Effects of age and body mass index on pharyngeal residue in healthy subjects

Ahmed H. Khafagy and Mohamed S. Taha

Otolaryngology-HNS, Ain Shams University Hospital, Cairo, Egypt
ahmedkhafaagy@yahoo.com

Abstract: Objective: This study compared fiberoptic endoscopic evaluation of swallowing findings in healthy volunteers over 50 years of age versus those less than 50 years old. **Design:** Prospective study. Participants: Forty male healthy volunteers, all over the age of 30 years, underwent nasopharyngoscopy for the evaluation of bolus dwell time, pharyngeal closure time, and pharyngeal residue after receiving four boluses of green-dyed food. Main outcome measures: Bolus dwell time, pharyngeal closure time, and pharyngeal residue scores. **Results:** Participants over 50 years of age (the >50 years group) were significantly more likely to have higher residue scores than younger participants. Residue deposition was most common in the valleculae, followed by lateral pharyngeal walls, the pyriform fossae, and lastly, the posterior pharyngeal wall. The >50 years group showed significantly longer bolus dwell time than younger patients but did not have significantly longer pharyngeal closure time. Residue severity scores were found to be positively correlated with age, body mass index, bolus dwell time, and pharyngeal closure time. As such, all of these factors were found to be sensitive predictors for residue severity. **Conclusion:** The frequency and severity of swallowing disorders in healthy volunteers increase as age and body mass index increase, and fiberoptic endoscopic evaluation of swallowing is a safe and appropriate screening modality for such disorders.

[Ahmed H. Khafagy and Mohamed S. Taha. **Effects of age and body mass index on pharyngeal residue in healthy subjects**. *Journal of American Science*. 2011;7(11):440-446]. (ISSN:1545-1003). http://www.americanscience.org. 54

Key words: Fiberoptic endoscope, swallowing difficulty, healthy elderly people.

1. Introduction

Dysphagia is a symptom that suggests either a structural or neuromuscular disorder of the oropharynx or oesophagus. Dysphagia should be distinguished from globus sensation and odynophagia. The two types of dysphagia, oropharyngeal and oesophageal, involve different phases of swallowing, are accompanied by different symptom complexes, and have different etiologies. The clinical evaluation of the dysphagic patient by the otolaryngologist requires the taking of a detailed history of the complaint, an extensive ENT physical examination, and the performing of fiberoptic nasopharyngolaryngoscopy to assess the oral and pharyngeal phases of swallowing. Special investigations, including radiography, oesophageal endoscopy, ultrasonography, pH metry, and manometry, may be needed to establish the full diagnosis [1, 2].

The prevalence of oropharyngeal functional dysphagia is very high. In fact, it affects more than 30% of patients who have had a cerebrovascular accident, 52–82% of patients with Parkinson's disease, and 84% of patients with Alzheimer's disease. In spite of the enormous impact of dysphagia on the functional capacity, health, and quality of life of individuals who suffer from it, oropharyngeal dysphagia is underestimated and underdiagnosed as a cause of symptoms and major nutritional and respiratory complications, especially in older patients [3, 4, 5].

The diagnosis of swallowing disorders and the assessment of their severity are still matters of controversy. **Nacci *et al.*** [6] stated that fiberoptic endoscopic evaluation of swallowing (FEES) is the current first choice method for the study of swallowing disorders due to its various advantages. Specifically, FEES is easy to use, very well tolerated, allows bedside examination, and is economical. Nevertheless, this diagnostic procedure is not without risks. The most common deleterious consequences of FEES include discomfort, gagging and/or vomiting, vasovagal syncope, epistaxis, mucosal perforation, adverse reactions to topical anaesthetics, and laryngospasm. **Leder & Murray** [7] have stated that the evaluation of swallowing by FEES allows for the assessment of pharyngeal dysphagia and the implementation of rehabilitation intervention with the goal of promoting safe and efficient swallowing. In line with FEES being a safe technique, **Warnecke *et al.*** [8] investigated the safety of FEES in patients with acute stroke and reported that the incidence of self-limited nosebleeds was 6% and did not significantly differ in relation to stroke type (ischemic versus hemorrhagic), acute treatment strategy (thrombolysis versus no thrombolysis), and secondary prevention regimen (anticoagulant therapy versus antiplatelet drugs). No alterations in diastolic blood pressure were noted, and an assessment of comfort revealed that >80% of patients tolerated FEES exceptionally well.

