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Deglutition and Respiratory Patterns During Sleep in the Aged with OSAS

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Objective: Clearance of the pharynx by deglutition, which removes matter that could be aspirated, is important in protecting the airways and lungs against aspiration. The deglutition and respiratory phase patterns during sleep in the aged with obstructive sleep apnea syndrome (OSAS) were investigated.

Study Design: Retrospective study with case groups.

Methods: Ten aged adults with severe OSAS (average age 75, average apnea-hypopnea index 43.8) were examined via time-matched digital recordings of polysomnography and surface electromyography of the muscles (thyrohyoid and suprahyoid) related to swallowing and compared with aged adults without OSAS previously reported on.

Results: During sleep, swallowing was infrequent and absent for long periods. The median number of swallows per hour during total sleep time was 4.1 and the median longest deglutition-free period was 70.5 minutes. Three-fourths of deglutition occurred in association with respiratory electroencephalographic arousal. Deglutition was related to the sleep stage. The deeper the sleep stage, the lower the mean deglutition frequency. The median number of swallows per hour was 5.7 during stage N1 sleep and 2.8 during stage N2 sleep. There was no deglutition during stage N3 (deep) sleep. The median number of swallows per hour was 0.6 during REM sleep. Approximately 40% of swallows occurred after inspiration and approximately 42% were followed by inspiration.

Conclusion: Deglutition was infrequent and respiratory phase patterns were unique during sleep in the aged with OSAS. Sleep-related deglutition and respiratory phase patterns may adversely influence aspiration-related diseases (aspiration pneumonia, etc) in the aged with sleep-related breathing disorders.

Level of Evidence: 4

Key Words: Sleep-related deglutition, nocturnal swallowing, respiratory phase pattern, electroencephalographic arousal, sleep, the aged, obstructive sleep apnea syndrome.

INTRODUCTION

It is generally accepted that deglutition is a vital function, and the clearance of the pharynx by deglutition, which removes matter that could be aspirated, is important in protecting the airways and lungs against aspiration. The recent data suggests that aspiration pneumonia due to silent aspiration or micro-aspiration is an important mechanism for the pathogenesis of pneumonia in older people.[1,2] In addition, as described previously, most hospitalized patients with pneumonia are older patients who are likely to experience unwitnessed aspiration of oropharyngeal contents during sleep.[2]

There have been some investigations into deglutition during sleep in human adults,[3–5] younger adults,[6] aged adults,[7] and children.[8] And sleep-related deglutition in patients with obstructive sleep apnea syndrome (OSAS) has been investigated.[9,10] These studies show that deglutition during sleep is infrequent and displays unique patterns. Consequently, it is suggested that certain clinical disorders, such as reflux-related and aspiration-related diseases are related to nocturnal deglutition.

Due to the complexity of swallowing processes in the aged, many adverse health conditions can influence swallowing functions during sleep. However, the relationship between sleep-related deglutition and nocturnal respiratory phase patterns in the aged with sleep-related breathing disorders is not clear.

The deglutition and respiratory phase patterns during sleep in the aged with OSAS were investigated in this study by means of time-matched digital recordings of polysomnography and surface electromyography (EMG) of the muscles related to swallowing.

MATERIALS AND METHODS

Deglutition and respiratory phase patterns during sleep in 10 aged adults with OSAS were examined by use of time-matched recordings of polysomnography and of surface EMG of the thyrohyoid and suprahyoid muscles, which are used in deglutition.

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Ten aged adults with OSAS ranging in age from 71 to 81 years (mean ± SD, 75 ± 4 years) were examined. Eight were males and two were females. The apnea-hypopnea index (AHI) ranged from 34 to 56.1 (median, 43.8). Their OSAS was rated as severe according to the American Academy of Sleep Medicine Task Force criteria of 1999.[11] The subjects did not take any medications or alcohol and did not have diseases that might affect sleep except OSAS. The patients were not treated for OSAS either prior or during this study. Informed consent was obtained for the subjects after the nature of the experimental procedure was explained.

