Original Article

The value of oropharyngoesophageal scintigraphy in the management of aspiration into the tracheobronchial tree in neurological patients

M. Grosso a, B. Fattori b, D. Volterrani a, S. Chondrogiannis c, G. Boni a, A. Nacci b, M.C. Marzola c, D. Rubello c,∗

a Regional Centre of Nuclear Medicine, Santa Chiara Hospital, University Hospital of Pisa, Pisa, Italy
b Ear, Nose and Throat Audiology Phoniatrics Unit, University Hospital of Pisa, Pisa, Italy
c Department of Nuclear Medicine, Santa Maria della Misericordia Hospital, Rovigo, Italy

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A B S T R A C T

Aim: Dysphagia and bolus aspiration are two of the most frequent and invalidating symptoms of various neurological diseases. Swallowing disorders often lead to tracheobronchial aspiration with consequent pneumonia episodes. Aspiration pneumonia per se constitutes the most frequent cause of death in these patients, with mortality rate ranging from 20% to 62%. Oropharyngoesophageal scintigraphy (OPES) permits functional quantitative assessment of the different stages of swallowing, together with the detection and quantitative measurement of bolus aspiration. In this work, we analyzed the role of OPES in patients with different neurological conditions to evaluate swallowing and to detect and quantify bolus aspiration.

Material and methods: We enrolled 43 neurological patients (25 women and 18 men, mean age 67.3 ± 12.4 yr) complaining of dysphagia with suspected inhalation. All patients underwent OPES with 99mTc-nanocolloid using a liquid bolus first, followed by a semi-solid bolus. We evaluated the following parameters: Oral, Pharyngeal and Esophageal Transit Time, Oro-Pharyngeal Retention Index, Esophageal Emptying Rate, and Aspiration Rate (% AR).

Results: OPES detected some airway aspiration in 26/43 patients. 19 patients had tracheal aspiration (with a mean 18.1% AR) and the remaining 7 patients had bilateral broncho-pulmonary aspiration (mean 44.9% AR).

Conclusions: OPES is a feasible, repeatable and noninvasive method that allows quantitative assessment of bolus aspiration into the tracheobronchial tract, thus representing a useful and accurate tool to guide the most appropriate treatment and to monitor response to therapy in neurological patients with dysphagia.

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El valor de la gammagrafía orofaringeoesofágica en el manejo de la aspiración en el árbol traqueobronquial en pacientes neurológicos

R E S U M E N

Objetivo: La disfagia y la broncoaspiración de comida son 2 de los síntomas más frecuentes e invalidantes de diversas enfermedades neurológicas. Los trastornos de deglución producen una aspiración traqueobronquial y episodios de neumonía. La neumonía por aspiración constituye en sí misma la causa más frecuente de muerte en estos pacientes, con tasas de mortalidad entre 20–62%. La gammagrafía orofaringeoesofágica (OPES) permite la evaluación funcional cuantitativa de los diferentes estadios de la deglución, junto con la detección y la cuantificación de la broncoaspiración. En este trabajo analizamos el papel de la OPES para evaluar la deglución y para detectar y cuantificar la broncoaspiración de comida en pacientes con variadas situaciones neurológicas.

Material y métodos: Se estudiaron 43 pacientes neurológicos (25 mujeres y 18 hombres, edad media 67.3 ± 12.4 años) que presentaban disfagia y sospecha de inhalación. A todos los pacientes se les realizó OPES con 99mTc-nanocoloido usando primero un bolo líquido y después un bolo semisólido. Se evaluaron los siguientes parámetros: tiempos de tránsito oral, faríngeo y esofágico, índice de retención orofaringea, tasa de vaciamiento esofágico, índice de retención orofaringea, tasa de vaciamiento esofágico y tasa de aspiración (%AR).

∗ Corresponding author.
E-mail addresses: domenico.rubello@libero.it, rubello.domenico@azisanrovigo.it (D. Rubello).