Another issue in regard to FEES is the interpretation of the findings of the procedure. However, this matter is related to operator training and experience and, as documented by **Warnecke *et al.*** [9] should not be viewed as an issue that prevents its use. These authors reported that the endoscopic examination protocol is reliably interpreted by inexperienced clinicians after a short lecture and thus can be easily and successfully adopted in dysphagia management.

The aim of this prospective study was to compare FEES findings in healthy volunteers from two age groups.

2. Material & Methods

The present study was conducted in Ain Shams University Hospital after the Local Ethical Committee approved the study protocol and fully informed consent was obtained in writing from the study participants. Forty study participants were enrolled in the study. Inclusion criteria included male gender (to obviate the impact of gender on the results), age older than 30 years, and the absence of cardiovascular, cerebrovascular, and neurocognitive disease. Males with chronic renal failure, hepatic diseases, or endocrine disorders and those who had undergone previous surgical procedures that involved the nose, mouth, pharynx, larynx, or oesophagus were excluded from the study.

All study participants underwent a complete history and general physical examination, including the determination of body weight and height for the calculation of body mass index (BMI) according to age-adjusted tables. Next, each study participant underwent an abdominal examination and a complete otorhinolaryngological examination. All participants were evaluated for the presence of dysphagia, and if dysphagia was found, the relationship of the dysphagia to certain types of food and/or fluids, and the duration, frequency, and progression of the dysphagia was examined. Any participant discovered to have any dysphagic manifestations or findings that induce dysphagia was excluded from the study and replaced.

All study participants underwent nasopharyngoscopy with an Olympus ENF-P4 fiberoptic nasoendoscope (Tokyo, Japan), a Rimmer Brothers CLS150-2 light source (London, UK), a Karl Storz camera 2010N and CCD camera 2010E (Tuttlingen, Germany), a Sony Trinitron Colour Video monitor (Tokyo, Japan), and a Panasonic SVHS Video Cassette Recorder AG-7330 (Tokyo, Japan). Nasendoscopy was performed by an otorhinolaryngologist.

A 4.1-mm digital flexible endoscope was lubricated with 2% viscous KY jelly and passed transnasally on the floor of the nose to obtain a superior view of the hypopharynx. The distal end of the endoscope was situated just above the top of the epiglottis to allow for visualization of the entire base of the tongue, the tip of the epiglottis, the posterior and lateral pharyngeal walls, and the laryngeal vestibule. Such a swallowing position was maintained during all bolus administrations except for during the seconds when the scope was advanced to the post-swallow position after the presentation of a bolus.

The swallowing position allowed for the visualization and scoring of the bolus dwell time, pharyngeal closure time, and residue severity. Bolus dwell time was measured in seconds from the first frame in which the head of the bolus was at the level of the valleculae and/or the pyriform sinuses until the first frame of lingual bolus propulsion associated with the pharyngeal swallow. If the swallow started before the head of the bolus reached the level of the valleculae and/or pyriform sinuses, a score of 0 was assigned. Pharyngeal closure time was measured in seconds from the first to the last frames of complete whiteout, which occurs as the result of the oropharyngeal mucosa enveloping the distal end of the endoscope and is an estimate of the pharyngeal stage of a swallow.

Pharyngeal residue severity was graded according to the rating scale described by **Kelly *et al.*** [10] as follows: 0=no residue, 1=just coating, 2=mild residue, 3=moderate residue and 4=severe residue. Residue severity was scored for the right and left valleculae, right and left lateral channels, right and left pyriform fossae, posterior pharyngeal wall, laryngeal inlet, interarytenoid space, subglottis, and proximal trachea. The lateral channels were bordered by the pharyngoepiglottic fold, the apex of the pyriform fossa, the aryepiglottic fold, and the lateral pharyngeal wall.

