Published in final edited form as:
Laryngoscope. 2014 February ; 124(2): 494–497. doi:10.1002/lary.24284.

CT Pulmonary Findings in Healthy Older Adult Aspirators versus Nonaspirators

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Abstract

Objectives/Hypothesis—In previous studies, we consistently found that approximately 30% of asymptomatic healthy older adults silently aspirated liquids during a flexible endoscopic evaluation of swallowing (FEES), and that their aspiration status was stable for the following year. However, no studies have systematically evaluated effects of silent aspiration on lung parenchyma and airways. We used computed tomography (CT) to compare lungs of healthy older adult aspirators versus nonaspirators. We hypothesized that CT images would show pulmonary differences in healthy older adult aspirators versus nonaspirators.

Study Design—Prospective study.

Methods—Fifty healthy older adults (25 aspirators and 25 nonaspirators) who participated in a previous FEES were randomly selected. CT scans were performed; on inspiration, lung views were taken at 1.25 mm and 2.5 mm windows; on expiration, lung views were taken at 2.5 mm. CT scans were reviewed by radiologists blinded to group assignment. Outcomes included bronchiectasis, bronchiolectasis, bronchial wall thickening, parenchymal band, fibrosis, air trapping, intraluminal airway debris, and tree-in-bud pattern.

Results—Chi-square analyses between aspirators and nonaspirators found no statistically significant differences between aspirators and nonaspirators for any outcomes ($p > 0.05$). Logistic regression analyses adjusted for smoking did not change the results.

Conclusion(s)—There were no differences in pulmonary CT findings between healthy older adult aspirators and nonaspirators. This study adds to the evidence that some aspiration may be within the range of normal for older adults, or at least does not contribute to a change in pulmonary appearance on CT images.

Keywords

aspiration; computed tomography; pulmonary; swallowing

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The authors have no financial interests in companies or other entities that may have an interest in the information in this contribution. The authors have no other financial disclosures.

Conflict of Interest: None

INTRODUCTION

Knowing the range of normal swallowing function and pulmonary consequences of prandial (while eating and drinking) aspiration are critical to the successful management of patients with dysphagia. Lack of evidence in these two main parameters may result in under- or overmanagement. Undermanagement of aspiration increases the likelihood of pneumonia; overmanagement results in unnecessarily restrictive diet recommendations (e.g., thickened instead of thin liquids) and increases the likelihood of dehydration, malnourishment, and related sequelae.

Literature documenting the presence of prandial aspiration on Modified Barium Swallowing Studies (MBSS) and Flexible Endoscopic Evaluations of Swallowing (FEES) across the lifespan of healthy adults is sparse. This limits the evidence base needed by professionals to accurately assess and manage swallowing pathophysiology. Historically, it was assumed that healthy older adults, without a predisposing condition for dysphagia, should not aspirate. The available literature on aspiration in healthy adults, contains some reports of aspiration that were considered isolated events[1–6]. All of the referenced studies, except one, evaluated swallowing via MBSS; this is important as MBSS may lack the sensitivity of aspiration detection compared to FEES[7].

In four different studies, using FEES, we consistently found that approximately 30% of healthy older adults had intermittent and trace aspiration of thin liquids[8–11]. Further, aspiration status (i.e., aspirator vs. nonaspirators) remained stable over a 1-year test, re-test period. These consistent findings demonstrate the range of swallowing in healthy older adults is broader than was typically assumed, and that intermittent liquid aspiration may be normal. These findings could alter clinical management of patients with dysphagia. However, the potential impact of intermittent, trace aspiration of liquids on pulmonary health must first be identified.