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**Introduction**

Dysphagia is defined as difficulty in swallowing food (semi-solid or solid), liquid, or both. Lots of neurological conditions may predispose a person to difficulty in swallowing (Table 1). Also radiation therapy damage can be considered as neurological damage, because it can produce sensory and motor denervation and fibrosis of the upper aero-digestive tract musculature and mucosa. The first two phases of swallowing are usually impaired in dysphagia caused by neurological disorders (being also defined as oropharyngeal dysphagia). The impairment usually goes hand in hand with the primary disorder and dysphagia can appear with two different modalities. In some cases (as stroke and traumatic brain injury) there is an acute onset and an apparently favorable course. In other cases, as neurodegenerative diseases, a chronic and progressive impairment with more invalid consequences is presented. All forms are anyway associated with an increased risk of tracheobronchial aspiration, a condition that can be life threatening by itself (because of suffocation) or because of the associated aspiration pneumonia. Silent aspiration, which occurs as a physiological event also in normal subjects while sleeping, appears to be particularly frequent in patients presenting dysphagia of neurological origin, reaching 40–60% of subjects according to reports in the literature. This event leads to an increase in morbidity and mortality of the patients affected, as well as a deterioration in quality of life and a marked increase in public health spending.

Pathophysiologic studies of dysphagia have involved overtime physicians from various specialties such as neurologists, gastroenterologists, otorhinolaryngologists, radiologists and nuclear medicine specialists. An appropriate management of dysphagia would require a prompt diagnosis – based on the early identification of those patients having/or presenting risk of aspiration – and a characterization as best as possible of the impairment of each phase of swallowing (oral, pharyngeal, and esophageal phases).

There are few diagnostic examinations for dysphagia assessment.

**Table 1**

<table>
<thead>
<tr>
<th>Neurological diseases</th>
<th>Conditions associated with dysphagia and aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrovascular disease</td>
<td>Parkinson disease</td>
</tr>
<tr>
<td>Head/spinal injury</td>
<td>Amyotrophic lateral sclerosis</td>
</tr>
<tr>
<td>Anoxia</td>
<td>Huntington disease</td>
</tr>
<tr>
<td>Myositis</td>
<td>Myasthenia Gravis</td>
</tr>
<tr>
<td>Guillain-Barre Syndrome</td>
<td>Alzheimer disease</td>
</tr>
</tbody>
</table>

Modified from Radiographics 2006.

**Results:** La OPES detectó broncoaspiración en 26/43 pacientes. Diecinueve pacientes tuvieron aspiración traqueal (media AR 18,1%) y los restantes 7 pacientes aspiración broncopulmonar bilateral (media AR 44,0%).

**Conclusions:** La OPES es un método no invasivo, factible y repetible que permite la evaluación cuantitativa de la aspiración de comida en el tracto traqueobronquial. Por ello, representa un procedimiento útil y exacto para guiar el tratamiento más apropiado y para monitorizar la respuesta terapéutica en pacientes neurológicos con disfagia.

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The patient kept in his/her mouth a 10–ml bolus of water labeled with 37 MBq of $^{99m}$Tc-albumin nanocolloid, which was swallowed 2 s after starting a dynamic acquisition for 60 s (0.125 s/frame, matrix 64 × 64, zoom 1). At the end of dynamic recording, keeping the patient in the same position, a 60-s static image was acquired to detect any penetration or tracheobronchial aspirate. After images examination, with a negative study for presence of aspiration and after a 30 min rest, the patient underwent the semi-solid test. For this part of the exam, we used 10 ml of a jellied drink (Bevanda Gelificata, Novartis S.A.®) labeled with 37 MBq of $^{99m}$Tc-albumin nanocolloid and the test was performed as for the liquid bolus, repeating timing of acquisition and patient protocol.