The sleep structures of the subjects were as follows: total sleep time ranged from 325.5 to 462 minutes (median, 404.5 minutes) and sleep efficiency from 64.6% to 91.7% (81.1%). Arousal index ranged from 31.2 to 54.8 (40.4). Non–rapid-eye-movement (REM) sleep stage N1 ranged from 16.1% to 76.2% (32.4%), stage N2 from 16% to 69.9% (53.4%), stage N3 from 0% to 0.6% (0%). REM sleep ranged from 1.3% to 22.6% (10.7%).

Polysomnography

Polysomnography was performed using a digital (computerized) system (Neurofax, NIHON KOHDEN, Inc., Tokyo, Japan). It simultaneously recorded multiple physiological variables related to sleep staging: an electroencephalogram (EEG), eye movement (electrooculogram: EOG), chin muscle activity (by EMG), respiration (nasal and oral airflow), breathing effort (measured at the chest and abdomen), oximetry, heart rate, electrocardiogram (ECG), sound of snoring, body position, and the recording of leg anterior tibialis muscle activity (by EMG). Airflow was measured by thermocouples and by nasal cannula pressure. Nasal prongs were used to measure the nasal pressure signal.

The exploring electrode of the EEG was placed over specific anatomical sites: C3, C4, O1, and O2 (C3, C4, O1, and O2 are symbols of the international 10/20 system of scalp electrode placement identifying the central electrode placement site over the left [C3, O1] and right [C4, O2] hemispheres of the brain.). The time scale used in the polysomnography was 10 mm/s.

Surface EMG

Surface electrodes (silver-silver chloride, 8-mm-diameter disc, Nihon Kohden, Tokyo, Japan) were used. Before the two bipolar surface electrodes were applied, the skin just above the thyrohyoid and suprahyoid muscles was properly cleansed and abraded to ensure low (less than 10 Ω) and relatively equal electrode impedances. Before a recording was initiated, electrode connections to each subject were checked with an impedance meter to verify low and relatively equal impedance levels.

Before sleep and deglutition recording, a biocalibration routine was performed to confirm the integrity of each of the recorded parameters. The subject was asked to perform voluntary saliva deglutition, which was designed to stimulate certain deglutition-related behavior. The resulting tracings of surface EMG were annotated and carefully examined to verify correct signal derivations and signal quality.

Polysomnography Scoring and Interpretation

The completed polysomnogram was scored epoch by epoch by a sleep technologist and a physician. Each 30-second epoch of the polysomnogram was analyzed to determine sleep state and to identify respiratory events, thereafter deglutition event scoring was conducted. The standard method for identifying and scoring sleep stages was used.[12]

The deglutition frequency (median number of swallows) was calculated as follows: the number of swallows divided by each sleep hour was calculated in each case. Then, the data for all ten cases was calculated to obtain the median with range. Wilcoxon t-test was used for statistical comparison.

Assessment of Respiratory-Swallowing Interaction

The relation between swallowing and respiratory cycle using thyrohyoid and suprahyoid muscle EMG, respiration patterns (nasal airflow), and thoracic and abdominal respiratory inductance plethysmography (piezo crystal transducer) were analyzed. Since nasal pressure monitoring is more sensitive than thermocouples in detecting airflow, airflow was measured by nasal cannula pressure transducers recording nasal pressure.

The percentage of swallows associated with respiratory phase patterns was calculated as follows: the number of swallows for each respiratory phase pattern was divided by the total number of swallows and multiplied by 100 in each case. And then, the percentage data for all 10 cases was calculated to obtain the median.

Comparison of Deglutition and Respiratory Phase Patterns during Sleep between Aged Adults with and without OSAS

For the purpose of comparison of deglutition and respiratory phase patterns during sleep between aged adults with and without OSAS, data (median) on 10 normal-aged adult (71 ± 6 years) deglutition and respiratory phase patterns during sleep that we previously reported[7] were used for statistical comparison (Mann-Whitney's U test).

