

Videofluoroscopy: Current Clinical Impact in Deglutology

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Received: January 31, 2014

Revised: March 26, 2014

Accepted: April 1, 2014

Published online: May 21, 2014

in Deglutology. *Journal of Gastroenterology and Hepatology Research* 2014; 3(5): 1061-1065 Available from: URL: <http://www.ghrnet.org/index.php/joghr/article/view/695>

EDITORIAL

Swallowing is a complex process involving voluntary and involuntary/reflex phases of deglutition. It can be divided into three anatomically and sequent phases: oral, pharyngeal and esophageal phase. The complicated anatomical and functional relationships of deglutition are susceptible for specific diseases. Such disorders of swallowing impact the quality of life of a large amount of patients across all ages with a prevalence ranging from 5-30% depending on population^[1,2]. A wide variety of conditions may alter deglutition including neurological causes as cerebrovascular accidents, tumors, demyelinating diseases, connective tissue diseases, metabolic disorders, infections, and others. Assessment of swallowing disorders requires a multidisciplinary workup involving otolaryngologists, speech/ language pathologists, gastroenterologists, neurologists, surgeons and specialists of other disciplines. Beside a clinical assessment, also instrumental investigations are mandatory for determining cause and extent of swallowing disorders.

Dynamic recording of swallowing enables analysis of the whole swallowing tract in a "one-stop fashion" and is therefore the method of choice for evaluation of functional as well as morphological abnormalities along the whole swallowing tract.

Fluoroscopy has been used since the early 1900's especially for the examination of bones and soft tissue and some extent also motion. It was not until the 1930's that the work of Janker, Russell Reynolds and Barclay began to yield useful results^[3]. It became a routine practical procedure in the 1980's especially after description of advantages for detection of neurogenic dysphagia of cineradiography by the group around Martin W. Donner^[4,5]. Several authors have modified the investigation procedure over the 1980s and 1990s based on the increasing knowledge of regular swallowing physiology^[6-8].

The studies are performed by recording swallowing loops using videofluoroscopy. A frame rate of 25-30 frames per second is mandatory, as well for perception of the oropharyngeal phase of swallowing, which lasts only for 0.7 seconds, as for subtle esophageal strictures, visible for splits of a second only. Indications include dysphagia, suspicion of aspiration, globus sensation, non cardiac

ABSTRACT

Dynamic recording of swallowing enables analysis of the whole swallowing tract and is therefore the method of choice for evaluation of functional as well as morphological abnormalities in patients with swallowing disorders. It is a very useful tool in the evaluation of the oropharynx and the esophageal phase of swallowing as well. Videofluoroscopy can be performed in children and adults of any ages. Weakness of this method is need of radiation exposure, the fact, that malignancy may not be ruled out completely, and longer education and experience time. According to the clinical problem, a tailored investigation with additional modifications including therapeutic swallowing maneuvers or a tablet test allow exact analysis of the whole swallowing tract as a basis for other diagnostic tests or to complete their results in a complementary way. A variety of different disciplines are involved in the management of patients with deglutition disorders using different techniques. Videofluoroscopy serves as an ideal first test complementary to other investigations, requiring close cooperation between involved disciplines.

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Key words: Deglutition disorders/radiography; Deglutition disorders/etiology; Fluoroscopy; Video recording

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chest pain, reflux patients or unexplained epigastric or respiratory symptoms.

Taking the history of the patient prior to the examination is mandatory for an appropriate tailoring of the videofluoroscopic swallowing study. A standardized investigation protocol can then be modified to provoke swallowing symptoms by using different consistencies and provocative tests. The examination is also depending on whether the patient is suffering from aspiration or other swallowing disorders and requires a different investigation protocol. Beside a diagnostic study, also a therapeutic study can be implemented for evaluation of the effectiveness of swallowing maneuvers, dietary changes or selected postures under fluoroscopic surveillance^[8]. These examination results help in designing appropriate diet and compensatory techniques to reduce aspiration. The presence of the treating speech therapist in a hospital setting facilitates ideal modification of the investigation.

