Swallowing function and the incidence of fever in older residents with special care needs: a one-year longitudinal prospective study

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Abstract

Background

Infectious diseases including aspiration pneumonia are the most frequent causes of fever, common in older residents of nursing homes. We investigated whether swallowing dysfunction was related to fever in such residents.

Methods

Older residents aged ≥ 65 years from three nursing homes were included in this prospective study conducted from July 2017 to May 2019. The follow-up period was 13 months. The outcome was fever incidence in relation to swallowing function. Baseline data on the activities of daily living, cognitive function, swallowing function, respiratory function, tongue pressure, and comorbidity conditions were collected. Dates on which the body temperature of participants was more than 37.5 °C during the follow-up period were also recorded. For statistical analysis, swallowing function assessed by the modified water swallow test (MWST) scores were used to divide the participants into three groups; scores ≤ 3, 4, and 5.

Results

A total of 52 participants [median age, 89.5 (67–104)] were enrolled. Kaplan-Meier analysis showed that the average periods until onset of fever in participants with MWST scores of ≤ 3, 4, and 5 were 8.0 (6.0–11.0), 10.0 (7.0–12.0), and 12.0 (10.0–13.0) months, respectively. Cox's proportional hazards regression model revealed that participants with an MWST score ≤ 3 were at a higher risk of fever compared to those with an MWST score of 5 (hazards ratio 13.0, 95% confidence interval 1.9–87.6), adjusted with possible confounders.

Conclusions

Swallowing dysfunction correlated with the risk of fever in older residents of nursing homes.

Background

Fever is a cardinal clinical sign, especially in geriatric individuals. However, symptoms accompanying fever are frequently atypical, showing non-classical patterns[1, 2]. Since the immune function in geriatric individuals is compromised in comparison to younger individuals, an absent or blunted fever response in inflammatory diseases is often observed. In older individuals, bacteremia[3], endocarditis[4, 5], pneumonia[6, 7], and meningitis[8] often present with low-grade fever when compared to younger individuals. Infectious diseases are the most frequent nosogeny of fever; other causes being chronic

inflammatory collagen diseases, tumors, and drug-related fevers[9, 10]. A previous study reported that the proportion of severe infectious diseases is higher in older individuals than in younger individuals, and is associated with increased risk of morbidity and mortality [11]. In nursing homes, fever is more likely to occur in older residents with care needs, and pneumonia/bronchitis, urinary tract, skin, and soft tissue infections are the common causes [12, 13]. The onset of fever, particularly at night, imposes a significant burden not only on the patients but also on medical professionals and the nursing home staff. Since most nursing homes lack the required human resources, the incidence and risk factors of fever should be thoroughly investigated. Thus, predictors of fever are the key to provide optimum health to geriatric individuals requiring care.

The swallowing function degrades with aging [14]. Although bolus transit time does not change with age, the swallow response time is often delayed in older individuals [15]. Swallowing dysfunction is a risk factor for malnutrition [16], aspiration [17], recurrent pneumonia [18, 19], and poor vital prognosis [20] in older individuals.

Hence, the aim of this study was to determine the factors associated with fever in older residents of nursing homes. Considering they show an increased risk of aspiration pneumonia, we further investigated whether swallowing function can predict the onset of fever in older individuals requiring special care.

Methods

Study setting and study population

This prospective cohort study was performed in three nursing-care insurance facilities in Kitakyushu City, Fukuoka Prefecture, Japan, from July 2017 to May 2019. The follow-up period was 13 months. Individuals who could not sit or communicate were excluded, as a spirometer was used for the accurate measurement of respiratory function. Fifty-seven geriatric residents aged ≥ 65 years were enrolled, four refused to participate in the baseline survey, and one left the nursing home before onset of fever during the follow-up period. Finally, 52 residents were analyzed. A flow diagram showing the process of participant selection is shown in Fig. 1.

