seen in a subject.