

Effect of a large meal on measurements of lung function

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SUMMARY AT A GLANCE

The study aim was to determine the effect of a large meal consumed prior to lung function measurement. No effect of meal on FEV₁, FVC, TLC or DL_{CO} was seen. This result does not support the recommendation that patients need to abstain from large meals prior to lung function testing.

ABSTRACT

Background and objective: It is currently recommended that patients avoid large meals prior to their lung function tests. The aim of this study is to determine if this recommendation is necessary in clinical practice.

Methods: A randomised controlled cross-over trial was conducted. Subjects performed lung function tests (spirometry, measurement of lung volumes and gas transfer) prior to, directly following, and two hours after consuming a large breakfast. On the control arm, subjects performed the same lung function tests whilst fasting for the duration of the morning. The study subjects comprised twelve healthy subjects, ten COPD patients, and ten patients with interstitial lung disease.

Results: There were no significant differences between measurements on the meal and control days for FEV₁, FVC, TLC or DL_{CO}. There were no significant changes with time in any of these parameters over the course of either the meal or control morning.

Conclusions: Common measures of lung function are not affected by the prior consumption of a large meal and it is unnecessary to advise patients to avoid a large meal prior to lung function assessment.

KEY WORDS

- Lung Volume Measurements
- Postprandial period
- Pulmonary Diffusing Capacity
- Respiratory Function Tests
- Spirometry

SHORT TITLE

Effect of a large meal on lung function

INTRODUCTION

To obtain repeatability of lung function test results, all sources of technical and environmental variation must be controlled. This in turn will ensure the quality of information used for diagnosis and management of respiratory disease. To this end, guidelines have been published to minimise intra-test variability, and to decrease variability between testing centres. One recommendation by the American Thoracic Society (ATS) and European Respiratory Society (ERS) joint statement *General considerations for lung function testing*¹ is that patients do not consume a large meal prior to testing. The American Association of Respiratory Care (AARC) considers consuming a large meal prior to testing, as a contraindication for measuring the diffusing capacity of the lung for carbon monoxide (DL_{CO}).²

A number of physiologic factors have the potential to impact a patient's respiration following a meal. In particular, cardiovascular, metabolic and gastrointestinal effects have been suggested to impact on lung function.^{3,4,5} The primary reference⁶ given by previous ATS guidelines⁷ hypothesises that following a meal, blood is redistributed from the pulmonary capillaries to the other organs, leading to a decrease in DL_{CO}. In the current ATS/ERS guidelines¹ no reference to the rationale for avoiding a large meal prior to testing is provided.

Adherence to pre-test recommendations, for example, refraining from a meal two hours prior to testing, is difficult to ensure in clinical practice. In our experience, patients attending the respiratory laboratory are frequently non-compliant with other instructions,

such as withholding short-acting bronchodilators, or cigarettes. In addition to this, respiratory patients may be elderly, and often demonstrate cognitive dysfunction due to long term hypoxia.^{8,9} These patients may misunderstand the instruction, and fast inappropriately prior to testing. Fasting unnecessarily increases the risk of adverse events, particularly in patients who may be acutely unwell and have other co-morbidities. The purpose of this study is to determine if abstaining from a meal prior to lung function testing is necessary in clinical practice.

METHODS

Subjects

Three groups were recruited for this study: healthy subjects, patients with interstitial lung disease (ILD), and patients with COPD. The healthy subjects were non-smoking hospital staff with no history of lung disease. This group included five out of twelve subjects, who were laboratory staff, and who were not naïve to lung function testing. ILD and COPD patients were recruited from respiratory outpatient clinics at Royal Perth Hospital over a one-year period. Patients who had attended the laboratory as an outpatient for full lung function tests, who fulfilled entry criteria and who lived locally, were approached to participate in the study via telephone call by the primary investigator. No patients were naïve to lung function testing.