At the end of both studies, images were interpreted in both a qualitative and semi-quantitative way. For the qualitative assessment, we valued the kind of swallowing (as a result of unique movement or of fragmentation of bolus), starting from the oral to the esophageal phase, and we also considered the presence of any retention or penetration/aspiration. Scans were classified as either negative (no activity noted lateral to the midline that was distinct from the esophagus and stomach, and in the neck) or positive, defined as activity lateral to the midline in the neck region or the chest.

For the semi-quantitative assessment the following parameters were analyzed: Oral, Pharyngeal and Esophageal Transit Time (OTT-PIT-ETT), Oro-Pharyngeal Retention Index (OPRI$_{10}$), Esophageal Emptying Rate (EER$_{10}$), and Aspiration Rate (AR). The pharyngeal region of interest (ROI) was that between the oral cavity and the external reference corresponding to the pharyngoesophageal transition (Figs. 1 and 2).

AR was calculated as: AR = (IA/AT$_0$ – AT$_1$) × 100, where IA stands for inhaled activity, while AT$_0$ and AT$_1$ stand for oral activity before and after swallowing the radioactive bolus, respectively.

In order to better characterize aspiration, a complementary SPECT/CT acquisition was performed in 3 patients with massive bilateral pulmonary aspiration. We applied the following parameters for acquisition: 360° rotation (180° each head) in the step-and-shoot mode (60 frames, 20 s/frame, matrix of 128 × 128 and zoom factor 1.00). The CT study was performed with a 128 × 128 matrix, zoom 1, 25 mA and 140 keV, acquiring 120 views (1/3°, 360°).

### Results

OPES was positive in 26/43 patients (60% totally), showing presence of some aspiration. In particular, 19 patients showed tracheal aspiration (mean 18.1% AR), and the remaining 7 patients had bilateral broncho-pulmonary aspiration (mean 44.9% AR) (Fig. 3) (Table 2). In 18/43 patients OPES changed patient management in terms of follow-up or dietary intake. In 13/43 patients allowed to evaluate the improvement of the swallowing in relation to patient positions as well as speech rehabilitation strategies.

In the remaining 17 patients with a negative liquid test for the presence of aspiration, the semi-solid test was also performed, which confirmed the absence of tracheobronchial aspiration.

In these patients we confirmed the alteration of some functional parameters, particularly the longer OTT (1.6 ± 1.1 s) and PTT (1.6 ± 1.4 s) and higher OPRI 10 s (20 ± 13%).

### Table 2

Mean percentages of tracheal and pulmonary aspiration in different diseases.

<table>
<thead>
<tr>
<th></th>
<th>N pts</th>
<th>Tracheal aspiration Mean (%)</th>
<th>Pulmonary aspiration Mean (%)</th>
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</thead>
<tbody>
<tr>
<td>SLA</td>
<td>16/25</td>
<td>12 (17.7%)</td>
<td>4 (45.6%)</td>
</tr>
<tr>
<td>Stroke</td>
<td>5/9</td>
<td>2 (18.4%)</td>
<td>3 (44.2%)</td>
</tr>
<tr>
<td>Parkinson</td>
<td>5/9</td>
<td>5 (18.3%)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>26/43</td>
<td>19 (18.1%)</td>
<td>7 (44.9%)</td>
</tr>
</tbody>
</table>
The occurrence of aspiration is established most reliably and comprehensively by conventional imaging techniques. Videofluoroscopy and fiberoptic endoscopic evaluation of swallowing are still the gold standard for determining deglutition impairment. Their information make possible the assessing of airway penetration by the food bolus, thus guiding clinicians in dysphagia treatment plan. It is however well established that both techniques are inadequate for determining the extent of the respiratory tree penetrated and the amount of material aspirated, that constitute critical factors for the development of pneumonia. Oropharyngoesophageal scintigraphy can detect the extensiveness of aspiration below the glottis, giving also possibility for a semi-quantitative measurement of aspirate, that is useful to adopt some different rehabilitative strategies in patients’ management.