All participants swallowed four boluses in the following order: a large mouthful of liquid consisting of 50% half-fat milk and 50% water, 10 ml smooth vanilla yoghurt, 10 ml chopped banana, and a 3×3-cm cheese sandwich. All boluses were dyed with green food colouring to allow for better endoscopic visualization.

Statistical analysis

Data are presented as means ± SD, numbers, and percentages and were analyzed with the Wilcoxon ranked test for unrelated data. Possible correlations were evaluated with Pearson's correlation coefficient. Variable independency, as a predictor of residue severity, was evaluated with regression analysis that used a stepwise method for multivariants and the receiver operating characteristic (ROC) curve as judged by the area under the curve (AUC). Statistical analyses were conducted using SPSS program (Version 10, 2002), and $p<0.05$ was considered significant.

3. Results

The study included 40 participants that were categorized into two groups based on age. One group consisted of participants 50 years of age and younger (≤50 years group), and the other was composed of the participants older than 50 years (>50 years group). To standardize comparisons, an equal number of participants were placed in the two groups. Body weight and BMI were significantly higher in the >50 years group (Table 1).

All enrolled participants had no swallowing complaints, and all completed the study protocol successfully. There was a total of 1,760 data points available for statistical analyses concerning residue severity (40 participants × 4 swallows × 11 sites), and 80 data points were available for the statistical analysis of fluid bolus dwell time and pharyngeal closure time.

In regard to residue severity, the ≤50 years group had a significantly lower (X^2= 3.731, p<0.05) frequency of higher residue scores than the >50 years group (Fig. 1).

Among the participants found to have had residue, irrespective of severity, yoghurt was the most frequent residue-inducing food (66.7%), followed by chopped bananas (43.3%), and fluid (30%). The semi-hard food (cheese sandwich) was the least likely food to induce residue, leaving residue in only 16.7% of the participants.

Residue was most commonly detected in the valleculae (both sides), with detection frequencies of 63.3% and 60% for the left and right sides, respectively. The lateral pharyngeal walls had residue detection frequencies of 60% (left) and 50% (right), the pyriform fossae had detection frequencies of 36.7% (left) and 33.3% (right), while the posterior wall had a residue detection frequency of 16.7%. Such high frequencies of residue detection indicate that residue could be detected in multiple sites in the same subject.

The bolus dwell time was significantly longer in the >50 years group compared to the ≤50 years group, whereas there was no significant difference between the groups in the pharyngeal closure time (Table 2).

Evaluation of the relationships of residue severity scores with age and anthropometric measures revealed significant positive correlations between residue severity score and age (r=0.358, *p*=0.023) and BMI (r=0.408, *p* =0.009). On the other hand, residue severity score was significantly negatively correlated with body height (r=-0.410, *p* =0.009). In regard to the evaluated swallowing measures, the residue severity score was significantly positively correlated with the bolus dwell time (r=0.474, *p* =0.002) and the pharyngeal closure time (r=0.384, *p* =0.014) (Table 3).

The ROC curve analysis of evaluated constitutional and swallowing parameters as predictors of residue severity identified age and the pharyngeal closure time as significant, sensitive predictors [AUC=0.238 (*p* =0.007) and AUC=0.220 (*p* =0.004), respectively] (Table 4, Fig. 2).

Regression analysis of the evaluated constitutional and swallowing parameters as predictors of residue severity identified BMI and bolus dwell time as significant predictors of residue severity in all three models used, bolus dwell time, and pharyngeal closure time as significant predictors in two of the models, and body weight as a significant predictor in one model (Table 5).

Table 1. Enrolment data of the study participants

	All participants	<50 years group	>50 years group	Statistical analysis	
				Z	*p*
Age (years)	55.3±13.3	43.2±3.9	67.5±6.3	3.923	<0.001
Body weight (kg)	85.8±7.6	82.4±8.5	89.1±4.7	2.557	0.011
Body height (cm)	170.8±3	170.6±3.1	170.9±3	0.453	>0.05
BMI (kg/m^2)	29.5±3	28.4±3.5	30.5±1.9	2.091	0.037

Data are presented as mean±SD; BMI: body mass index

Table 2. Estimated bolus dwell time and pharyngeal closure time in the study participants