The data of deglutition and respiratory phase patterns during sleep in the aged without OSAS was obtained with the same study design as this present study.[7]

A summary of the deglutition and respiratory phase patterns during sleep in the aged without OSAS, obtained from this prior study and which we use as reference (non-OSAS) data for this study, is as follows.[7] During sleep, swallowing was extremely infrequent and absent for long periods in the aged.[7] The median number of swallows per hour during total sleep time was 0.6 and the median longest deglutition-free period was 134.8 minutes.[7] Most deglutition occurred in association with spontaneous electroencephalographic arousal both in REM and non-REM sleep.[7] The deeper the sleep stage, the lower the mean deglutition frequency.[7] There was no deglutition during deep sleep.[7] Approximately one-third of swallows occurred after inspiration and were followed by inspiration.[7] Precise data is shown in the results section.

RESULTS

Deglutition during sleep was infrequent in the aged with OSAS. Deglutition did not occur during apnea or hypopnea periods. Approximately three-fourths of deglutition (74.4% ± 17.6%) occurred in association with respiratory EEG arousal (an abrupt shift in EEG frequency) after apnea or hypopnea in non-REM (rapid eye movement) sleep and REM sleep (Fig. 1). Approximately one-fourth of deglutition (25.2% ± 17.7%) occurred in association with spontaneous EEG arousal after snoring or without snoring. Polysomnography showed a delay between the onset of respiratory or spontaneous arousal and the EMG activity of deglutition. In most cases, deglutition occurred after (Fig. 1) or together with arousal, but in some cases deglutition occurred before arousal. The temporal relationship between EEG arousal and deglutition was ambiguous. Deglutition associated with respiratory or spontaneous arousals occurred not only between, but also during sleep stages.

