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Scintigraphic Detection of Salivary Aspiration: Description of a New Diagnostic Technique and Case Reports

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Abstract. Pneumonia is the feared consequence of persistent aspiration of saliva. Although some persons with impaired protection of the laryngeal airway are thought to be at risk, it is not known with certainty which factors are important. Some patients receive tracheostomies to enhance airway safety, often without clear evidence of aspiration of oropharyngeal secretions. A simple, readily available technique is described by which oral secretions are scintigraphically labeled with technetium-99m sulfur colloid via slow intraoral infusion. Subsequent sequential chest imaging with a gamma camera allows detection and tracking of the aspirated material. Three persons are described in whom this technique was used. In one, the scintigraphic analysis was instrumental in implicating infected saliva as the likely source of recurrent pulmonary infections. Although the method is useful in detecting aspiration of saliva in high risk persons, more study is needed to equate the degree of aspiration visualized with the risk of pulmonary disease.

Key Words: Aspiration — Scintigraphy — Saliva — Pneumonia — Deglutition — Deglutition disorders.

Aspiration of saliva resulting in bronchopneumonia is one of the feared risks in patients with severe deficits of pharyngeal or laryngeal control [1, 2]. It is not uncommon for patients with copious oral secretions and swallowing difficulties to receive tracheostomies [2] or other surgical procedures [3, 4] to avoid aspiration pneumonia. This is often done without objective evidence of significant airway aspiration. The effect of persistent aspiration of saliva is not known with certainty for either normal persons or those with depressed airway reflexes [5–7]. Since it has been shown clinically and experimentally that bronchopneumonitis may result from the aspiration of ingested or regurgitated solids and liquids [2, 8, 9], it is assumed easily by many that laryngeal penetration by saliva is an abnormal occurrence and similarly can result in pulmonary disease. Unfortunately, few studies have examined the incidence and ultimate outcome of airway contamination by oropharyngeal secretions. Moreover, there has been no reliable diagnostic method to study this problem. We describe here a simple, readily available method to detect salivary aspiration in patients considered to be at high risk for such a complication. We also present a case study in which the technique was used to implicate salivary secretions as the source of aspiration pneumonia. We present two other examples in which the technique was used in persons who did not have a history of aspiration pneumonia, one of whom was thought to be at risk.

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Technique

Each subject lay supine, positioned over a large field-of-view scintillation camera (Technicare) and an all-purpose collimator (Fig. 1). Technetium-99m sulfur colloid (10 μCi/ml normal saline) was slowly dripped into the oral cavity of the supine subject

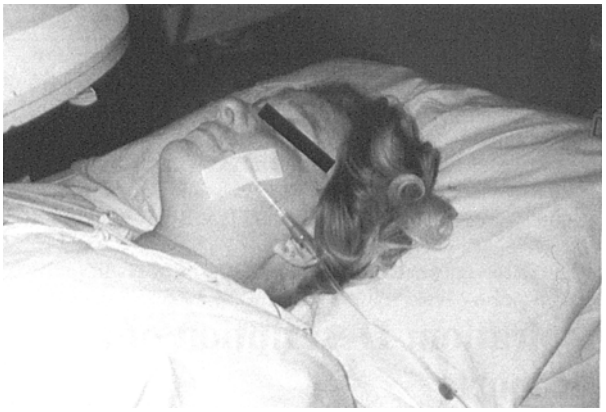

Fig. 1. The set up for intraoral radionuclide infusion through a thin plastic cather using electronic pump control. The subject is positioned over a large field-of-view gamma camera with an all-purpose collimator.

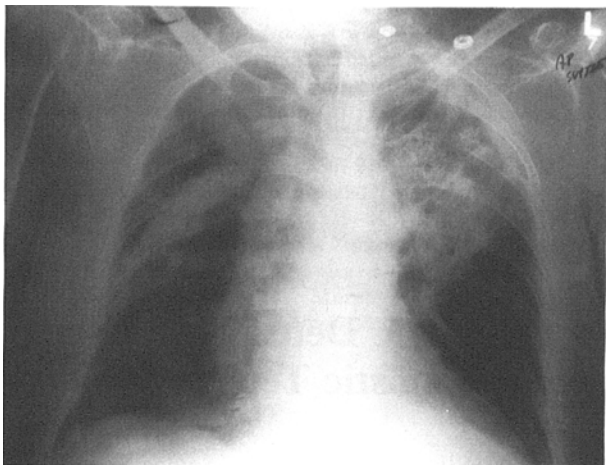

Fig. 2. *Case 1.* Chest radiograph demonstrates bilateral lung infiltrates before removal of infected dentition.