	All participants	<50 years group	>50 years group	Statistical analysis	
				Z	*p*
Bolus dwell time (sec)	0.95±0.25	0.87±0.1	1.03±0.37	2.450	0.014
PCT (sec)	0.52±0.21	0.52±0.22	0.53±0.21	0.298	>0.05

PCT: Pharyngeal closure time

Table 3. Correlation coefficients between the residue severity scores and the evaluated constitutional and swallowing parameters

	r	*p*
Age (years)	0.358	0.023
Body weight (kg)	0.293	>0.05
Body height (cm)	-0.410	0.009
BMI (kg/m^2)	0.408	0.009
Bolus dwell time (sec)	0.474	0.002
Pharyngeal closure time (sec)	0.384	0.014

BMI: body mass index

Table 4. Receiver operating characteristic curve analysis of the evaluated constitutional and swallowing parameters as predictors of residue severity

	AUC	Std Error	*p*	Asymptotic 95% confidence interval	
				Lower boundary	Upper boundary
Age (years)	0.238	0.084	0.007	0.073	0.402
BW (kg)	0.359	0.099	>0.05	0.165	0.552
BH (cm)	0.688	0.095	>0.05	0.503	0.874
BMI (Kg/m^2)	0.330	0.095	>0.05	0.143	0.516
Bolus dwell time (sec)	0.486	0.115	>0.05	0.262	0.711
PCT (sec)	0.220	0.075	0.004	0.074	0.366

BMI: body mass index; BW: body weight; BH: body height; AUC: area under curve; Std error: standard error.

Table 5. Regression analysis of the evaluated constitutional and swallowing parameters as predictors of residue severity

Models	Parameters	Age	Body weight	Body height	BMI	Bolus dwell times	PCT
Model 1	ß	0.254	0.288	0.233	0.355	0.327	0.230
	t	1.927	2.262	1.653	2.669	2.469	1.672
	p	>0.05	0.030	>0.05	0.011	0.018	>0.06
Model 2	ß	0.132	0.270	0.076	0.335	0.276	0.320
	t	0.932	0.682	0.488	2.669	2.176	2.565
	p	>0.05	>0.05	>0.05	0.011	0.036	0.015
Model 3	ß	0.048	0.145	0.029	0.409	0.237	0.320
	t	0.348	0.388	0.198	3.286	1.971	2.565
	p	>0.05	>0.05	>0.05	0.002	>0.05	0.015

ß: standardized coefficient; BMI: body mass index; PCT: pharyngeal closure time.

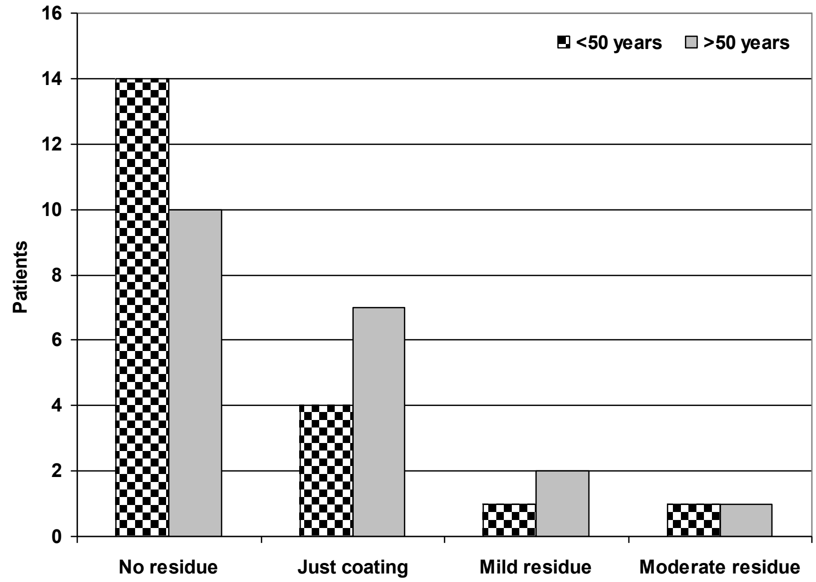

Fig. (1): Residual severity scores of examination points of study participants' categorized according to age