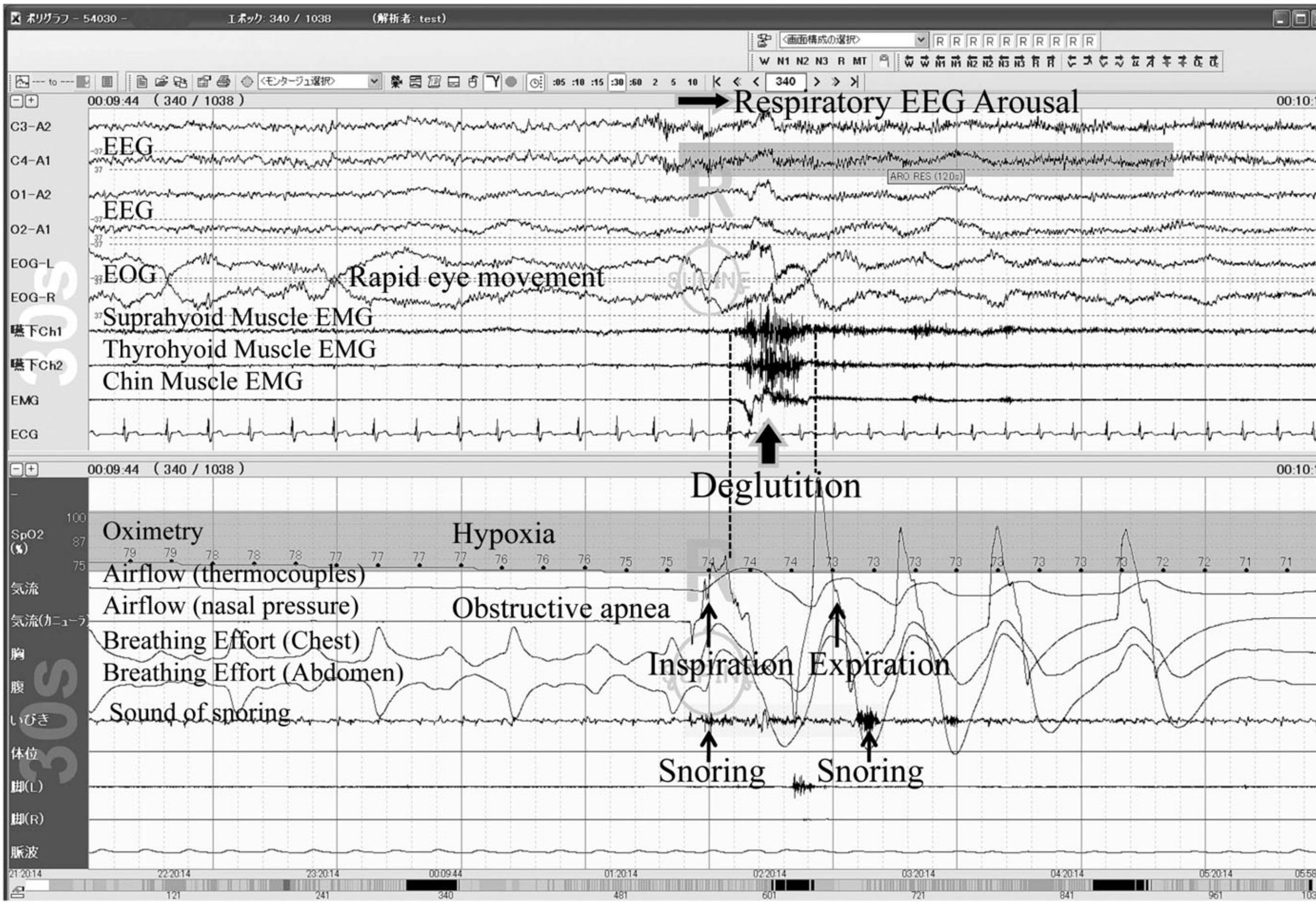

Fig. 1. Deglutition (large arrow) during rapid eye movement (REM) sleep.Deglutition occurred after obstructive apnea and respiratory EEG arousal. Deglutition occurred immediately after inspiration and was followed by expiration.

Deglutition Frequency During Sleep

Swallows per hour ranged from 0.3 times to 5.6 times (median, 4.1 times) during the total sleep time (Table I).

Stage wake

Deglutition occurred most often during the falling-asleep and awakening period (stage wake).

Non-REM sleep

The median number of swallows per hour was related to the sleep stage in non-REM sleep (Table I). The deeper the sleep stage, the lower the deglutition frequency.

During stage N1 sleep, swallows per hour ranged from 1.1 times to 8.1 times (median, 5.7 times). During stage N2 sleep, swallows per hour ranged from 0 times to 5.5 times (median, 2.8 times). The frequency of deglutition during stage N2 sleep was lower than during stage N1 sleep. During stage N3 sleep, swallows per hour were 0 (median, 0 times). There were no deglutition during deep sleep (delta sleep, slow wave sleep, stage N3 sleep).

REM sleep

The suprahyoid and thyrohyoid surface EMG amplitude dropped to its lowest level of recording during REM sleep (Stage R). However, deglutition also occurred in association with respiratory EEG arousal during REM sleep (Table I). During stage R sleep, swallows per hour ranged from 0 times to 15 times (median, 0.6 times).

TABLE I.
Deglutition Frequency, EEG Arousal Frequency, and the Ratio of EEG Arousal With Deglutition to EEG Arousal Frequency During Sleep in the Aged With OSAS

Sleep Stage	Deglutition frequency (times/hour)	EEG arousal frequency (times/hour)	EEG arousal with deglutition/ EEG arousal frequency(%)
Non-REM sleep			
Stage N1	5.7 $\mid P < 0.05$	46.5 $\mid P < 0.05$	11.4 $\mid$--NS
Stage N2	2.8 $\mid P < 0.01$	28.3 $\mid P < 0.01$	11.2 $\mid P < 0.01$
Stage N3	0	0	0
REM sleep	0.6	30.1	2.6
Total	4.1	40.4	11.3

Data are median Wilcoxon t-test
EMG = electromyography; NS = not significant; OSAS = obstructive sleep apnea syndrome; REM = rapid eye movement.