through a thin, 3½ inch Silastic tube secured to the corner of the mouth by adhesive tape. Cobalt markers were affixed to the sternal notch and xiphoid as anatomical landmarks. Infusion rates of 10–30 ml/hr were controlled by a standard electronic infusion pump that allowed gradual admixing with the subject's saliva. If studied in the awake state, the patient was asked to relax and swallow his or her own secretions normally during radionuclide infusion. Posterior imaging was commenced immediately and continuously in 5 min collection periods for the first 1½ hr of infusion. Infusion was stopped at 1½ hr if the images were positive, as defined by activity within the thorax lateral to midline. If images for tracheobronchial activity were negative following the first 1½ hr, infusion was continued at the same rate for an additional 1½ hr, and stopped. In each instance, anterior, left anterior oblique, and right anterior oblique views were obtained after 3 hr to assess the presence and/or persistence of tracer in the lungs. If intrathoracic activity was present, delayed images were obtained 2–3 hr later (approximately 5–7 hr after the onset of infusion) and, if necessary, the following morning to evaluate clearance of the tracer.

Case Reports

Case 1

A 65-year-old man was admitted to an inpatient rehabilitation unit for the management of physical disabilities including weakness and severe orthostatic hypotension associated with olivopontinecerebellar degeneration (Shy-Drager disease), which had been diagnosed several years earlier. Two months before admission, he had an episode of aspiration pneumonia for which he was hospitalized. Early in the present hospital stay, he exhibited frequent episodes of sleep apnea often lasting 30 s and associated with vigorous attempts to resume inhalation. A relative verified that apneic events had been occurring for several years. Five days after admission, the patient developed fever, productive cough, and a left shift without leukocytosis. Radiographs confirmed right-sided pneumonia. Following antibiotic treatment, he became afebrile. However, chest radiographs revealed progression of the disease with patchy left-sided infiltrates in addition to extensive pneumonia on the right (Fig. 2). Oropharyngeal examination demonstrated mild dysarthria but intact gag reflexes as well as severe dental caries. A videofluoroscopic swallowing study, performed to assess aspiration as a possible cause, revealed only esophageal dysmotility without oropharyngeal dysfunction. A barium esophagram was consistent with disordered motility characterized by spasm and deficient peristaltic activity. Evocative maneuvers on subsequent radiologic studies did not reveal evidence of gastroesophageal reflux. An overnight radionuclide reflux/aspiration study was also negative. The patient was empirically begun on bethanacol and elevation of the head of the bed at all times. Repeat videofluoroscopy 5 weeks after the first evaluation revealed no evidence of aspiration and only mild esophageal discoordination despite the continued presence of bilateral infiltrates and pleural effusions on chest x-rays. Extensive pulmonary work-up, including thoracentesis and transbronchial biopsy, gave no clue to the cause of persistent asymptomatic lung infiltrates.

It was hypothesized that septic emboli originating from the patients poor dentition were being aspirated during sleep as a result of the turbulent airflow associated with the apneic events. To test this conjecture, a special salivary aspiration study was designed using the radionuclide labeling technique described above. To replicate sleep conditions, the patient was deprived of sleep the night before the study, and given lorazepam 5 mg intramuscularly. Radioactivity lateral to the midline was seen within 30 min of the commencement of infusion (Fig. 3a), consistent with penetration of left and right mainstem bronchi. Delayed imaging at 5 hr showed clearing of the large bronchi with peripheralization of the isotope into the right lung field (Fig. 3b). These results were thought to be suggestive of pulmonary aspiration of oral secretions and a likely explanation for the recurrent pneumonias. Subsequently, the patient underwent total extraction of dentition to eliminate a presumed source of infected saliva. He experienced no further episodes of pneumonia. Chest radiographs prior to discharge showed near-complete resolution of prior infiltrates. Pharmacologic therapy for sleep apnea was initiated late in the hospital course. At 6 months after discharge, there had been no clinical or radiologic evidence of recurrent pneumonitis.