Data collection

Swallowing function, tongue pressure, activities of daily living (ADL), cognitive function, respiratory function, pneumococcus vaccination, and comorbidity conditions at baseline were assessed. During the follow-up period, dates, when the participant exhibited a body temperature of more than 37.5 °C, i.e., fever, were also recorded. Daily axillary temperature was measured at 7:00 am by the nursing home staff. Information on demographic characteristics, pneumococcal vaccination, and physical health status were obtained from a standard questionnaire and medical records of the nursing-care insurance facility. Data were collected from 3:00 pm to 5:00 pm at the participant’s nursing home.

Swallowing function

Swallowing function was evaluated using the modified water swallow test (MWST), with sensitivity and specificity of 70% and 88%, respectively, in predicting aspiration [21], one of the most significant consequences of dysphagia. A 10-mm syringe was used to pour 3 ml cold water into the floor of the mouth of the participant, and he/she was instructed to swallow it. The swallowing was scored as follows: score 1, inability to swallow with choking and/or breathing changes; score 2, swallowing complete, but with breathing changes; score 3, swallowing complete with no breathing changes, but with choking and/or wet hoarseness; score 4, swallowed successfully with no choking and/or wet hoarseness; score 5, combined with meeting the requirements of score 4, additional deglutition (dry swallowing) was performed more than twice within 30 s. If the score was equal to or above 4 (score 4 or score 5), the test was repeated twice, and the lowest score was considered. A score of ≤ 3 indicated a risk of dysphagia. For statistical analysis, the participants were classified into three groups by MWST scores of ≤ 3, 4, and 5.

Maximum tongue pressure

Tongue pressure was evaluated using a specific tongue pressure measurement device (JMS Co, TPM-01, Tokyo, Japan). TPM-01 is a handheld manometry device consisting of a small, balloon-type, disposable oral probe. At zero calibration, the probe is inflated with air at a pressure of 19.6 kPa. Tongue pressure was measured with the participants in a relaxed, seated position. They were instructed to compress the balloon-type probe between the tongue and palate with the maximum possible force. All measurements were performed by a single dental hygienist. The measurements were performed three times, and the maximum value was considered for the analysis.

Peak expiratory flow rate

A simple electronic spirometer (CHESTGRAPH HI-105; CHEST M. I., Tokyo, Japan) was used to measure the peak expiratory flow rate (PEFR). All measurements were performed by a single dental hygienist. Participants were asked to take a deep breath, and then exhale while sitting in an upright position to yield the highest PEFR. For each participant, the highest of three consecutive measurements was considered as the correct PEFR.

ADL, cognitive activity, and comorbidity conditions

Trained nursing home staff assessed the functional dependence in ADL using the Barthel index, which includes the domains of personal care and mobility. The scores ranged from 0 to 100, with higher scores representing greater independence. Cognitive function was assessed using the mini-mental state examination (MMSE), which includes the domains of registration, orientation, attention, concentration, memory, language, and ability to follow simple commands [22]. The total score ranged from 0 to 30 (higher scores represent better cognition). Comorbidity conditions were assessed with the Charlson comorbidity index (CCI) [23, 24] because older individuals were frequently affected by one or more diseases.

Statistical analysis

Descriptive statistics were used to characterize the participants. Each value was represented as median (minimum-maximum) and was evaluated using the Mann-Whitney *U* test for continuous variables and the chi-square test for categorical variables. The incidence curves of initial onset of fever during the follow-up period were analyzed using the Kaplan-Meier method. The Cox proportional hazards model was used to estimate hazard ratios (HRs) for onset of fever among the three groups. The following variables were identified as possible confounders of the association between swallowing function and onset of fever: sex, age, ADL, body mass index, CCI, respiratory function, and tongue pressure. All analyses were performed using the SPSS statistical software version 22 (SPSS, Chicago, IL, USA), and the level of significance was set at 5% for all cases. We followed the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines for reporting the analysis of observational data.