The ILD cohort comprised seven patients with diffuse interstitial fibrosis and three with focal fibrosis. All had been diagnosed by a respiratory physician and were clinically

stable. The COPD cohort comprised ten patients, all of whom had an FEV₁/FVC ratio less than the lower limit of predicted,¹⁰ the recommended classification of an obstructive ventilatory defect by ATS/ERS.¹¹ Patients with severe COPD (FEV₁ <1L) were not recruited for the study on ethical grounds. Exclusion criteria were: pregnancy, diabetes, mixed obstructive and restrictive respiratory disease, inability to perform lung function testing, inability to give consent or acute illness. This study was approved by the Royal Perth Hospital Ethics Committee, and the Charles Sturt University Human Research Ethics Committee.

Study protocol

All subjects attended the respiratory laboratory on two separate days, no more than one week apart. On both study days, subjects fasted from midnight and performed a set of lung function tests at 8am. On the first visit, the subjects were randomised to the meal or control arm of the study. Subjects on the meal arm of the study were taken to a nearby eatery where they consumed a large meal. Subjects were encouraged to consume a cooked breakfast, and to eat as much food as they could, without feeling uncomfortable. Tea or coffee was to be included with their meal. Following the breakfast meal, they returned to the respiratory laboratory and repeated their lung function tests at 9.30am and 11.30am. Subjects on the control arm of the study continued fasting and repeated their lung function tests at 9.30am, and 11.30am.

All subjects completed a food diary to determine their usual breakfast intake. This enabled calculation of a kilojoule target for their large meal on the study day. The target for the large meal was >125% of the kilojoules in the subject's usual breakfast.

Lung function testing

Each set of lung function testing included spirometry (Spiroflow, PK Morgan, Kent UK), measurement of lung volumes and single breath diffusion capacity (Autolink, PK Morgan). Lung volumes were performed by plethysmography (PK Morgan) in the healthy group and the helium dilution method (Transfer Test, PK Morgan) in the patient group, due to plethysmograph failure.

The ATS/ERS guidelines¹²⁻¹⁴ for acceptability and repeatability were adhered to. The requirement for DL_{CO} repeatability was set to the criterion of two tests within 10%, rather than 3 mL/min/mmHg. In both of our patient groups, 10% of their DL_{CO} equates to 1-2 mL/min/mmHg. DL_{CO} measurements were not corrected for haemoglobin or carboxyhaemoglobin. The scientist performing the testing was not blinded to the study arms, for practical reasons.

Statistical analysis

Statistical analyses were performed using a linear mixed model¹⁵ using meal as a fixed effect, and time as a random effect. The data analysed comprised forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), total lung capacity (TLC) and the diffusing capacity of the lung for carbon monoxide (DL_{CO}). Power calculations were based

on the detection of a 200mL change in FEV₁, using matched data, where each subject was their own control. Power calculations indicated that 10 subjects would be required in each group.

RESULTS

Sixty-three eligible subjects were approached to participate in the study. Thirty-two subjects completed the study, ten patients with interstitial lung disease, ten patients with COPD, and twelve healthy subjects. Subject demographics and baseline lung function are provided in Table 1. The demographics of the ILD and COPD groups were similar, however, the healthy subjects tended to be younger and taller. The primary reason for non-participation in the study was that patients felt it would be “too much”.

All subjects consumed >125% of the kilojoules in their usual breakfast during the meal arm of the study, and were therefore considered to have eaten a large meal. The total kilojoule content of the meals is also shown in Table 1.