TABLE II.
Percentage of Swallows Associated With Respiratory Phase Patterns During Sleep in the Aged With OSAS

Respiratory phase patterns	Mean (±SD) %
Arrested Breathing ~ Swallow ~ Arrested Breathing	7.5 ± 5.2
Arrested Breathing ~ Swallow ~ Inspiration	10.7 ± 8.5
Arrested Breathing ~ Swallow ~ Expiration	12.3 ± 9.1
Inspiration ~ Swallow ~ Arrested Breathing	2.9 ± 3.3
Inspiration ~ Swallow ~ Inspiration	17.1 ± 15.5
Inspiration ~ Swallow ~ Expiration	20.4 ± 16
Expiration ~ Swallow ~ Arrested Breathing	4.6 ± 4.5
Expiration ~ Swallow ~ Inspiration	14.4 ± 7.7
Expiration ~ Swallow ~ Expiration	10.2 ± 7

Data are mean ± SD.
OSAS = obstructive sleep apnea syndrome; SD = standard deviation.

The Longest Deglutition-Free Period During Sleep

The median longest deglutition-free period was 70.5 minutes, and the range extended from 41 to 165 minutes.

EEG Arousal Associated With Sleep-Related Deglutition

Table I shows the median EEG arousal frequency and the median ratio of EEG arousal with deglutition to EEG arousal frequency during sleep.

The deeper the sleep stage, the lower the median EEG arousal frequency. The deeper the sleep stage, the lower the median ratio of EEG arousal with deglutition to EEG arousal frequency.

The median EEG arousal frequency and the median ratio of EEG arousal with deglutition to EEG arousal frequency were related to the sleep stage.

Respiratory Phase Patterns Associated With Sleep-Related Deglutition

Table II shows the respiratory phase patterns associated with sleep-related deglutition.

In 20.4 ± 16.0% (mean ± SD) of swallows, deglutition occurred immediately after inspiration and was followed by expiration. In 17.1 ± 15.5% of swallows, deglutition occurred immediately after inspiration and was followed by inspiration. In 14.4 ± 7.7% of swallows, deglutition occurred immediately after expiration and was followed by inspiration. In 12.3 ± 9.1% of swallows, deglutition occurred immediately after arrested breathing and was followed by expiration.

Of all swallows, 30.6 ± 19.2% (mean ± SD) of deglutition occurred immediately after arrested breathing, 29.1 ± 13.7% after expiration, and 40.3 ± 27.5% after inspiration during sleep (Table III). Of all swallows, 14.9 ± 10.1% of swallows were followed by arrested breathing, 42.9 ± 13.6% by expiration, and 42.2 ± 13.4% by inspiration during sleep (Table III). Approximately 40% of swallows occurred after inspiration and were followed by inspiration.

TABLE III.
Percentage of Swallows Associated With Respiratory Phase Patterns During Sleep in the Aged With OSAS

Respiratory-phase patterns	Mean (±SD) %
Arrested Breathing ~ Swallow	30.6 ± 19.2
Expiration ~ Swallow	29.1 ± 13.7
Inspiration ~ Swallow	40.3 ± 27.5
Swallow ~ Arrested Breathing	14.9 ± 10.1
Swallow ~ Expiration	42.9 ± 13.6
Swallow ~ Inspiration	42.2 ± 13.4

Data are mean ± SD.
OSAS = obstructive sleep apnea syndrome; SD = standard deviation.

TABLE IV.
Comparison of Deglutition Frequency During Sleep Between the Aged With and Without OSAS

	The aged with OSAS		The aged without OSAS*
Total sleep time	4.1	-- $P < .01$ --	0.6
Non-REM sleep			
Stage N1	5.7	-- $P < .01$ --	1.3
Stage N2	2.8	-- $P < .01$ --	0.2
Stage N3	0	-- NS --	0
REM sleep			
Stage R	0.6	-- NS --	0
Longest deglutition-free period (min)	70.5	-- $P < .05$ --	134.8

Data are median. Mann-Whitney's U test *Data from Sato, et al.[7]
NS = not significant; OSAS = obstructive sleep apnea syndrome; SD = standard deviation.

Comparison of Deglutition and Respiratory Phase Patterns During Sleep Between the Aged With and Without OSAS

Tables 4–5, and VI show the comparison between deglutition and respiratory phase patterns during sleep between the aged with and without OSAS.