A 1:1 association between prandial liquid aspiration and pulmonary harm (e.g., pneumonia, chronic lung changes) has not been demonstrated. Many studies, typically limited in scope, have examined pneumonia risk in patients with dysphagia[12–23], and several demonstrated that aspiration poses an increased risk for pneumonia. Yet, except for a few studies[20,21], most aspirators did not develop pneumonia[12–18,21,24,25] (Sala et al. as cited [26]). It is probable that not all aspiration carries the same risk for pulmonary consequences, and accordingly may not necessitate the same management. In a one-year follow-up survey of previously identified healthy older adult aspirators and nonaspirators, there was no difference in self-reported pneumonia incidence between aspirators and non-aspirators (c.f., 1/21 [4.76%] versus 2/44 [4.55%]) [unpublished data]. Although pneumonia is an important pulmonary health outcome, it may not be the most relevant way to assess effects of chronic trace aspiration of liquids in a healthy cohort. Thus, given the paucity of studies systematically evaluating the effects of thin liquid aspiration on lung parenchyma and airways, we designed a study using computed tomography (CT) to compare the lungs of healthy older adult aspirators versus nonaspirators. We hypothesized that CT images would reveal pulmonary differences in aspirators compared to nonaspirators.

MATERIALS AND METHODS

Participants

We enrolled 50 healthy older adults between 65 and 90 years of age, comprised of 25 aspirators (mean age = 77 yrs; 15 women) and 25 non-aspirators (mean age = 76 yrs; 9 women). These participants were randomly identified (within their aspiration status) from a cohort of 93 older adults who had previously undergone a flexible endoscopic evaluation of swallowing (FEES)[10] and identified as aspirators or nonaspirators at that time. Participants reported no history of swallowing, speech, and voice problems; no known neurologic or otolaryngologic disorders; and that they were in good health. Participants were recruited by bulletins approved by the Wake Forest University Health Sciences Institutional Review Board. Informed consent was obtained.

Procedure

Aspiration status was acquired 6 to 10 months before the x-ray computed tomography (CT) procedure. Detailed procedures of FEES (with classification of aspiration status) are described elsewhere[10]. Briefly, participants underwent FEES while sitting upright. A 3.1 mm digital flexible endoscope was lubricated with Surgilube® (Altana Inc., Melville, NY) and passed transnasally, typically on the floor of the nose, by the first author to obtain a superior view of the hypopharynx.

Four liquid boluses (i.e., water, skim milk, two percent milk, and whole milk) with four volumes (i.e., 5, 10, 15, and 20 ml) were administered with two delivery methods (i.e., straw vs. cup). Approximately 0.3 ml of green food coloring was added per 118 ml liquid. The boluses were randomly presented to each participant in one data collection session of approximately 15 minutes. Swallows were reviewed in real-time, slow motion, and frame-by-frame. If a participant aspirated (liquid material passed below the vocal folds into the trachea with or without a cough reflex) on a minimum of one swallow, then s/he was categorized as an aspirator. All (i.e., 25/25, 100%) of the aspirators demonstrated at least one aspiration event during the study bolus protocol with no throat clear or cough (i.e., silent aspiration). Forty-four percent of those who silently aspirated also demonstrated at least one aspiration event with a sensorimotor response on a different swallow during the study protocol.

A GE Lightspeed® Pro 16 CT scanner was used to image the lungs. Participants were positioned in the supine position on the CT table. A scanogram at 0 and 90 degrees was performed identifying the superior landmark of the sternal notch. The scanogram was used to plot a helical scan and images were acquired through the entire chest at full inspiration and full expiration. Participants were asked to practice the breathing instructions just prior to the scan. CT scan parameters were 100 kVp, 1.375:1 pitch, and an auto mA of 200–700. Axial images were acquired at 1.25 mm slice thickness. Inspiration images were reconstructed in lung algorithm at 1.25 mm and 2.5 mm and in soft tissue algorithm at 2.5 mm. Expiration images were reconstructed in lung algorithm at 1.25 mm.