Videofluoroscopy can be performed in children as well as in adults of any ages. While conducting the investigation, the patient should be standing or be seated upright in two lateral or oblique views and should get boluses of different volumes and different consistencies. The graduation of bolus volume is an important factor for evaluation of airway closure and upper sphincter opening. Larger volumes at the beginning of the study could lead to severe aspiration. On the other hand a graduation allows an approach to larger volumes to detect decompensation of an impaired swallowing function with larger volumes. For investigation of esophageal function without influence of gravity, the patient should be investigated in prone and supine position. For radiological interpretation of film sequences it is useful to summarize the anatomical structures involved into seven functional units along the upper digestive tract. These units are suitable for reporting videofluoroscopic studies and help to deconstruct the act of swallowing into its constituent parts: Oral cavity and tongue, Soft palate, Epiglottis, Hyoid and Larynx, Pharyngeal constrictor, Pharyngo-esophageal sphincter, Esophagus and lower esophageal sphincter^[9]. These seven functional units provide the basis for a systematic approach to the evaluation of videofluoroscopic studies, especially for radiologists, who perform diagnostic studies

and in patients without knowledge of the level and the extent of their pathology. This division into functional units can also be used for therapeutic studies. Especially for therapeutic decisions and monitoring of speech and language pathologies imaging interpretations were improved in the last years^[10]. After results of the fluoroscopic swallowing study or endoscopic evaluation, patients are divided into two groups: aspirators and nonaspirators. Each group is treated differently. Patients with severe risks of aspiration should not be allowed to receive food orally unless intensively swallowing therapy is performed and appropriate instructions and maneuvers as well as changes in consistency and volume help to reduce the likelihood of aspiration. Especially the identification of persons with silent aspiration is essential, since they are more likely to develop aspiration pneumonia than patients with sufficient laryngeal closure during bolus passage^[11].

During passage of the bolus, entrance of contrast medium into the laryngeal vestibulum above the vocal cords is called penetration. If laryngeal penetrations are the only pathological finding during several swallows, it can be assessed as an indication of the presence of a neuromuscular swallowing disorder. Single penetrations, often observed during the first passage, may occur sporadically also in healthy individuals, especially in stressful situations. A cough reflex following sporadic penetration is mandatory for confirming harmlessness of intermittent laryngeal entrance of contrast media. Aspiration is defined as contrast medium entering the trachea. Aspiration can occur before initiation of swallowing (predeglutitive figure 1A), during swallowing (intradeglutitive figure 1B) and after the involuntary automatic act of swallowing (postdeglutitive, figure 1C). For an adequate therapy of oropharyngeal swallowing disorders in patients with aspiration, it is of importance, if the patient aspirates at one or more points of time. In many cases aspiration occurs at different points in time and to different degrees. Therefore a precise description of pathological findings facilitates planning of an adequate therapy. Pharyngeal retentions may lead to aspiration after deglutition (postdeglutitive), if the larynx is lowering and opens. The amount of pharyngeal retentions is a predictive factor for the incidence of penetration and subsequent aspiration^[12]. By the use of