The deglutition frequencies during total sleep time, stage N1, and stage N2 in the aged with OSAS were higher than those in the aged without OSAS (Table IV).

TABLE V.
Comparison of EEG Arousal Frequency and EEG Arousal With Deglutition/EEG Arousal Frequency Between the Aged With and Without OSAS.

	The aged with OSAS		The aged without OSAS*
EEG arousal frequency	40.4	-- $P < .01$ --	23.0
EEG arousal with deglutition/EEG arousal frequency (%)	11.3	-- $P < .05$ --	4.1

Data are median. Mann-Whitney's U test.
[1] Data from Sato, et al.[7]
OSAS = obstructive sleep apnea syndrome; SD = standard deviation.

TABLE VI.
Comparison of Percentage of Swallows Associated With Respiratory Phase Patterns During Sleep Between the Aged With and Without OSAS.

Respiratory phase patterns	The aged with OSAS	The aged without OSAS[1]
Arrested Breathing ~ Swallow	30.6 ± 19.2	19 ± 24.8
Expiration ~ Swallow	29.1 ± 13.7	47.3 ± 36.7
Inspiration ~ Swallow	40.3 ± 27.5	33.7 ± 42
Swallow ~ Arrested Breathing	14.9 ± 10.1	33.7 ± 35
Swallow ~ Expiration	42.9 ± 13.6	38.8 ± 36.4
Swallow ~ Inspiration	42.2 ± 13.4	27.5 ± 31.5

Data are mean (±SD)%
[1] Data from Sato, et al.[7]
OSAS = obstructive sleep apnea syndrome; SD = standard deviation.

The longest deglutition-free period during sleep was shorter in the aged with OSAS than that in the aged without OSAS (Table IV).

EEG arousal frequency in total sleep time and the median ratio of EEG arousal with deglutition to EEG arousal in total sleep time were higher in the aged with OSAS (Table V).

In the aged without OSAS, approximately 30% of swallows occurred after inspiration and were followed by inspiration. In the aged with OSAS, approximately 40% of swallows occurred after inspiration and were followed by inspiration (Table VI).

DISCUSSION

OSAS is a sleep-related breathing disorder defined as the cessation of airflow for a minimum of 10 seconds and is usually associated with sleep fragmentation (EEG arousal) and a drop in oxygen saturation.[13] Since the prevalence and clinical importance of OSAS have become increasingly apparent, greater interest in its influence on other clinical disorders has developed. In addition, it is generally accepted that the occurrence of sleep-related breathing disorders increases with age.

In this study, we have preliminarily demonstrated in-depth pathophysiological research of deglutition during sleep in the aged with OSAS, especially the relationship between sleep-related deglutition, EEG arousal, and respiratory phase patterns using time-matched digital (computerized) recordings of polysomnography and surface EMG of the muscles related to swallowing.

Deglutition Frequency and Patterns in the Aged with OSAS

The present study revealed a pattern of sleep-related deglutition in aged patients with severe OSAS. Sleep-related deglutition was infrequent as well as absent for long periods in the aged with OSAS.

Regarding non-REM sleep, deglutition was related to the sleep stage. The deeper the sleep stage, the lower the deglutition frequency. There was no deglutition during deep sleep (delta sleep, slow wave sleep, stage N3 sleep). Consequently, clearance of the pharynx and esophagus by deglutition was reduced during sleep in the aged with OSAS.

Regarding REM sleep, overall muscle tone is inhibited and surface EMG amplitude drops to its lowest level of recording during REM sleep. However, deglutition also occurred in association with EEG arousal.

Deglutition did not occur during apnea or hypopnea periods. Approximately three-fourths of deglutition occurred in association with respiratory EEG arousal after apnea or hypopnea. Approximately one-fourth of deglutition occurred in association with spontaneous EEG arousal after snoring or without snoring.

Comparison of Deglutition Frequency and Patterns in the Aged With and Without OSAS

When we compared the deglutition frequencies between the aged with and without OSAS, the frequency was higher in the aged with OSAS during total sleep time, Stage N1 sleep and Stage N2 sleep. There were no statistical differences in deglutition frequencies during Stage N3 sleep (deep sleep) and Stage R sleep (REM sleep). The longest deglutition-free periods during sleep were shorter in the aged with OSAS.

