Figure 1

THE EFFECT OF POSTURE ON VENTILATION USING STRUCTURED LIGHT PLETHYSMOGRAPHY (SLP) IN ALPHA-1 ANTITRYPSIN DEFICIENCY (AATD).

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Introduction

Patients with a PiZ AATD phenotype tend to develop predominantly basal emphysema as opposed to the central emphysema typically associated with usual COPD. However, a proportion of AATD patients have exhibited a greater involvement of the apex of the lungs [1].

High resolution CT scans can detect emphysema earlier than traditional lung function tests (such as spirometry) allow, although they are costly and in high demand. Structured Light Plethysmography (SLP) measurements are quicker and less costly than imaging scans, and can easily be incorporated into a patient's routine lung function tests.

SLP utilises two digital cameras to track the 3D position of a checkerboard grid projected onto the subject's anterior chest and abdomen (Figure 1). The reflected grid creates 200 crossing points, which is then recorded by two integrated high-speed video cameras and relayed to the computerised system to produce a 3D graphical reconstruction of a virtual chest (Figure 2).

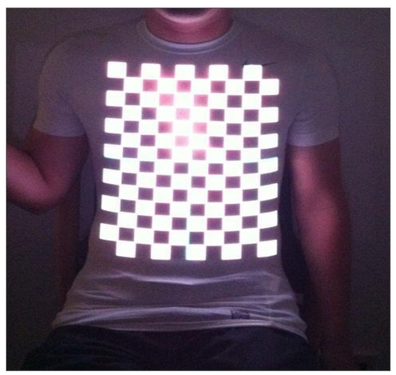

Figure 1: The SLP device (Left). The projected light grid from SLP onto a subject's anterior chest and abdominal wall (Right).

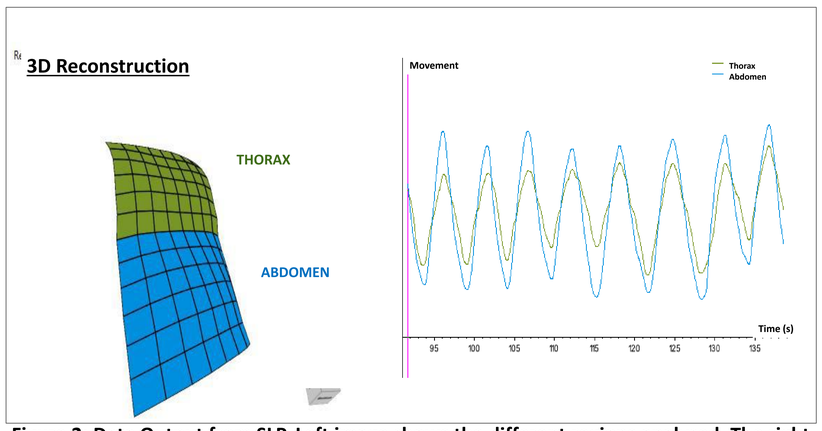

Figure 2: Data Output from SLP. Left image shows the different regions analysed. The right image showing the relative movements of the thorax and abdomen.

Relative Thoracic Contribution (RTC) is the ratio of a region's movement change to the tidal volume (Vt), where Vt is taken to be the total chest wall movement, averaged over all breaths in the selection.

Phase Angle (PA) provides a measure of synchronicity between two regions (e.g. Thorax and Abdomen or Upper and Lower Thorax). 0^o or 360^o indicates both regions are in perfect synchrony. A phase of 180^o means one region moves in paradox to the other (Figure 3).