CT images were reviewed by the third and fourth authors, both Board Certified fellowship-trained radiologists in thoracic imaging, who were blinded to aspiration status. They read the images independently with 92% agreement. They agreed on the remaining 8% of readings by consensus during a second, paired rating session. All 50 CTs were reviewed for the following findings: bronchiecstasis[27], bronchiolectasis[27,28], bronchial wall thickening[28–30], parenchymal band[29], air trapping[28,29], and tree-in-bud pattern[27] as defined by the Fleischner Society: Glossary of Terms for Thoracic Imaging[31,32]. The findings of fibrosis[29,30] and intraluminal airway debris are not specifically defined in the Fleischner Society Glossary and were operationally defined as follows. Fibrosis was defined as subpleural reticulation, interlobular septal thickening, architectural distortion, and honeycombing either found singularly or in combination that was felt to be secondary to pulmonary fibrosis. Intraluminal airway debris was defined as noncalcified intraluminal opacities within the trachea, bronchi and/or bronchioles causing partial or complete luminal narrowing.

Data Analysis

CT pulmonary findings (bronchiectasis, bronchiolectasis, bronchial wall thickening, parenchymal band, fibrosis, air trapping, intraluminal airway debris, and tree-in bud pattern) were compared between aspirators and non-aspirators using either Chi-Square test or Fisher's Exact test if some cells have expected counts less than 5. Furthermore, logistic regression models were used to compare the rates of CT pulmonary findings between aspirators and non-aspirators, after adjusting for smoking status. Significance level was set at 0.05 for all analyses. Analyses were performed using SAS 9.2 (Cary, NC).

RESULTS

CT pulmonary findings as a function of aspiration status are summarized in Table I. There were no statistically significant differences between aspirators and nonaspirators for any of the possible findings ($p > 0.05$). Logistic regression analyses adjusted for smoking did not change the results.

DISCUSSION

This is the first study to demonstrate that healthy older adults who have intermittent, trace aspiration of liquids lack discernible pulmonary changes (e.g., bronchiectasis, bronchiolectasis, bronchial wall thickening, parenchymal band, fibrosis, air trapping, intraluminal airway debris, and tree-in-bud pattern) as measured via CT.

We previously identified, in three separate cohorts, that approximately 30% of healthy older adults had intermittent and trace aspiration of thin liquids, and aspiration status remained stable over a 1-year period of swallowing test and retest. Thus, evidence is mounting that the range of normal swallowing is much broader than previously thought. Nonetheless, if intermittent, trace aspiration of liquids in healthy older adults carries a greater risk for pneumonia or negative pulmonary changes, and would still necessitate active management. We previously found no difference in self-reported pneumonia (c.f., 1/21 [4.76%] versus 2/44 [4.55%], unpublished data) between healthy older adult aspirators and nonaspirators.

Although contrary to our underlying hypothesis, the lack of difference in pulmonary CT images between healthy older adult aspirators and nonaspirators further supports the idea that intermittent, trace aspiration of liquids is in the range of normal swallowing function and is not harmful for healthy older adults. If intermittent, trace aspiration of liquids without negative pulmonary sequelae in healthy older adults is confirmed by other studies, this concept may change the benchmark of "normal" swallowing in diagnosing and managing patients with dysphagia. The next critical step would then be to determine if intermittent, trace aspiration of liquids is harmful in dysphagic patients who only aspirate liquids. Preliminary evidence already exists in stroke patients that the relative risk for developing pneumonia was 8.36 times less for those who aspirated ≤ 10% of liquids on one or more test swallows [12]. Although not randomized clinical trials, our research to date and that of Holas et al.[30] suggests that intermittent, trace aspiration of liquid may not necessitate the traditional treatment of thickening liquids, thus avoiding the risk for dehydration and related medical sequelae (e.g., urinary tract infections, mental confusion)[25].

It is probable the results of this study may only be applicable to thin liquid aspiration. In our previous work evaluating swallowing function in healthy older adults we tested swallowing ability with both purees and solid consistencies[11], and aspiration with those consistencies was rare. In a cohort with stroke, Schmidt and colleagues reported that the odds ratio for developing pneumonia was 5.6 times greater for those who aspirated thickened liquids or solids compared to those who did not aspirate or only aspirated thin liquids[33]. Thus, if aspiration of thicker or solid consistencies was present in healthy older adults, it may yield significant differences in pulmonary CT findings and/or pneumonia incidence.