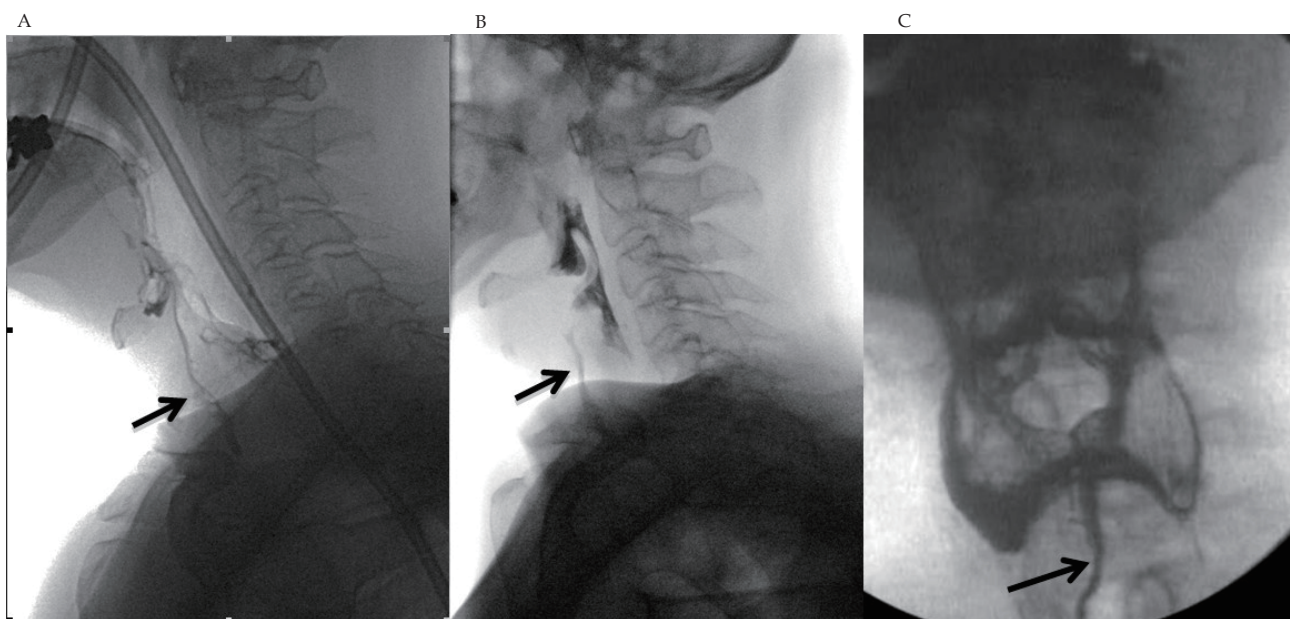


Figure 1 Shows three different patients with aspiration at different time points of swallowing: before (A), during (B) and after (C) elicitation of pharyngeal swallow.

a.p. projection additionally, videofluoroscopy can detect unilateral defects in function of the pharynx and the upper esophageal sphincter as well (Figure 2).

For evaluation of solid food dysphagia, usage of a tablet with a standardized diameter of 14 mm has been proven useful. According to the Schatzki-rule^[13], ring like stenoses with a diameter of 13 mm or less are always symptomatic, whereas none greater than 25 mm are symptomatic and for those in between symptoms are depending on eating habits. Assessment of symptoms evoked during the radiological study, e.g. dysphagia during swallowing a solid bolus, is very important for determination the cause the patient was referred for. For example, a tight lower esophageal sphincter with hindering of bolus passage may not induce any symptoms, whereas functional esophageal disorders may be symptomatic.

Due to the overall investigation of swallowing, not only oropharyngeal disorders are detected, but also esophageal findings. This is of utmost importance, since often swallowing symptoms may not correlate exactly with pathological findings, e.g. sensation of food getting stuck in the esophagus is often referred to a level much higher than the stenosis itself (Figure 3)^[14]. Related to different clinical symptoms, abnormal functional patterns of swallowing can be identified. In an evaluation of more than 2000 patients, 8% showed to have pharyngeal and esophageal pathologies as well^[15]. This fact underlines the value of a complete investigation of all seven stages of swallowing.

Other radiological modalities for recording dynamic swallowing include ultrasonography, which can be used for evaluation of the



Figure 2 Unilateral pharyngeal constrictor paresis on the right side in a patient with history of carcinoma of the floor of the mouth. The divergence of contrast medium to the right side may erroneously pretend a pharyngeal mass on the left side (arrow). Additionally this patient suffered from unilateral dyskinesia of the upper esophageal sphincter (black arrow).

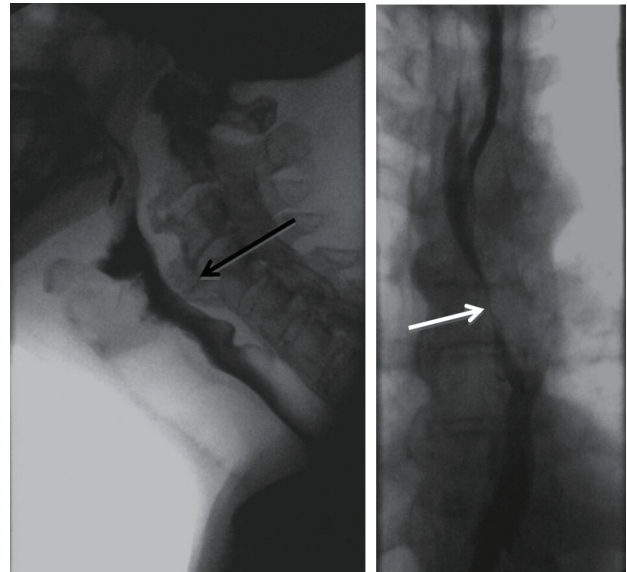


Figure 3 In this 72-year old patient with dysphagia a large anterior osteophyte impinging on the pharynx is visible (black arrow). Passage of liquid and solid boluses did not provoke symptoms at this level, but during delayed passage at the esophageal phase (> 1minute in erect position, white arrow).