Results

Data obtained from the 52 participants (11 male and 41 female) were analyzed. The median age of the participants was 89.5 (67–104) years. The number of participants with MWST scores of ≤ 3, 4, and 5 were 13 (25.0%), 17 (32.7%), and 22 (42.3%), respectively. The baseline characteristics of participants according to the swallowing function are shown in Table. 1. Age, sex, Barthel index scores, MMSE scores, body mass index, tongue pressure, CCI scores, and comorbidities except cancer showed no statistical differences across the three groups. The group with an MWST score ≤ 3 included three participants with cancer ($p = 0.008$). Respiratory function, assessed by PEFR, showed significant statistical difference among the three groups; PEFR in the group with an MWST score of 5 was significantly higher than those in other groups. MWST scores and PEFR were significantly correlated ($r = 0.463$, $p = 0.001$, analyzed by the Spearman's rank correlation coefficient).

The empirical incidence curves of initial fever during the follow-up period for the three groups are shown in Fig. 2. The incidence of initial fever in the group with an MWST score ≤ 3 markedly increased at 6 and 8 months. During the follow-up period, 29 initial fevers in 1251.5 person-years were observed. The group with an MWST score ≤ 3 showed significantly higher initial fevers per person-years than the group with an MWST score of 5 (Table 2). The average periods until fever in groups with MWST scores of ≤ 3, 4, and 5 were 12.0 (95% confidence interval (CI) 10.0–13.0) months, 10.0 (95% CI 7.0–12.0) months, and 8.0 (95% CI 6.0–11.0) months, respectively (Table 2). The median number of days of initial fever in the participants was 1.0 (1–5). In 51.7% participants, the initial fever period was of 1 day. No participant was hospitalized due to pneumonia during the follow-up period. In the three participants with cancer, two participants exhibited fever, while one did not.

Table 1
Characteristics of participants divided by swallowing function

Independent variable	MWST			p value
	< 3 (*n* = 13)	4 (*n* = 17)	5 (*n* = 22)	
Age, *m* (min-max)	90.5 (79–96)	89.5 (67–104)	89 (67–97)	0.855†
Barthel index, *m* (min-max)	42.5 (10–75)	37.5 (10–75)	32.5 (5–70)	0.278†
MMSE, *m* (min-max)	14.5 (5–28)	13 (0–29)	17 (3–28)	0.618†
BMI, *m* (min-max)	20.4 (14.2–31.6)	19.2 (13.4–31.6)	20.0 (12.8–28.2)	0.858†
CCI, *m* (min-max)	2 (0–4)	1.5 (0–3)	1 (0–3)	0.229†
PEFR, *m* (min-max)	1.16 (0.49–1.81)**	1.38 (0.14–4.58)*	1.87 (0.72–4.68)	0.004†
Tongue pressure, *m* (min-max)	12.8 (2.8–25.7)	15.1 (4.2–35.2)	17.9 (1.7–44.4)	0.482†
Sex, *n* (%)				
Man	3 (23.1)	1 (5.9)	7 (31.8)	0.142‡
Woman	10 (76.9)	16 (94.1)	15 (68.2)	
Comorbidity, *n* (%)				
Myocardial infarction	4 (30.8)	3 (17.6)	4 (18.2)	0.618‡
Cardiac insufficiency	4 (30.8)	7 (41.2)	2 (9.1)	0.062‡
Cerebrovascular disease	2 (15.4)	8 (47.1)	4 (18.2)	0.073‡
Dementia	2 (15.4)	4 (23.5)	8 (36.4)	0.372‡
Chronic hepatitis	0 (0)	0 (0)	1 (4.5)	0.499‡
Diabetes mellitus	3 (23.1)	4(23.5)	6 (27.3)	0.948‡
Cancer	3 (23.1)	0 (0)	0 (0)	0.008‡
Pneumococcal vaccination	4 (30.8)	3 (17.6)	3 (13.6)	0.453

† Kruskal Wallis test, ‡: chi square test, * $p < 0.05$ compared to MWST 5, ** $p < 0.01$ compared to MWST 5.

m: median, n: number, MWST: modified water swallowing test, BMI: body mass index, MMSE: mini-mental state examination, PEFR: peak expiratory flow rate, CCI: Charlson comorbidity index

Table 2
Incidence of fever per person-years, period until fever, and hazard ratio for fever by MWST

MWST	Incidence of fever per person-years	p-value†	Average of period until fever (95% CI)‡	Cox proportional hazard model	
				HR (95%CI)§	p-value
5	0 (0-0.50)	0.022	12.0 (10.0–13.0)	1	0.009
4	0.77 (0-0.17)		10.0 (7.0–12.0)	1.6 (0.5–5.4)	0.427
≤ 3	0.77 (0-0.33)*		8.0 (6.0–11.0)	12.9 (2.0-82.6)	0.007

HR: hazard ratio, CI: confidence interval, MWST: modified water swallowing test.