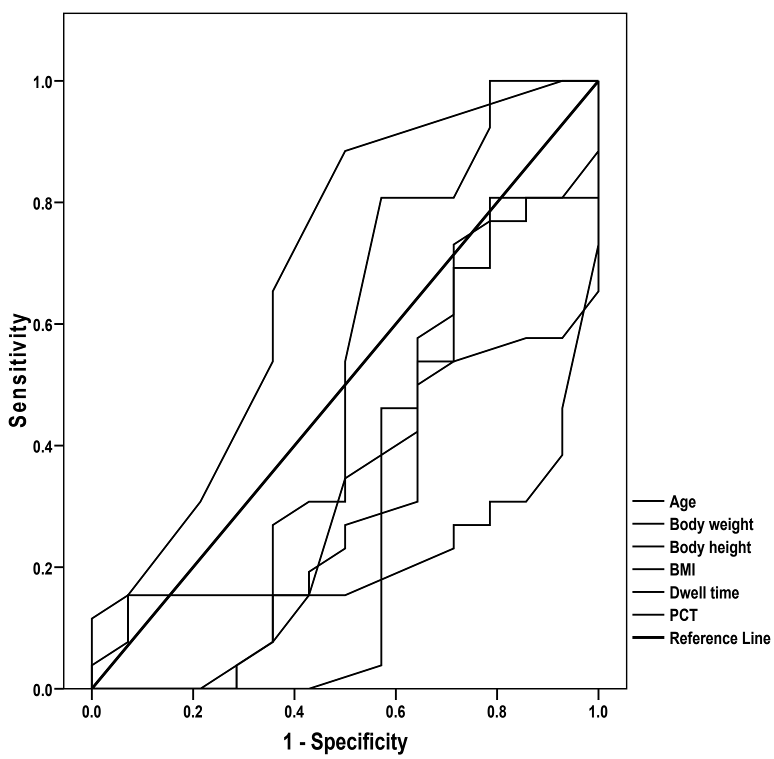

Fig. (2). Receiver operating characteristic (ROC) curve analysis of the evaluated constitutional parameters and swallowing data as predictors of residue severity.

4. Discussion

The evaluation of swallowing dynamics and the detection of food residue represent important markers in the differentiation between not only normal people and those who have definite dysphagia, but also between people with functional and organic dysphagia. Such differentiations are important for the proper planning of oral nutrition for ICU patients, especially those in a coma. Moreover, the determination of a patient's risk for aspiration is very important when planning the rehabilitation of a dysphagic patient [11, 12, 13]. The current prospective study compared swallowing parameters in volunteers from two age groups, ≤ 50 years and > 50 years.

In the present study, we used nasopharyngeal endoscopy for the swallowing evaluation due to the accuracy of this technique, which was documented by **Coscarelli *et al.*** [12]. These investigators indicated a change in nutritional methods in 60% and percutaneous endoscopic gastrostomy in 20% of studied patients and found that with these indications, none of these patients developed aspiration pneumonia. These investigators found that none of their patients developed aspiration pneumonia and thus concluded that bedside fiberoptic study of neurological patients with dysphagia had demonstrated its effectiveness by eliminating the incidence of aspiration pneumonia. Also, **Bader & Niemann** [14] found that FEES was a feasible tool for the diagnosis of paediatric swallowing disorders that had a low rate of complications. **Warnecke *et al.*** [15] determined that the fiberoptic endoscopic dysphagia severity scale strongly and independently predicted the outcome and intercurrent complications after acute stroke and that a baseline FEES examination provided valuable prognostic information for the treatment of acute stroke patients. Moreover, **Suiter & Moorhead** [16] reported that the presence of a flexible fiberoptic endoscope in the pharynx during swallowing did not significantly affect pharyngeal swallow physiology in the patients studied. In addition, the use of nasopharyngeal endoscopy eliminated the need for the patient transfer and exposure to radiation that occurs in fluoroscopy.