When compared with the aged without OSAS, sleep-related deglutition is high in the aged with OSAS, however, deglutition was still infrequent. Fragmentation of the sleep cycle and its effect on sleep structure and sleep-stage distribution in the aged with OSAS may be related to the difference in sleep-related deglutition frequencies and the longest deglutition-free period between the aged with and without OSAS.

EEG Arousal Associated With Sleep-Related Deglutition

As described in detail previously, the deglutition occurred in association with spontaneous EEG arousals in healthy adults, and was independent of sleep stage changes, body movements, or awakenings.[5–7] This study revealed that approximately three-fourths of deglutition occurred in association with respiratory EEG arousal after apnea or hypopnea in the aged with OSAS.

The latest research shows that swallowing occurs in association with arousal during sleep.[5–10] However, the relationship between EEG arousal and deglutition is ambiguous. And the temporal relationship between EEG arousal and deglutition is also ambiguous.

In this study, arousal frequency was higher in the aged with severe OSAS than that in the aged without OSAS. In addition, the ratio of EEG arousal with deglutition to EEG arousal frequency in the aged with OSAS was higher than those in the aged without OSAS. Arousal frequency in the aged with OSAS may be related to the difference in sleep-related deglutition frequencies and the longest deglutition-free period between the aged with and without OSAS.

Respiratory Phase Patterns Associated With Sleep-Related Deglutition in the Aged With OSAS

It is generally accepted that breathing is arrested, at whatever the actual phase of respiration, during the act

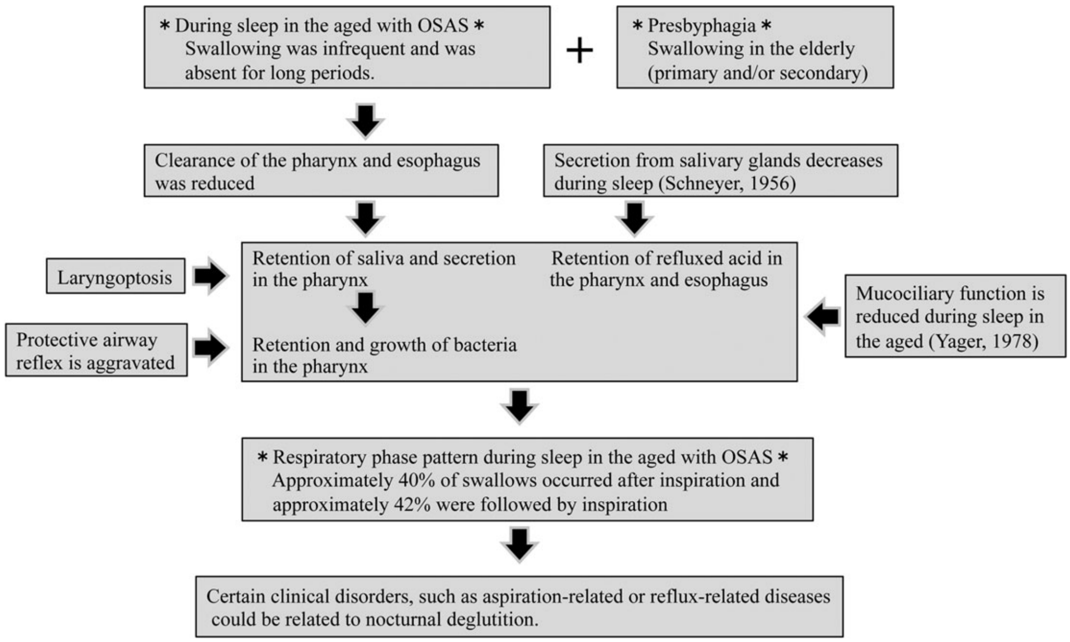

Fig. 2. Relationship between deglutition during sleep in the aged with OSAS and aspiration-related or reflux-related diseases.