† Kruskal Wallis test, * $p < 0.05$ compared to MWST 5 assessed by post-hoc analysis of Kruskal Wallis test, ‡ Obtained from Kaplan-Meier model. § Adjusted by sex, age, activity of daily living, cognitive function, body mass index, Charlson comorbidity index, tongue pressure, respiratory function, and pneumococcus vaccination.

In the Cox regression models, the HR for initial fever in the group with an MWST score ≤ 3 was 13.0 (95% CI 1.9–87.6, $p = 0.009$) compared to the group with an MWST score of 5, adjusted by possible confounders (Table 2).

Discussion

The findings of this study were analyzed by the Cox proportional hazard model adjusted with possible confounders. The model demonstrated that swallowing dysfunction, assessed by MWST, increased the risk of fever, which was designated as a body temperature of 37.5 °C and above, in older Japanese residents of nursing homes.

In this study, 51.7% of participants had a fever period of one day, which is consistent with previous reports demonstrating that the proportion of one-day fever was 47.5% in all fever episodes in elderly inpatients [25]. A study previously reported that the most common nosogeny of fever in older inpatients was infectious diseases: respiratory tract infection (34.5%), urinary tract infections, (23.8%), other infectious diseases (12.2%), and infections of unknown origin (26.9%) [26]. Similarly, another study reported that the most common nosogenies of fever in patients of the recovery phase rehabilitation ward were respiratory tract (60.2%) and urinary tract infections (27.8%) [27]. As quoted by Sir William Osler, “pneumonia is the friend of the aged,” a frequent, painless, and lethal event occurring in elderly patients [28]. Although the nosogeny of fever was not determined in the nursing home residents of this study, as shown by these multiple lines of evidence, the predominant cause of fever is expected to be respiratory tract infection. The risk factors of pneumonia in older residents of long-term care facilities were identified

as individual (malnutrition, long-term disease, functional impairment, medications, and prolonged antimicrobial exposure) and institutional (larger facilities with shared nursing staff, group activities, low immunization rates, and excessive anti-microbial use) factors [29]. Swallowing dysfunction is also closely related to aspiration pneumonia in older adults [19, 30]. Most older individuals tend to dismiss dysphagia as a symptom of normal aging [31]. However, though swallowing function declines with age [32, 33], regular examinations are critical to maintain the swallowing function and to prevent onset of fever in older individuals with the need for care. Our findings suggest that older individuals with swallowing dysfunction should be taken in account for onset of fever caused by pneumonia in the nursing home.

According to the clinical practice guideline for evaluation of fever and infection in older adult residents of long-term care facilities established by the infectious diseases society of America, the following types of fever are signs of suspected infection: (1) A single oral temperature > 37.8 °C; or (2) repeated oral temperatures > 37.2 °C or rectal temperatures > 37.5 °C; or (3) an increase in temperature of > 1.1 °C above the baseline temperature[34]. The response to infectious assault in older individuals tends to be atypical with no fever episodes. A decrease in immune cells, followed by a reduction in innate pyrogen and inactivation of arachidonic acid metabolism[35, 36] is frequently observed with aging. Since the normal body temperature in older individuals is generally lower than that of younger individuals, the fever threshold should be estimated at a lower value. The mortality rate in older individuals with body temperature ≥ 37.5 °C or ≥ 1.5 °C above the usual body temperature has been reported to be 5% [37]. In older individuals, if fever is defined as a body temperature of ≥ 37.2 °C, the sensitivity and specificity of detecting infections become 83% and 89%, respectively[38]. This evidence suggests that even a slight pyrexic event can lead to poor vital prognosis in older individuals. Considering that pyrexia in older individuals can be easily missed, individuals with swallowing dysfunction should be monitored more attentively. In our study, the proportion of participants with ≤ 3 was 25.0%. In a previous study, the proportion was 18.5% in older residents of nursing homes[39]. The evidences strongly suggest there are many older individuals with a high risk of pneumonia in nursing homes.