Case 2

A 61-year-old man was admitted for rehabilitation services related to cerebellar and brainstem infarctions diagnosed several

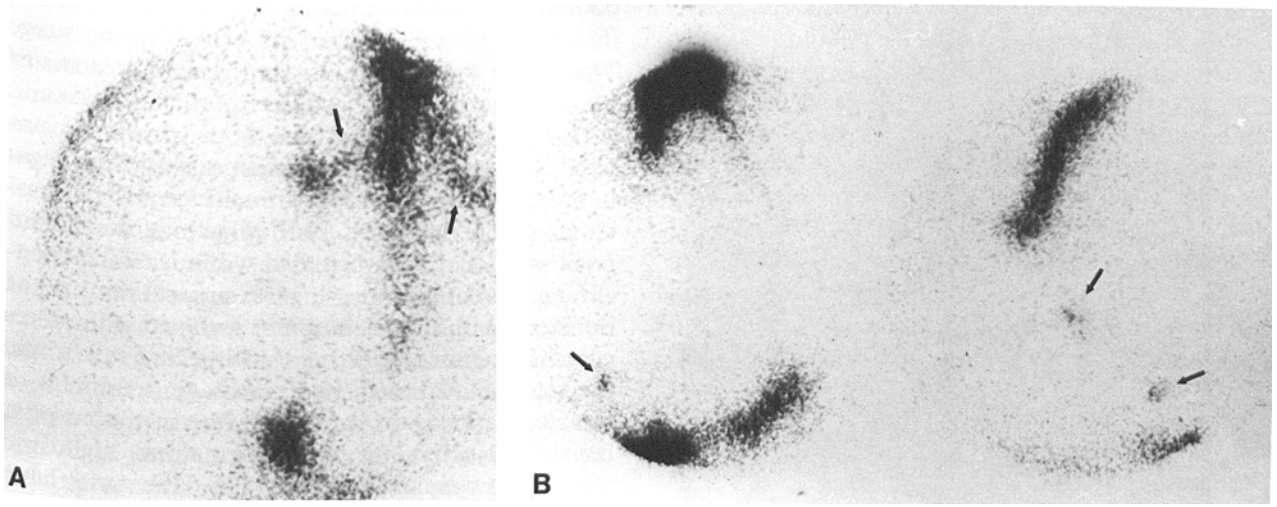

Fig. 3. *Case 1.* **a** Scintigraphy reveals radioactivity in both mainstem bronchi 30 min after onset of oral infusion (see *arrows*). **b** 5 hr after infusion, delayed images show clearing of the large airway, but there is now evidence of activity in the right peripheral lung field (see *arrows*).

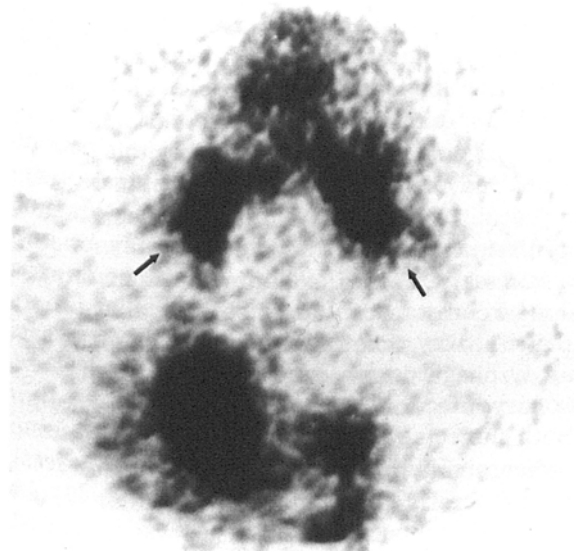

Fig. 4. *Case 2.* Scintigram demonstrates immediate presence of activity in bilateral mainstem bronchi following infusion of the radioisotope. Complete clearing of airways was noted following cessation of infusion.

months earlier. Swallowing studies before he was admitted documented aspiration of foodstuffs. Because the aspiration of salivary secretions was also suspected at that time, a cuffed tracheostomy tube had been placed surgically. The patient was fed exclusively by nasogastric tube. Oropharyngeal examination revealed a decreased pharyngeal gag reflex. Because of difficulty in handling his own secretions, he required suctioning of the tracheostomy tube every 1–2 hr. His condition improved such that therapeutic feedings were begun. A metal uncuffed tracheostomy tube was inserted and plugged much of the daytime. He still manifested frequent spontaneous coughing of copious secretions, and required tracheostomy suctioning every 4 hr. Despite continued clinical signs of airway penetration by secretions, at no time during the hospitalization did he show clinical or radiographic evidence of pneumonia.