of swallowing and swallowing is followed by expiration in adults. Clark recorded deglutition apnea during swallowing and the act of swallowing was followed by expiation.[14] Selley et al. studied awake healthy subjects at rest and 95% of their swallows were followed by a large expiration at ingestion.[15] Paydarfar et al. reported that the incidence of spontaneous deglutition was influenced by the position of the swallow in the respiratory cycle and most spontaneous swallows occurred from late inspiration to mid-expiration.[16] And Deglutition caused an abrupt decrease in airflow leading to an interval of apnea, followed by a period of expiration.[16]

It is accepted that clearance of the pharynx and esophagus by deglutition is important in protecting the airway and lungs against aspiration. The pharyngeal stage of swallowing is almost always followed by expiration, reducing the risk of aspiration.

In the aged with OSAS, this study showed that approximately 40% of swallows occurred after inspiration and approximately 42% were followed by inspiration during sleep. As previously reported in detail, approximately 34% of swallows occurred after inspiration and approximately 28% were followed by inspiration during sleep in the aged without OSAS.[7] The respiratory phase patterns associated with sleep-related deglutition were adverse in the aged with OSAS compared with those without OSAS. In addition, during episodes of upper airway obstruction, respiratory efforts tend to decrease intrathoracic pressure.[13] Breathing effort and decreased intrathoracic pressure as well as respiratory phase patterns were associated with sleep-related deglutition in the aged with OSAS. Sleep-related deglutition in the aged with OSAS may increase the risk of aspiration and adversely influence aspiration-related diseases (aspiration pneumonia, etc).

The above results of this study are consistent with the hypothesis that certain clinical disorders, such as aspiration-related and reflux-related diseases, could be related to nocturnal deglutition in the aged with OSAS.

Ageing Effects on Swallowing Function During Sleep

The present study showed sleep-related deglutition was still infrequent as well as absent for long periods in the aged with OSAS, even when compared with the aged without OSAS. Furthermore, swallowing physiology changes with the normal aging process of the organs related to swallowing (primary presbyphagia). In addition, secondary presbyphagia caused by other diseases such as cerebrovascular diseases afflicts the clinically significant dysphagia in the elderly (secondary presbyphagia). Consequently, clearance of the pharynx and esophagus appear to be reduced during sleep in the aged with OSAS (Fig. 2).

Deglutition during sleep is a dry swallow. Mannson and Sandberg reported saliva stimulates a swallowing reflex.[17] Schneyer et al. reported that secretion from salivary glands decreases during sleep.[18] Consequently, sleep-related saliva secretion adversely influences sleep-related deglutition in the aged with OSAS (Fig. 2).

Laxity of tissues surrounding the larynx and trachea leads to laryngoptois, which is an abnormally low position of the larynx seen especially in the aged male and adversely influences the swallowing function (Fig. 2).

The laryngeal surface epithelium appears to become less sensitive to aspirated material with ageing. Yager et al. reported that mucociliary function (protective airway function) is reduced during sleep in the aged.[19]

Consequently, the protective airway reflex is aggravated in the aged with OSAS (Fig. 2).

As a result, as reported previously, retention of saliva and secretion in the pharynx during sleep causes retention and growth of bacteria in the pharynx. And refluxed acid is retained in the pharynx and esophagus (Fig. 2).

As mentioned above, deglutition was still infrequent and respiratory phase patterns were unique during sleep in the aged with OSAS. Due to the complexity of swallowing processes, many adverse health conditions can influence swallowing functions during sleep. Sleep-related deglutition and respiratory phase patterns may adversely influence aspiration-related diseases (aspiration pneumonia, etc.) in the aged with sleep-related breathing disorders.

CONCLUSION

Deglutition was still infrequent and respiratory phase patterns were unique during sleep in the aged with OSAS, even though it was higher than in the aged without OSAS. Sleep-related deglutition and respiratory phase patterns may adversely influence aspiration-related diseases (aspiration pneumonia, etc.) in the aged with sleep-related breathing disorders.

In addition to the presbyphagia, sleep-related deglutition in the aged with OSAS may increase the risk of aspiration and adversely influence aspiration-related diseases.

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