oral stage and movement of the hyoid bone and MRI fluoroscopy. Due to fast gradient sequences and shorter acquisition times, an almost “real-time” evaluation of swallowing is possible without radiation exposure. This new technique allows the analysis of bolus transportation in relation to movement of anatomical structures such as tongue, soft palate and pharyngeal constrictors. Disadvantages include the fact, that liquid and solid swallows in dorsal decubitus are not physiological and patients with risk of severe aspiration may not undergo this investigation. Additionally, motion artifacts and a lack of temporal resolution compared to videofluoroscopy still remain a drawback. Simultaneous videofluoroscopy and manometry (videomanometry) provide information about morphological and functional information as well as interpretation of intraluminal pharyngeal pressures. Additionally, a variety of different disciplines are involved in the management of patients with swallowing disorders. They have different perspectives on the patient and use different techniques for assessment of pathologies. Fiberoptic endoscopic evaluation of swallowing (FEES) is a well-established method for assessment of nasal, velopharyngeal, and laryngeal pathology. By inserting a flexible instrument through the nose, swallowing of different consistencies can be observed and documented. FEES is complementary to videofluoroscopy, because assessment of essential foodway structures and the bolus during swallowing, direct assessment of the upper esophageal sphincter as well as evaluation of esophageal function is not possible. For evaluation of esophageal pathologies, endoscopy performed by gastroenterologists and surgeons may detect even subtle mucosal abnormalities and facilitate biopsies and histopathological workup. Esophagoscopy is routinely performed to exclude malignancy or to extract a foreign body. It enables biopsies for histopathological workup and therapeutic manipulations. Radiology and endoscopy are both standard procedures complementing each other. Concerning the question, whether videofluoroscopy or endoscopy should be performed primarily in dysphagic patients without known underlying disease, in a considerable number of patients both methods will be necessary for exact distinction of structural and functional disorders and exclusion of mucosal abnormalities such as Barrett’s

epithelium or achalasia. However, despite an accurate evaluation of the appearance of mucosal surface, gastroenterologists should be aware, that endoscopic evaluation may pass subtle stenoses or ring like strictures without identification of its clinical relevance, since they may cause dysphagia when swallowing larger solid boluses. For this reason, videofluoroscopy as first imaging technique in dysphagic patient has the advantage to depict one or more esophageal stenoses and the physician performing endoscopy is prepared for further clarification of these pathologies. Additional, evaluation distal to a severe stenosis (for example high grade dyskinesia of an upper esophageal sphincter, figure 4) and assignment of topographic relationship may be difficult. In these patients, videofluoroscopy may help by testing different (e.g. solid) consistencies for detection of subtle stenosis and examining the esophagus distal to a stenosis. Manometry (and impedance-manometry) serve as gold standard for assessing esophageal motility disorders. For evaluation of gastroesophageal reflux disease, pH probe studies (e.g. impedance ph-metry) can detect pathologic gastroesophageal reflux, while videofluoroscopy offers demonstration of the dynamic appearance of the esophagogastric junction during and after the bolus passage. Intraluminal impedance monitoring is a relatively new technique offering the possibility to measure esophageal bolus movement without use of radiation. In combination with manometry or pH-monitoring, changes of intraluminal pressure and bolus transit as well as detection of reflux episodes independent of the pH, can be evaluated^[16]. Especially in patients with persisting GERD symptoms after acid suppressive therapy or with non-acid reflux with these investigations imply new additional investigation methods. Comparison of impedance and videofluoroscopy has revealed almost identical volume clearance of the swallowed contrast material^[17]. Impedance planimetry is also a relatively new technique to perform measurements of cross sectional areas in the esophagus in order to graduate esophageal stenosis. Presence of a hiatal hernia, signs of cardiac insufficiency, and the esophagogastric junction after operations are studied by dynamic radiologic recording to rule

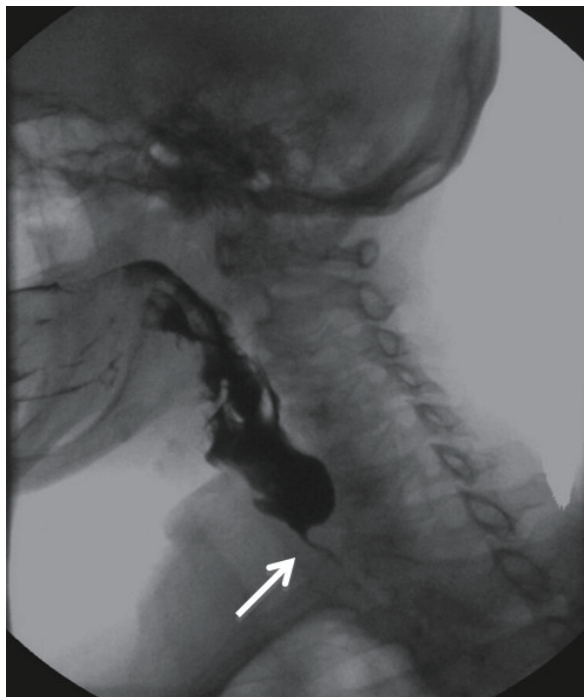


Figure 4 A 75-year old female patient with a marked cricopharyngeal bar (arrow) narrowing the upper esophageal sphincter opening and causing severe pharyngeal retentions of contrast material.

out early and late postoperative complications, such as stenosis, leakage or perforation (Figure 5). Nevertheless a number of benign and malignant structural abnormalities may be identified along the esophageal tube^[18].