The presence of pharyngeal residue after the swallowing of boluses of food of various consistencies was a definite problem in both groups, although it occurred much less frequently in the younger group. This finding indicated the true sense of residue as a complaint of some patients when they present at various clinics. Moreover, the valleculae, lateral pharyngeal wall, pyriform fossae, and posterior pharyngeal wall were the sites of residue accumulation (listed in descending order of frequency). The accumulation of residue at the valleculae may explain the sense of choking after drinking that is often encountered because the residue may overflow into the larynx during respiration and induce aspiration or a sense of choking.

It was evident that there were age-dependent changes in the swallowing parameters, with the residue severity score being significantly positively correlated with age and bolus dwell time. Moreover, ROC curve analysis identified older age as a sensitive and significant predictor of the presence and severity of pharyngeal residue. These findings are contradictory with those of **Kelly *et al.*** [10] who reported that substantial pharyngeal residue is not common in young or elderly individuals and that there was only a slight difference due to age, which probably was due to disordered swallowing. However, **Kelly *et al.*** [10] could not explain these results, and their explanation depending on their exclusion criteria are misleading. This is because we followed the same rules for inclusion of participants and it was evident that the deterioration of deglutition functions was age dependent. This is quite interesting because we used the same inclusion criteria and found that the deterioration of deglutition function was dependent on age.

In support of our results concerning age dependency, **El-Solh *et al.*** [17] assessed the prevalence of swallowing dysfunction after prolonged endotracheal intubation in critically ill elderly patients and the time it took for recovery compared to a younger cohort. They reported aspiration in 52% of the elderly patients and 36% of the younger patients. Further, no patient in the younger group had swallowing deficits after 2 weeks, whereas 13% of the elderly patients showed persistent impairment of the swallowing reflex. **Leder & Suiter** [18] found that dysphagia referral rates doubled between 2000 and 2007, with increases of 20% per year and increases in all years from 2002 through 2007. Over 70% of dysphagia referrals were for patients of 60 years and older and over 42% of these referrals were for patients older than 80 years. Between 2000 and 2007, referrals for 80- to 89-year-old patients almost doubled and referrals for patients older than 90 years more than tripled. **Lelovics** [19] assessed the nutritional status and changes in BMI of people older than 60 years (elderly) living in long-term care institutions and reported that the risk of malnutrition is high (26.8-77.0%) among this population. The presence of swallowing difficulties may be an important factor contributing to malnutrition in this population, as **Lelovics** [19] reported that swallowing difficulties are 2.5-fold more common in this population versus people less than 60 years of age.

A few of the most interesting findings of the current study were the significantly positive correlation between the residue severity score and BMI and the significantly negative correlation between the residue severity score and body height. The latter finding suggests a problem with short stature, which could be associated with the short neck and its sequelae often found in shorter people. In agreement with these findings, **Lundkvist & Friberg** [20] investigated the extent of improvement in pharyngeal symptoms in patients with obstructive sleep apnea syndrome with a median BMI of 28 kg/m^2 (range: 20-38 kg/m^2) and found that their median score for pharyngeal symptoms was unchanged after uvulopalatopharyngoplasty with tonsillectomy. Thus, the problems with swallowing could be attributed to the impact of obesity, although no comment on the possible effect of weight reduction was made. **Nam *et al.*** [21] found that erosive oesophagitis was positively correlated with obesity measured by BMI, waist circumference, and abdominal visceral adipose tissue volume. Moreover, **Sproule *et al.*** [22] reported that the fat mass index was increased in high-functioning non-ambulatory subjects compared to both ambulatory and low-functioning non-ambulatory subjects with type-2 spinal muscular atrophy and that these high-functioning non-ambulatory subjects had swallowing and/or feeding dysfunction.

In summary, it can be concluded that swallowing disorders in healthy volunteers increase in frequency and severity as age and BMI increase. Furthermore, FEES is a safe and appropriate screening modality for such disorders. However, wider-scale comparative studies are warranted for verification of these results.