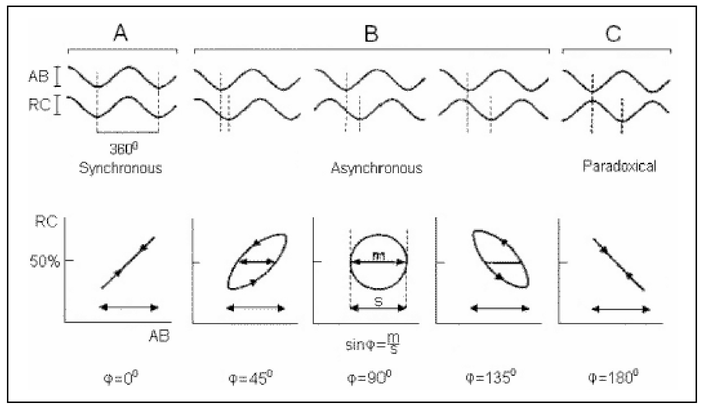

Figure 3: Illustration showing the different phase angles in relation to the synchronicity of breathing.

SLP is a new technology but it could be a sensitive tool in assessing different patterns of ventilation in different postures. In addition, it may be possible to detect specific areas of the lung that have ventilatory impairment.

Methods

SLP was measured in 27 patients with varying severities of AATD using Thor3Di (PneumaCare, Cambridge, UK). 50 simultaneous tidal breaths were recorded (approximately 5mins) in both a seated and supine positions.

27 AATD patients were recruited. Comparisons of RTC and PA in a seated to supine posture were made for the whole group.

Patients were then split into those with airflow obstruction (FEV_1/FVC below the normal range) and further comparisons of RTC and PA were made.

AATD Group	Sex (M:F)	Age (years) Mean (Range)	FEV_1 % Pred (Mean + SD)	FEV_1/FVC (%) (Mean + SD)
Non-Obstructive	**6:3**	**58** (41-85)	**105** (16.6)	**73** (5.4)
Obstructive	**10:8**	**54** (38-68)	**47** (21.8)	**37** (11.3)

Table 1: Demographic data for AATD patients with and without airflow obstruction.

Results

Significant differences were seen in both RTC and PA between a seated and supine posture (Table 2).

Parameter	Seated (Median)	Supine (Median)	p-value
RTC	51 (41-56)	39 (30-52)	**< 0.01**
PA	5.7 (5.3-9.1)	11.3(6.7-17.2)	**< 0.01**

Table 2: A comparison of Relative Thoracic Contribution (RTC) and Phase Angle (PA) in a seated and supine position for all patients with AATD (n=27). Data are Median (IQR).

When non-obstructive and obstructive AATD patients were separated, RTC was significantly higher and PA was significantly lower in patients with airflow obstruction in a supine (but not seated) position (Figure 4).

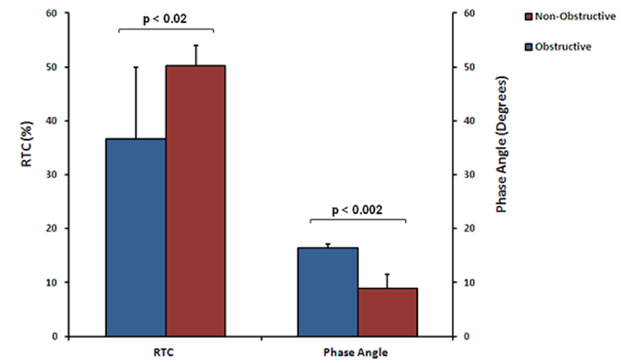

Figure 4: Comparisons of Relative Thoracic Contribution (RTC) and Phase Angle (PA) in a supine position for AATD patients with (n=18) and without (n=9) airflow obstruction.

Conclusions

Breathing becomes more abdominally dominant in a supine position, which is consistent with our current understanding.

Breathing is also more asynchronous in the supine position and this effect is increased in the presence of airflow obstruction.

Further investigations comparing SLP to CT densitometry and spirometry would prove useful in determining whether or not SLP can detect and accurately monitor early pathological changes.

References

1. D. Parr, et al. Pattern of Emphysema distribution in A1-Antitrypsin deficiency influences lung function impairment. *Am J Respir Crit Care Med* 2004; 170: 1172–1178.