A challenge in developing the current study was the lack of literature on expected CT pulmonary findings relative to prandial aspiration. However, well-defined lists of CT pulmonary findings relative to aspiration are found in articles on familial dysautonomia (FD), where reflux and dysphagia are common[29]. Although the pulmonary complications of patients with FD are usually more related to reflux versus prandial aspiration, their pulmonary results on CT testings provided a good model of expected findings for the current study. In 34 patients with FD, they reported that bronchial wall thickening was prevalent in 94%, followed by atelectasis (73%), ground glass opacities (53%), focal hyperinflation (44%), fibrosis (29%), and bronchiectasis (26%). In the present study, the most common pulmonary CT finding, regardless of aspiration status, was bronchial wall thickening (Table I). This may indicate that bronchial wall thickening is a prevalent pulmonary CT finding in healthy older adults, or that a larger sample is needed to detect statistical differences between aspirators and nonaspirators.

Still uncertain is what happens to the aspirated liquids, identified on FEES, in healthy older adults. Identification of aspiration on FEES has excellent inter- and intra-rater reliability regardless of FEES experience (novice, intermediate, advanced) [data submitted for publication]. While there could be chronic lung changes in healthy older adult aspirators, CT imaging may not be resolute or sensitive enough to detect them. It is possible that if changes are not detectable on CT, they may not be clinically important. Our two radiologists, both Board Certified and fellowship-trained in thoracic imaging, agreed on the CT findings 92% of the time, providing confidence in the presence and/or absence of the study’s CT findings. The current study’s results suggest that lungs from healthy older adult aspirators versus nonaspirators are largely indistinguishable. Furthermore, all of the aspirators in the current study had previously demonstrated at least one episode of silent aspiration during their FEES. That is, the aspirators demonstrated aspiration with no sensorimotor response. These results leave open the possibility that the pulmonary system in healthy older adults can handle trace amounts of thin liquid aspirate. These traces of liquid may never reach the lung, or the amounts are small enough to be cleared by cilia with no noticeable sensorimotor effort.

A limitation to this study is that even the nonaspirators had pulmonary CT findings; however, this was expected given the age of this cohort ($M = 76$ years). Given our findings, a larger sample would be needed to more definitively determine whether a valid difference exists between these two groups.

CONCLUSION

This is the first study to evaluate CT differences in lung parenchyma and airways between healthy older adult aspirators and nonaspirators. We observed no statistically significant differences in CT pulmonary findings between a total of 50 healthy adults previously identified as aspirators versus nonaspirators. This finding is in line with our previous studies that consistently found approximately 30% of asymptomatic healthy older adults [8–11] intermittently tracely aspirated liquids, and that their aspiration status was stable over a 1-year period. Thus, there is increasing evidence that the range of normal swallowing is much broader than originally considered. An inaccurate assumption that all thin liquid aspiration is abnormal may lead to overmanagement of patients with dysphagia, placing them on thickened liquids and at a greater risk for dehydration. To clarify this issue, a clinical trial is needed to randomize patients with dysphagia and intermittent thin liquid aspiration to thickened liquid or continued drinking of thin liquid interventions, to assess relative risk of pneumonia.

Acknowledgments

This work was supported by NIDCD R03 DC009875, Wake Forest School of Medicine Claude D. Pepper Older Americans Independence Center (P30 AG21332), and the GCRC grant of Wake Forest University Baptist Medical Center (M01-RR07122). These data were presented in part at the Nineteenth Annual Meeting of the Dysphagia Research Society, March 2–5, 2011, San Antonio, Texas. We thank Karen Potvin Klein, MA, ELS (Research Support Core, Wake Forest University Health Sciences) for her editorial contributions.

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TABLE I

CT Lung Findings as a Function of Aspiration Status.

CT Lung Findings	Aspiration Status	
	Aspirator (N=50)	Nonaspirator (N=50)
Bronchiectasis	1	4
Bronchiolectasis	5	3
Bronchial Wall Thickening	11	6
Parenchymal Band	4	2
Fibrosis	8	8
Air Trapping	10	13
Intraluminal Airway Debris	3	4
Tree-in-bud Pattern	3	2