Our goal was to assess how the results of a scintigraphic swallowing test, detecting or confirming presence of aspiration, can change clinical management of 43 neurological patients suspected to have aspiration, assessing the severity of aspiration. The decision to either continue or further limit liquid intake in a person who aspirates often occurs without knowledge of the fate of the material penetrating the glottis. In individuals so diagnosed, liquid may or may not migrate further into the respiratory tree. Aspiration is believed to be caused by alteration of the oral and/or pharyngeal phase of swallow, both as a consequence of neuromuscular incoordination or defective reflexes related to pathological involvement of cranial nerves IX-XII. Anatomic and pathophysiologic alterations of the upper aero-digestive tract such as fistulae, diverticulae, or changes resulting from surgery or radiation are other known causes of dysphagia. Aspiration may result in various clinical presentations.

Discussion

Normal swallowing requires the coordinated activity of the muscles of the mouth, pharynx, larynx, and esophagus, which are innervated by the central and peripheral nervous systems. Respiration and swallowing are coordinated systems that share some common anatomy and physiology. The time–activity curves obtained in the oral cavity (A) and pharynx (B) show a slowing of the pharyngeal transit with bolus liquid that becomes more evident with semi-solid bolus (C) in patients with neurological disease. The use of the semi-solid bolus increases the sensitivity of the scintigraphic study identifying a greater number of swallowing disorders as it is necessary for a greater peristaltic activity and coordination between different muscle segments to facilitate the progression of the semi-solid bolus.
such as choking or coughing during swallowing, chronic cough, or voice changes such as hoarseness, pneumonia or even bronchial asthma.\textsuperscript{15,16} Mortality rates ranging from 20 to 65% have been reported for aspiration pneumonia.\textsuperscript{16}

In case of aspiration, indications are needed to suspend oral feeding and to adopt other alternatives, which in most cases is performed by means of percutaneous endoscopic gastrostomy (PEG). OPES can help clinicians in programming of the specific therapeutic strategy, which includes the choice of the type of food to be given and/or planning of the speech rehabilitative treatment. In our patient population, OPES changes management in patients with asperture. These patients with a mild to moderate inhalation (lower than 20%) underwent a change in their feeding, or underwent a limitation in oral feeding. In cases of more severe inhalation in which rheological changes of the bolus and/or rehabilitation techniques of compensation were not able to prevent tracheobronchial aspiration, application of PEG (8 cases, 19%) was recommended.

OPES is a simple, inexpensive, non-invasive and reliable technique in demonstrating the presence of aspirated bolus and quantifying the tracheobronchial aspiration. It also enables to measure transit times and retention indices, and to assess at the same time both upper digestive tract and esophagus. The clinical role of OPES is therefore to be recognized in its ability to identify swallowing abnormalities, and to provide not only diagnostic information, but also for evaluation of response to medical and/or surgical treatment, as well as for follow-up\textsuperscript{17} (Fig. 4).

The main disadvantage of this technique is represented by poor anatomical detail, and the consequent inability to provide a topographical diagnosis. In our patient population and in selected cases the use of SPET/CT improves identification and characterization of the anatomic structures involved.

In these particular cases OPES showed as constituting a valid technique for detecting the presence of tracheobronchial aspiration and evaluating the response to the different management procedures.

Conclusions

OPES allows an objective, quantitative evaluation of bolus inhalation into the tracheobronchial tract. It is easy to perform, well tolerated by patients, repeatable, and inexpensive. Although the place of scintigraphy in the management of dysphagia is not considered a gold standard, we believe it is presently useful for patients with known or suspected aspiration in whom further understanding of the extensiveness of aspiration would be critical to the decision of whether to allow liquids by mouth. Determining the exact fraction of the inhaled bolus into the tracheobronchial tree, in neurological patients with dysphagia, represents a useful and accurate tool to change patient management and to monitor response to medical and/or surgical therapy.

Conflict of interest

The authors declare no conflict of interest.

References