Fig. 1 shows the mean postprandial values for FEV₁, FVC, TLC and DL_{CO}, at 9.30am and 11.30am, in all groups. The ordinate axis in the graph represents the repeatability criteria of the measurement based the ATS/ERS criteria.¹²⁻¹⁴ For both patient groups and healthy subjects, the FEV₁ was reproducible over the course of the morning (Fig. 1a). The linear mixed model analysis for FEV₁ showed no statistical significant effect of a meal, with $p > 0.8$ for all groups. Fig. 1b displays the data for FVC which, similarly to FEV₁, remained unchanged with all $p > 0.9$. TLC, shown in Fig 1c, also showed no effect of a meal ($p > 0.8$

in all groups). Additionally, there was no evidence of effect on DL_{CO} (data shown in Fig 1d.) with $p > 0.4$ in all groups.

DISCUSSION

The results from the current study do not support the suggestion that a large meal prior to lung function testing will affect results. Other studies investigating the effect of meals have focused on spirometry, measurements of airway inflammation and basal metabolic rates. Akrabawi et al³ investigated the effect of meals in COPD patients. In that study, 36 patients consumed a 12 ounce meal, of either high or moderately high fat formula. Spirometry, V_{O_2} and V_{CO_2} were measured at 0, 30, 90 and 150 minutes post meal. No meal effect was seen in spirometry; however changes in V_{O_2} and V_{CO_2} did occur. Rosenkranz⁵ also reported no effect of a meal on spirometry in healthy subjects. Another study¹⁷ which examined the effect of Ramadan fasting on lung function showed no difference in spirometry between pre and during Ramadan; however details of the meal times in the pre-Ramadan period compared to test times were not specified. In contrast to these reports, a study by Mroueh et al⁴ found four out of twelve stable cystic fibrosis patients had a decrease in FVC of more than 5%, which occurred 10 minutes post meal. This was considered to be statistically significant, although would not be considered clinically significant.^{11,18} The data in the current study showed no postprandial effect on FEV_1 or FVC in healthy subjects, COPD or ILD patient groups.

Lung volume measurements in this study were performed by plethysmography in healthy subjects and the helium dilution method in the respiratory patients. Unlike plethysmography, helium dilution will only measure the ventilated spaces in the lungs and will exclude both non-ventilating bullae and extrapulmonary thoracic gas.¹⁹ This may account for the baseline % predicted TLC for the COPD group being similar to the baseline % predicted TLC for the healthy group. TLC measurement, by both techniques, is dependent on the subject's ability to inspire and expire maximally. Thus, TLC may be limited by abdominal distension, causing discomfort and restricting the ability of the lung to expand. Ventilatory pattern changes, such as an increase in respiratory rate with a fall in tidal volume, may affect lung volume subdivisions such as functional residual capacity, but would be compensated by changes in inspiratory capacity, so that no change is seen in TLC. In this study, there were no significant changes in TLC after subjects had consumed a large meal, either immediately or two hours prior to testing.

Mechanisms for postprandial changes in DL_{CO} have not been investigated, but it is widely assumed^{1,2,7,20} that meals prior to testing will decrease DL_{CO} . The rationale behind this is that the redistribution of blood flow from the pulmonary capillaries to the splanchnic regions, which occurs for digestive purposes after a meal, will reduce pulmonary perfusion. In addition to this, any mechanisms that affect FVC or TLC would also affect DL_{CO} . Besides pulmonary perfusion, the main factors that influence DL_{CO} are the conductivity of the alveolar-capillary membrane and the reaction rate of haemoglobin with carbon monoxide.¹⁴ Thus the reproducibility of DL_{CO} between sessions can vary depending on many different factors, including recent exercise, smoking, haemoglobin

level and time of day.²¹⁻²⁵ Technical factors, including equipment used, breath-hold time and depth of inspiration can also influence results. For these reasons, DL_{CO} has a much higher variability than other lung function tests. The ATS/ERS guidelines for measurement of diffusing capacity¹⁴ allow a repeatability of within 3 units, or 10%, whichever is greater. The acceptable results from a testing session are then averaged for the reported result. The change in DL_{CO} required for clinical significance is uncertain. Robson and Innes²⁶ studied the natural variability of DL_{CO} over one week. They reported co-efficients of repeatability for DL_{CO} of 1.84 mmol/min/kPa (5.5 mL/min/mmHg) in healthy subjects, and 1.30 mmol/min/kPa (3.9 mL/min/mmHg) in patients with emphysema. In the current study, the between session repeatability was found to be within these limits, and no statistically significant effect of meals on DL_{CO} was seen, providing further evidence that avoiding a large meal prior to lung function testing is unnecessary.

