BELGIAN RESPIRATORY SOCIETY

Statement concerning the measurement of lung volumes using a single-breath technique

(January 2025)

At the Vienna ERS congress in September 2024, we heard during informal contacts that some confusion has arisen among pulmonologists and pulmonary function technicians about the possibility to derive TLC- and RV-values from a single-breath manoeuvre, as performed in the context of the determination of the diffusion capacity (DLCO). Some are even considering to bill a volume measurement when measuring the diffusion capacity. This issue has caught the attention of the members of the Working Group "Pulmonary Function and Oxygen Therapy" of the BeRS. Admittedly, a subject in whom a diffusion capacity is measured, must first expire completely before taking a complete inspiration. The expired gas is then analyzed to measure the CO content as well as the concentration of the tracer gas.

From a theoretical point of view, one could derive total lung capacity (TLC) from the dilution of that tracer gas (often He or methane) during the expiratory phase. However, a measurement based on the dilution of a tracer gas after one single inhalation does not reflect the true TLC.

Indeed, the recent 2023 update of the ERS/ATS technical statement on the standardisation of the measurement of lung volumes unequivocally states that *"single-breath gas dilution methods as used [...] during measurement of diffusing capacity [...] are more susceptible to the problem of underestimation of TLC when there is regional ventilation inhomogeneity, are not linked with spirometric manoeuvres that allow determination of other lung volumes, do not primarily measure FRC, and do not include anatomical dead space.. Although there is improvement in estimation of TLC from the single-breath method by using total exhaled breath as noted in the 2017 ERS/ATS standard for carbon monoxide uptake in the lung (DLCO standard), the limited evidence available nonetheless shows underestimation"*[1].

The 2005 ATS/ERS Task Force on the Standardisation of lung function testing is even more explicit: *"a low TLC from a single-breath test (such as VA from the DLCO test) should not be interpreted as demonstrating restriction, since such measurements systematically underestimate TLC. The degree of underestimation increases as airflow obstruction worsens. In the presence of severe airflow obstruction, TLC can be underestimated by as much as 3 L, greatly increasing the risk of misclassification of the type of pulmonary function test abnormality"*[2].

From a physiological point of view, measurements of lung volumes using body plethysmograph, gas dilution and washout techniques and a single-breath technique represent three different things. A body plethysmograph measures the compressible gas volume within the thorax, the dilution- and washout techniques measure the communicating gas volume, the difference between both representing the trapped gas or areas within the lung not communicating well with outside, as often observed in obstructive pulmonary diseases.

A TLC measured using a single-breath dilution yields even lower values than that by multiple breath dilution or washout techniques, the difference representing regional ventilation inhomogeneity.

A pulmonary function report obtained in a COPD patient (Fig. 1) illustrates our point.

In conclusion, the Working Group "pulmonary Function" of the BERS highly discourages Belgian pulmonologists to measure TLC using a single-breath technique as this measurement severely underestimates lung volumes, may result in erroneous clinical decisions. First, it may eventually lead to unnecessary technical investigations to work out a suspected restrictive syndrome which does not exist at all. Moreover, one may miss COPD patients with severe dyspnoea who might benefit from interventional techniques such as lung volume surgery or endobronchial valve placement.

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		Pred	LL	Pre	% Pred	Z-Score									Z-sc
						-5	-4	-3	-2	-1	0	1	2	3	
Spirometry (Pred values GLI 2012)															
FVC	L	4,5	3,43	3,45	77					*					-1,62
FEV1	L	3,48	2,62	1,47	42				*						-3,64
FEV1%FVC	%	78	65	43				*							-4,02
Lungvolumes (Pred values GLI 2020)															
VC_max He	L	4,93	3,93	3,27	66				*						-2,77
VC_max Pleth	L	4,93	3,93	3,35	68				*						-2,62
TLC He	L	7,04	5,65	6,07	86					*					-1,15
TLC Pleth	L	7,04	5,65	7,13	101						*				0,1
RV He	L	2,18	1,34	2,8	128							*			1,04
RV Pleth	L	2,48	1,34	3,78	173								*		2,52
FRC He	L	3,56	2,46	3,97	111						*				0,52
ITGV	L	3,56	2,46	4,84	136							*			1,53
RV%TLC He	%	30,4	20,8	46,1	151								*		2,52
RV%TLC Pleth	%	30,4	20,8	52,9	174									*	3,58
Diffusion (Pred values GLI 2020)															
DLCO SB	ml/(min* mm Hg)	26,91	20,15	3,94	15	*									-8,11
KCO	ml/(min* mm Hg*L)	4,25	3,21	0,88	21	*									-6,26
VA-SB	L	6,38		4,45	70				*						-2,67
VIN-SB	L	4,93	3,93	3,37	68				*						-2,6

Fig. 1 Pulmonary function in a COPD patient. The pulmonary function was technically almost perfect, as the FVC (3.45 L), the slow VC during plethysmography (3.35 L), the slow VC during He dillution (3.35 L) and inspiratory for the DLCO measurement (3.37 L) are all in the same range, a prerequisite for a correct interpretation of pulmonary function.

Note that in that example VA-SB vastly underestimates TLC by 3.50 L
The difference between TLC Pleth and TLC He = 1.06 L, corresponding with the volume of trapped gas. The difference between TLC He and VA-SB is caused by region ventilation inhomogeneity: 1.62 L in that severe COPD patient

This document has been written and reviewed by the following members of the working group «Lung function & Oxygenation»:
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1 Bhakta NR, McGowan A, Ramsey KA, et al. European Respiratory Society/American Thoracic Society technical statement: standardisation of the measurement of lung volumes, 2023 update. Eur Respir J 2023; 62: 2201519 [DOI: 10.1183/13993003.01519-2022].
2 Pellegrino R, et al. Eur Respir J 2005; 26: 948–968. DOI: 10.1183/09031936.05.00035205