To assess the presence and extent of pulmonary penetration of oral secretions during sleep, the patient underwent slow oral infusion scintigraphy. He was deprived of sleep the night before the study and did not require a hypnotic agent to maintain sleep conditions during the test. There was immediate activity limited to the trachea and bilateral bronchi following the onset of infusion (Fig. 4). At 3 hr, complete thoracic clearing of the tracer had occurred except for residual contamination at the tracheostomy site. Delayed images at 5 and 24 hr revealed no pulmonary activity.

Case 3

A 36-year-old subject with no history of pulmonary disease volunteered for the study. The scintigraphic technique was performed in the supine position while the volunteer was awake. Infusion of radioisotope was begun at 10 ml/hr and advanced to 30 ml/hr. Imaging was performed both during quiet resting respiration and during vigorous efforts to create airway turbulence. No evidence of tracheobronchial activity was seen during infusion or on delayed images (Fig. 5).

Discussion

The occult aspiration of saliva in patients with certain medical conditions has been reported to cause pulmonary disease, particularly pneumonias [7]. Bacterial pneumonias are thought to be due in part to organisms that inhabit the pharynx and find their way to more distal pulmonary locations via aerosolization, aspiration of solid or liquid food, gastric reflux, or passive leakage of oronasopharyngeal secretions [8]. Other factors doubtless play roles in

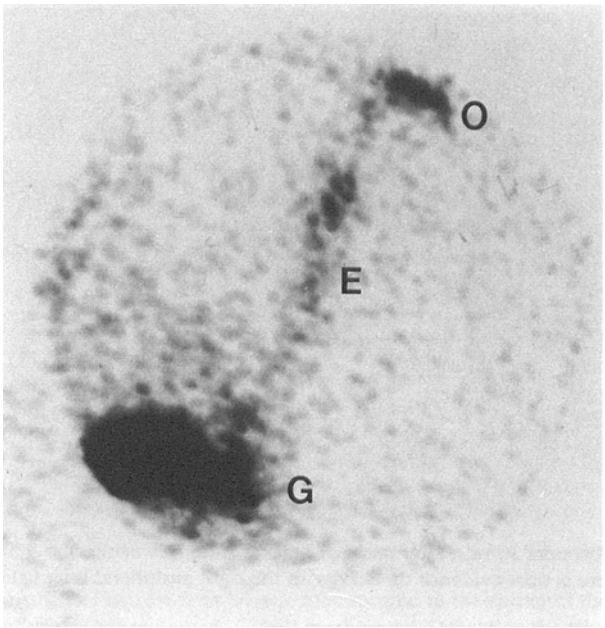

Fig. 5. *Case 3.* Radionuclide imaging in an awake normal volunteer following intraoral infusion. Activity is noted only in oropharyngeal and esophageal areas.

determining the ultimate development of aspiration pneumonia, including intrinsic pharyngeal and laryngeal reflexes, cilia-mediated bronchiole transport, and local antibacterial immune responses [1]. In addition, the amount and frequency of aspiration, the relative acidity [10], and the pathogenicity of resident organisms [8] affect the overall risk. It remains unclear if normal persons aspirate their own secretions. Passive contamination of the airway by saliva or other oronasopharyngeal secretions has been reported both in normal subjects and in persons with impaired consciousness. Amberson in 1954 [5], using iodized oils introduced orally, reported aspiration in sleeping patients who presumably did not have dysphagia. In a separate study, Winfield et al. [6], using either barium or iodized contrast instilled nasally via tubing, reported no airway contrast the next morning. Huxley et al. [7] reported that sleeping individuals normally aspirate nasopharyngeal secretions; lung scans were frequently positive following the introduction of indium 111 into the nasopharynx. However, the extent of airway penetration (proximal vs. distal) and the effect on pharyngeal reflexes by an indwelling tube were not considered.