This study has some limitations. First, we did not evaluate the causes of fever. Since most fever episodes are short-term, the nosogeny of fever is not determined in nursing homes. Second, we recruited participants from three nursing homes of two mid-sized cities in Japan. Therefore, caution is warranted in generalizing our findings to the wider older Japanese population. Third, fever was defined as a body temperature of ≥ 37.5 °C in this study. Hence, fever episodes in participants with lower normal body temperatures might have been overlooked. For the precise evaluation of such patients, it is necessary to collect data on pyrexia with body temperature of > 1.5 °C from the normal. A strength of this study is that variables used for analyses employed biological data such as tongue pressure, PEFR, and MWST for analyzing oral functions. Another study had employed a questionnaire, the EAT-10 [40, 41], for analyzing the swallowing function. To the best of our knowledge, this is the first study that attempts to determine the relationship between swallowing function and fever incidence in older residents of nursing homes. Our findings will help in the implementation of adequate precautionary measures such as swallowing training for older individuals with high incidences of fever. Hence, further research should be

interventional trials to investigate the effect of training and/or rehabilitation of swallowing function on fever incidence.

Conclusions

Swallowing dysfunction increased the risk of fever, defined as a body temperature of ≥ 37.5 °C, during a 13-month follow-up period in older Japanese residents of nursing homes. The findings of the study suggest that many older nursing home residents with the need for care have the risk of pneumonia.

Abbreviations

CCI: Charlson comorbidity index; MMSE:mini-mental state examination; MWST:modified water swallowing test; PEFR:peak expiratory flow rate

Declarations

Ethics approval and consent to participate

The study was approved by the Kyushu Dental University Institutional Review Board for Clinical Research (No. 17 – 1). Informed consent was obtained from all respondents, their surrogates, or legal representatives before data collection.

Consent for publication

Not applicable.

Availability of data and materials

Data and material are available by the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

All authors had significant roles in designing, conceiving, and conducting the study and drafting the manuscript. MI and SA contributed to designing the study. MI, KS, YO and MN collected the data, and SA analyzed it. MF and SA were the supervisor of the whole research and checked the data. The final report and article were written by IM and SA. All authors read and approved the final manuscript.