In the current study, tea or coffee was included in all of the meals. Caffeine is a known stimulant of ventilation²⁷ and has a bronchodilator effect similar to theophylline.²⁸ Caffeine has been shown to increase FEV₁ in asthmatics^{28,29} and is effective at preventing exercise induced bronchoconstriction at doses of 7mg/kg.³⁰ Bronchodilation of airways has been shown to increase DL_{CO} by reducing expiration time, and improvements in volume and distribution of inhaled gas.³¹⁻³³ In addition to this, similar to the proposed effect of a large meal, it is possible that the vasodilator effects of caffeine may decrease DL_{CO} by the redistribution of blood from the pulmonary capillaries to the muscles and brain. However, given that the doses of caffeine in previous studies (5-7mg/kg) are higher than in the present study, and we believe it unlikely that including tea or coffee with a meal has

affected results. Furthermore, we have previously evaluated the effects of drinking coffee on FEV₁ and DL_{CO} in a separate study,³⁴ using a similar protocol, which found no effect.

This study has several limitations. Firstly, we were unable to measure, and correct for haemoglobin. We did not consider measurement of carboxyhaemoglobin levels to be necessary, as none of the study subjects were current smokers. Another limitation to this study is that the scientist performing the lung function testing was not blinded to the study arm of the subjects. Additionally, the limited sample size may not have detected small changes in lung function which may be significant for research purposes, but these changes are unlikely to be clinically significant.

In conclusion, this study directly assessed the need to withhold large meals prior to lung function testing, and is the first study to examine postprandial effects on the measurement of lung volumes and gas diffusion. This study did not demonstrate any statistically significant postprandial changes in lung function. In the context of a clinical respiratory laboratory the present findings do not support the ATS/ERS recommendation that patients withhold meals prior to performing their lung function tests.

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TABLES

Table 1 Demographic characteristics, baseline lung function and large meal of the subjects who completed the study. Total kilojoule content for the large meal consumed on the study day is also shown.

	Healthy	COPD	ILD
Number of subjects	12	10	10
Sex, M/F	6/6	6/4	5/5
Age, years	40 ± 13	65 ± 9	65 ± 9
Height, cm	174 ± 11	165 ± 8	167 ± 10
Weight, kg	74 ± 16	75 ± 16	84 ± 17
BMI, kg/m ²	24 ± 4	27 ± 6	30 ± 5
FEV ₁ , % predicted ¹⁰	97 ± 18	73 ± 21	86 ± 19
FVC, % predicted ¹⁰	99 ± 15	99 ± 20	84 ± 20
TLC, % predicted ¹⁶	109 ± 12	112 ± 9	73 ± 12
DL _{CO} , % predicted ⁶	90 ± 11	78 ± 19	57 ± 9
Size of large meal, KJ	4135 (1495 - 9335)	2622 (795 - 3920)	2338 (2245 - 2390)
% of usual breakfast	445 (127 – 2416)	207 (141 – 316)	213 (133 – 371)

Data are presented as number or mean ± SD. ILD, Interstitial Lung Disease

FIGURE LEGENDS

Figure 1 Mean postprandial changes in lung function test results over the course of a morning, in patients with COPD (n=10), interstitial lung disease (n=10) and in healthy subjects (n=12). Lung function parameters included measurement of forced flows: (a) FEV₁ and (b) FVC, as well as static lung volumes (c) TLC and diffusion capacity (d) DL_{CO}. There was no significant effect of meal on lung function in any group, with all p > 0.4.