The strength of videofluoroscopy is the combined investigation of function and morphology as well^[18,19]. It is a very useful tool in the evaluation not only of the oropharynx, but also the esophageal phase of swallowing. Additional modification including therapeutic swallowing maneuvers and a detailed tailoring of the radiological examination enables evaluation of the entire swallowing tract from mouth to stomach.

Weakness of videofluoroscopy is the fact, that malignancy may not be ruled out completely, and endoscopic workup is needed in patients with suspicion of esophageal cancer. Radiation exposure limits variable follow-up investigations and long fluoroscopic times, although a tailored investigation with modern technology allows a safe investigation in terms of its radiation exposure risk^[20]. Dynamic recording of swallowing needs long education and experience, and a lot of radiologists are used to evaluation morphology only.

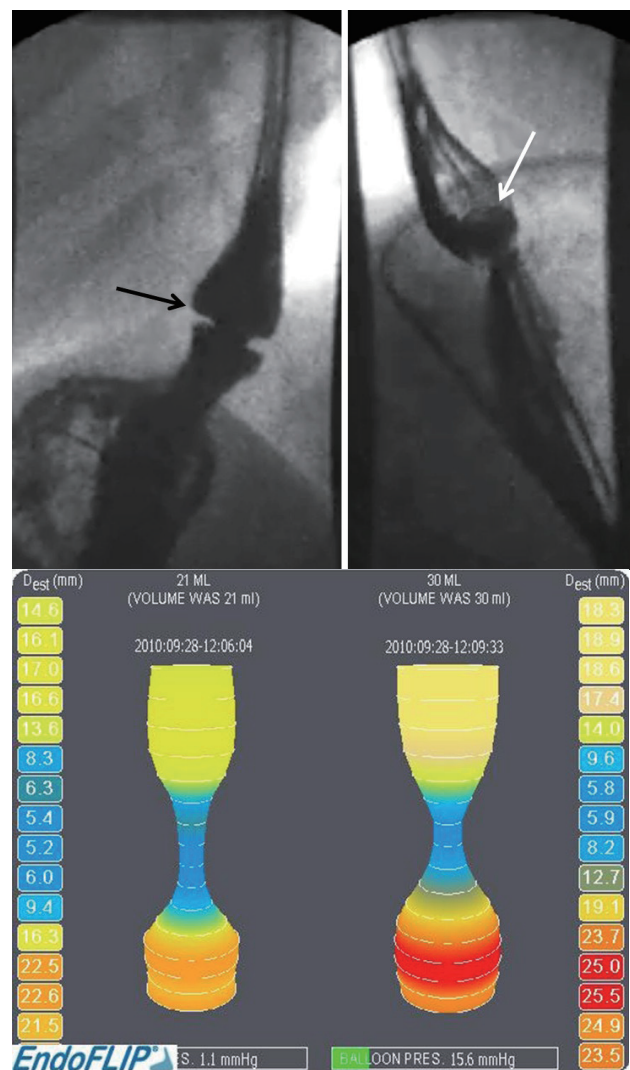


Figure 5 15-year old patient with solid-food dysphagia and history of three impactions. Videofluoroscopy revealed a Schatzki-ring above a small hiatal hernia (black arrow). A standardized tablet with a diameter of 14mm got stuck at the level of the ring (white arrow). Impedance planimetry proved existence of a ring like narrowing at the level of the lower esophagus (Courtesy Dr. Lenglinger, Vienna). Endoscopy and histologic workup showed presence of eosinophilic esophagitis.

Concluding, videofluoroscopy is the diagnostic test of choice for obtaining a descriptive overview of the whole swallowing tract, to detect macropathologic changes and functional disorders as well. It is an ideal first test for evaluation of swallowing disorders complementary to other morphological and functional investigations and requires a tight cooperation between involved disciplines for establishing correct diagnoses and guiding decisions regarding swallowing therapy. Accordant to the clinical problem, a tailored videofluoroscopic examination can be designed for base analysis for other diagnostic tests or to complete their results in a complementary way.

CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

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