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Figures

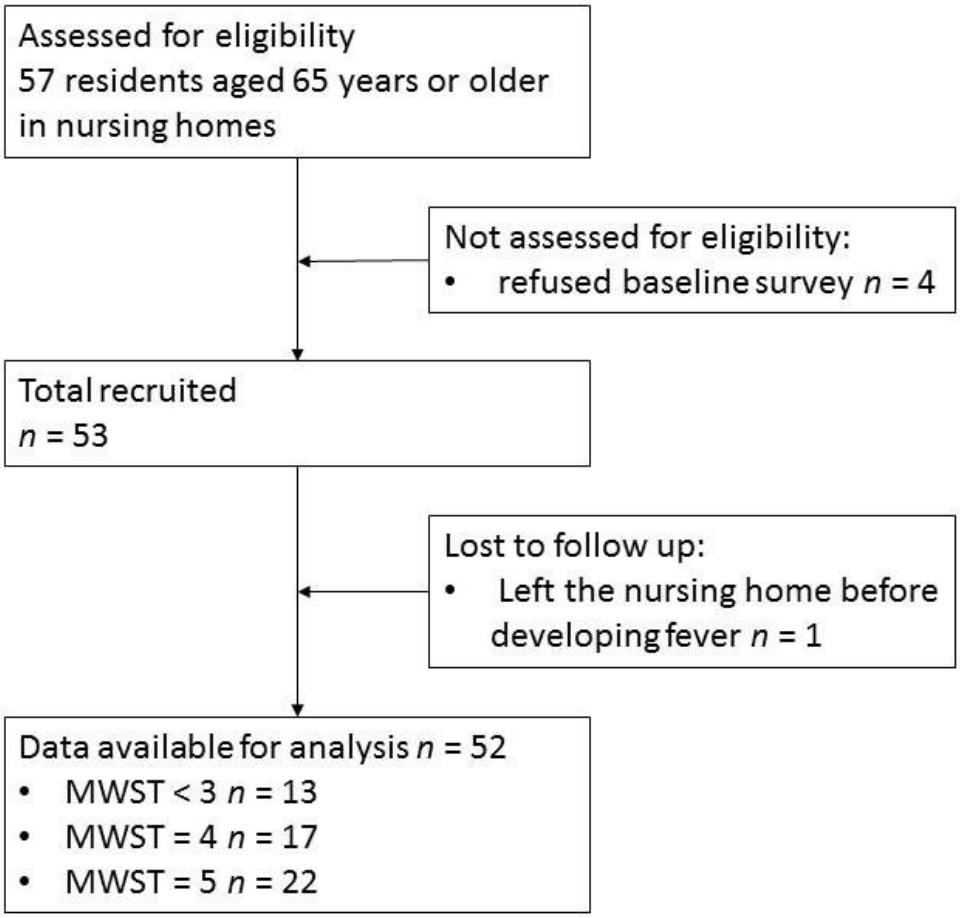

Fig. 1

Figure 1

Flow diagram of the study participants.

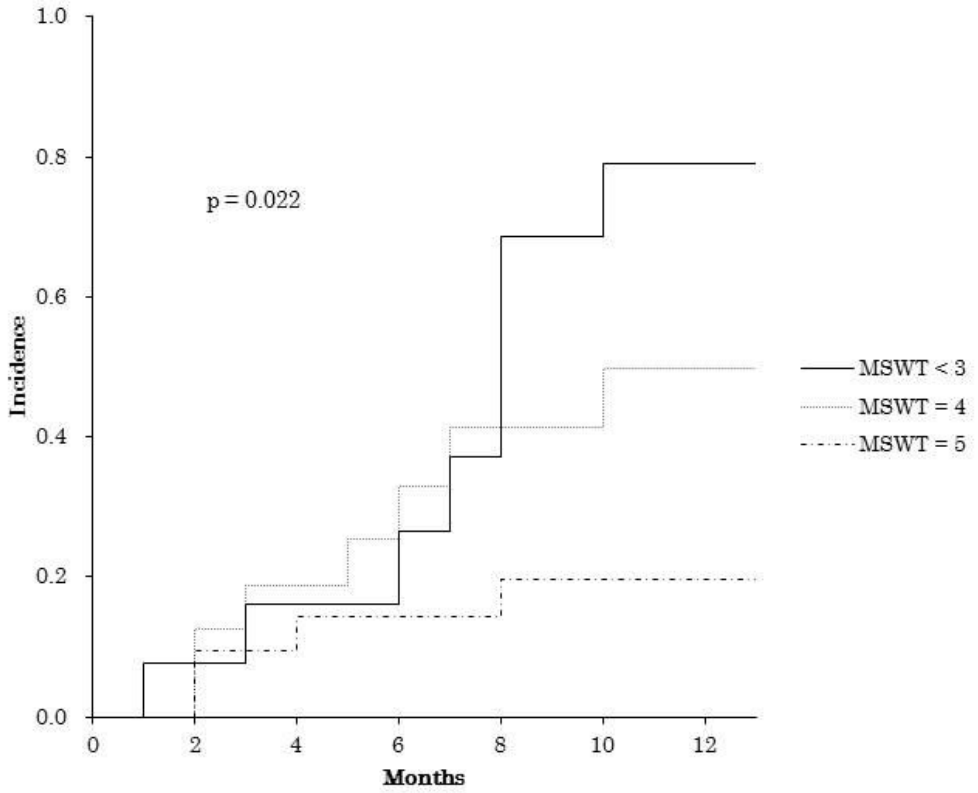

Fig. 2

Figure 2

Incidence curves according to the swallowing function. The x-axis shows the follow-up duration (months). (—) MWST < 3, (—) MSWT = 4, (—) MSWT = 5