Corresponding author:
Ahmed H. Khafagy;
Otolaryngology-HNS, Ain Shams University Hospital, Cairo, Egypt
ahmedkhafaagy@yahoo.com

References

1. Marshall JB (1985): Dysphagia. Pathophysiology, causes, and evaluation. Postgrad. Med. 77:58-63: 67-68
2. Halama AR (1994): Clinical approach to the dysphagic patient. Acta Otorhinolaryngol. Belg. 48: 119-126
3. Winterholler C (2008): Diagnosis and treatment of dysphagia in patients with neuromuscular disease. Pneumologie. 62 (Suppl 1): S35-38
4. Masiero S, Pierobon R, Previato C, Gomiero E (2008): Pneumonia in stroke patients with oropharyngeal dysphagia: a six-month follow-up study. Neurol. Sci., 29: 139-145
5. Manor Y, Balas M, Giladi N, Mootanah R, Cohen JT (2009): Anxiety, depression and swallowing disorders in patients with Parkinson's disease. Parkinsonism Relat. Disord. 15: 453-456
6. Nacci A, Ursino F, La Vela R, Matteucci F, Mallardi V, Fattori B (2008): Fiberoptic endoscopic evaluation of swallowing (FEES): proposal for informed consent. Acta Otorhinolaryngol. Ital. 28:206-211.
7. Leder SB, Murray JT (2008): Fiberoptic endoscopic evaluation of swallowing. Phys. Med. Rehabil. Clin. N. Am. 19:787-801
8. Warnecke T, Teismann I, Oelenberg S, *et al.* (2009): The safety of fiberoptic endoscopic evaluation of swallowing in acute stroke patients. Stroke. 40:482-486.
9. Warnecke T, Teismann I, Oelenberg S, *et al.* (2009): Towards a basic endoscopic evaluation of swallowing in acute stroke - identification of salient findings by the inexperienced examiner. BMC Med. Educ. 9: 13.
10. Kelly AM, Macfarlane K, Ghufoor K, Drinnan MJ, Lew-Gor S (2008): Pharyngeal residue across the lifespan: a first look at what's normal. Clin. Otolaryngol. 33:348-351.
11. Trapl M, Enderle P, Nowotny M, *et al.* (2007): Dysphagia bedside screening for acute-stroke patients: the Gugging Swallowing Screen. Stroke. 38:2948-2952.
12. Coscarelli S, Verrecchia L, Coscarelli A (2007): Endoscopic evaluation of neurological dysphagic patients. Acta Otorhinolaryngol. Ital. 27: 281-285.
13. Hafner G, Neuhuber A, Hirtenfelder S, Schmedler B, Eckel HE (2008): Fiberoptic endoscopic evaluation of swallowing in intensive care unit patients. Eur. Arch. Otorhinolaryngol. 265: 441-446.
14. Bader CA, Niemann G (2008): Dysphagia in children and young persons. The value of fiberoptic endoscopic evaluation of swallowing. HNO. 56:397-401.
15. Warnecke T, Ritter MA, Kroger B, *et al.* (2009): Fiberoptic endoscopic dysphagia severity scale predicts outcome after acute stroke. Cerebrovasc. Dis. 28: 283-289.
16. Suiter DM, Moorhead MK (2007): Effects of flexible fiberoptic endoscopy on pharyngeal swallow physiology. Otolaryngol. Head Neck Surg. 137: 956-958.
17. El Solh A, Okada M, Bhat A, Pietrantoni C (2003): Swallowing disorders post orotracheal intubation in the elderly. Intensive Care Med. 29:1451-1455.
18. Leder SB, Suiter DM (2009): An epidemiologic study on aging and dysphagia in the acute care hospitalized population: 2000-2007. Gerontology. 55:714-718.
19. Lelovics Z (2009): Nutritional status and nutritional rehabilitation of elderly people living in long-term care institutions. Orv. Hetil.150:2028-2036.
20. Lundkvist K, Friberg D (2010): Pharyngeal disturbances in OSAS patients before and 1 year after UPPP. Acta Otolaryngol. 130:1399-1405.
21. Nam SY, Choi IJ, Ryu KH, Park BJ, Kim HB, Nam BH (2010): Abdominal visceral adipose tissue volume is associated with increased risk of erosive esophagitis in men and women. Gastroenterology. 139: 1902-1911.
22. Sproule DM, Montes J, Dunaway S, *et al.* (2010): Adiposity is increased among high-functioning, non-ambulatory patients with spinal muscular atrophy. Neuromuscul. Disord. 20: 448-452.