The results of the scintigraphic study in case 1 suggested strongly that saliva was being inhaled and distributed in peripheral lung tissue. Although not definitely proven, it is likely that the cause of the patient's persistent pneumonias was the insidious inhalation of infected oral secretions during sleep. The search for other more commonplace causes of the occult pneumonias proved futile. Dysphagia and gastroesophageal reflux were both considered unlikely because relevant diagnostic tests were negative. Moreover, empiric treatment for possible gastroesophageal reflux, both pharmacologic and positional, had been initiated without clinical benefit. Immediately following the surgical removal of infected teeth, the pneumonias resolved without recurrence, again suggesting that infected saliva was their cause. Although pharmacologic treatment of the sleep apnea was attempted late in the hospital course, objective proof of normalized nighttime ventilation was never obvious. The patient may have continued to aspirate secretions following removal of his teeth, but the absence of pathogenic bacilli likely prevented pulmonary infection.

In contrast, case 2 demonstrates a negative scintigraphic study in a person whose neurologic impairment of pharyngeal and laryngeal reflexes was thought to place him at risk for aspiration of copious oral secretions. The isotope study clearly revealed penetration of labeled saliva to the level of the mainstem bronchi, but not beyond. Moreover, there was rapid, complete airway clearance. That this patient never showed pneumonia either on clinical or radiographical examination suggests, but does not prove, that small-airway inoculation may be one factor necessary for the development of pneumonia in these circumstances. It also suggests that proximal, large-airway penetration of saliva can occur in certain dysphagic persons, and may not in itself cause pulmonary infection.

Both subjects were tested when asleep, presumably when airway protective mechanisms are least active and the risk of aspiration is greatest [7]. In contrast, the normal subject in case 3 was evaluated scintigraphically only while awake. Consequently, the resulting absence of airway activity represents insufficient evidence that pulmonary penetration of salivary secretions does not occur in normal persons during sleep. It did demonstrate that aerosolization of the radioisotope does not take place to any extent that could explain the presence of technetium–sulfur colloid in the airways, which was one of our early concerns about the technique. The use of mild hypnotic agents in the first case may have had some depressant effect on pharyngeal or laryngeal protective reflexes, and consequently may have increased the likelihood of aspiration, although the dose used was minimal. Also, the intraoral infusion rate of radiolabeled liquid was arbitrarily set at approxi-

mately 15 ml/hr. Although an extremely small amount of material, this could represent a rate of delivery exceeding normally depressed overnight salivary production, and therefore be viewed as potentially overwhelming to even a normal individual's protective mechanisms. Perhaps in the future, slower infusion rates with an increased concentration of isotope may be more realistic.

In persons with tracheostomies, oral dye impregnation allows verification of proximal tracheal penetration of saliva, but it useless in describing its extent in regard to volume, duration of retention, or ultimate pulmonary destination. The detection of pulmonary aspiration of saliva is not routinely possible in patients suspected of having difficulties with oral secretions in the absence of a tracheostomy through which the contents of the airway can be sampled readily. It may be that some persons thought to be at high risk actually aspirate minimal amounts or that penetrated secretions remain confined to proximal, large airways and are cleared quickly, as in case 2. These subjects may represent a subpopulation of salivary aspirators who are at reduced risk of pulmonary sequelae.

Although we believe that the scintigraphic technique described is useful in allowing visualization of the pulmonary fate of aspirated secretions, there is as yet no evidence correlating the extent of airway penetration with risk from pulmonary disease. Many questions remain regarding salivary aspiration: Do normal persons aspirate in their sleep? Is distal penetration of saliva alone sufficient to give rise to clinical infection? Is the pathogenicity of the saliva the critical factor, regardless of depth of airway penetration? Future studies are needed to answer these questions.

The three cases discussed represent preliminary experiences with a technique that deserves further clinical evaluation. The scintigraphic technique involves minimal radiation exposure and is easily performed in any nuclear medicine department. Its future application may be relevant to such common issues as the performance of a tracheostomy and the cuffing of a tracheostomy tube where a more judicious use of such procedures could result. Salivary labeling may also prove useful as a heretofore unavailable diagnostic tool in patients who develop occult pneumonias that cannot be explained by the more likely occurrences of impaired swallowing of foodstuffs or reflux of stomach contents.

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