

Exacerbation criteria

The diary includes records of “major” symptoms, such as dyspnoea, sputum purulence and sputum quantity, and “minor” symptoms, such as wheeze, sore throat, cough and nasal congestion/discharge. Moreover, the uses of additional treatments for COPD, antibiotics and/or a systemic glucocorticosteroid were recorded.

Swallowing monitoring system and analysis methods

Respiratory flow is detected by a differential pressure transducer, and the piezoelectric signal is divided into low- and high-frequency components by bandpass filters. The low-frequency signal component represents the laryngeal movement, and the high-frequency signal component represents the laryngeal (swallowing) sound[E1].

These signals are stored on a micro-SD card for future analyses. Custom programs written in MATLAB R2014b (The MathWorks, Inc., Natick Massachusetts, USA) were developed to calculate the following parameters [E1]:

- 1) Duration of deglutition apnoea and swallowing latency

We calculated the swallowing latency in the context of breathing-swallowing coordination as the time from the onset of deglutition apnoea to the onset of the swallowing reflex. The onset of the swallowing reflex was defined as the time point at

which the speed of the laryngeal elevation reached the maximum value.

2) Breathing-swallowing coordination

We evaluated the breathing type before and after swallowing by evaluating the direction of respiratory flow before and after the deglutition apnoea. Normal healthy subjects tend to exhibit a swallow during expiration (E-SW) pattern and an exhale after swallow (SW-E) pattern. Namely, a typical swallow occurs during expiration, and the respiration is resumed with expiration (E-SW-E pattern). However, two unusual inspiration patterns, swallowing during inspiration (I-SW pattern) and inspiration immediately after swallowing (SW-I pattern), may occur.

We evaluated the occurrence of these two unusual patterns (I-SW and/or SW-I) from diagnostic patterns obtained from series of respiratory flow, laryngeal (swallowing) sound and movement data. Patterns were diagnosed by two readers (S.N. and Y.O.) who were blinded to the clinical data. After completing each assessment, consensus results were achieved through discussions between the two readers. The average and individual frequencies of the I-SW and/or SW-I patterns for all four or each type of test food were calculated.

REFERENCES

1. Yagi N, Nagami S, Lin MK, Yabe T, Itoda M, Imai T, Oku Y. A noninvasive swallowing measurement system using a combination of respiratory flow, swallowing sound, and laryngeal motion. *Med Biol Eng Comput* 2016. doi:10.1007/s11517-016-1561-2.