

Chapter 52. Lung Volumes by Body Plethysmography

52.1 Introduction

Body plethysmography will be used in the PVDOMICS study to determine lung function including functional residual capacity, residual volume, total lung capacity, and slow vital capacity. During the procedure the participant is seated in an enclosed chamber that measures changes in pressure, flow, or volume. Plethysmographic measurements of lung volumes can help differentiate restrictive and obstructive disease processes such as pulmonary fibrosis or COPD/asthma.

This document describes the specific procedures to be used for PVDOMICS study measurements. The procedures conform fully with the current ATS/ERS standards.

52.2 Definitions

- Thoracic Gas Volume (TGV) – the volume of gas measured at the time of shutter closure. May be slightly more or less than FRCpleth. Switch-in error, switch-in correction – the difference between FRC and TGV. Used to correct TGV to FRCpleth
- Functional Residual Capacity (FRC) – the volume of gas present in the lungs at end-expiration during tidal breathing. This may be determined by observing a volume-time tracing showing resting, non-coached tidal respiration. When a stable end-expiratory level is achieved (usually 3-10 breaths; no less than 3), the shutter is activated (closed) and remains closed for 2-3 seconds. The participant is instructed to perform a series of gentle ($\sim +10$ cmH₂O) ‘pants’ at a coached frequency between 0.5 and 1.0 Hz (30-60 cycles per minute).
- Residual Volume (RV) – the volume of gas remaining in the lung after maximal exhalation
- Expiratory Reserve Volume (ERV) – the volume of gas that can be maximally exhaled from the FRC
- Inspiratory Capacity (IC) – the maximum volume of gas that can be inspired from FRC
- Total Lung Capacity (TLC) – the volume of gas in the lungs after maximal inspiration
- Vital Capacity (VC) – the maximum volume of air that can be exhaled from full lung (TLC) to empty lung (RV) or the maximum volume that can be inhaled from empty lung to full lung (inspiratory vital capacity (IVC)).

52.3 Participant Preparation

Pre-Testing: Plethysmography should not be attempted if the participant is unable to sit upright in the chamber, unable to perform the panting maneuver, or unable to perform maximal inspiratory and expiratory efforts. If the participant has severe claustrophobia that would preclude sitting in a phone booth-like structure with the door closed for 1-2 minutes at a time, it may not be possible to obtain plethysmographic measurements. If the participant has a known

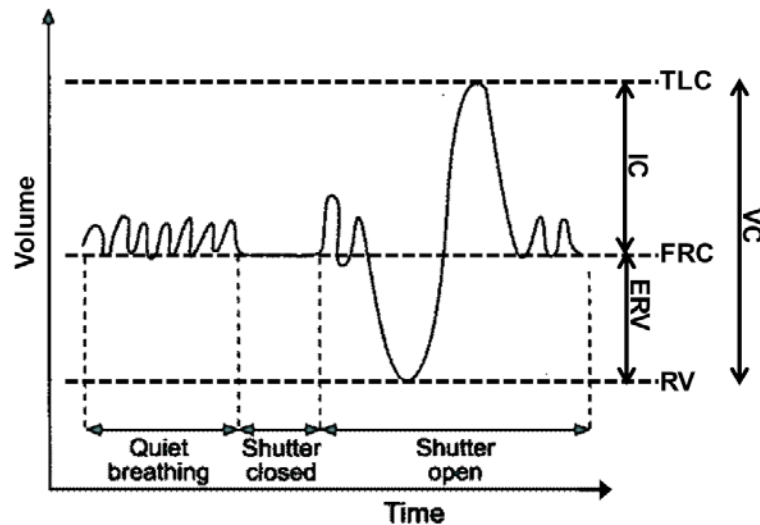
perforated tympanic membrane, a snug-fitting earplug may be used to prevent gas leaks during the panting maneuver. Supplemental oxygen flow must be discontinued during efforts.

Medication hold times are as per spirometry MOP. **Spirometry should be delayed or rescheduled, if feasible, in the event that a study participant used a medication within the restricted time period.** If the study participant is unable to hold bronchodilator medications due to severe respiratory disease it is acceptable to proceed with testing. However, the medications, doses and times of administration of all bronchodilators taken within the past 24 hrs should be recorded,

Testing Procedures: All measured lung volumes should be linked. TGV and lung subdivision measurement must occur without the participant coming off of the mouthpiece. The participant should be instructed about the maneuvers involved in each step of the procedure, the importance of exerting maximal expiratory and inspiratory efforts during the RV and TLC phases of the maneuver, and how to pant during the shutter closure to obtain 0.5-1.0 Hz (30-60 cycles/minute) frequency and airway opening pressure changes of about ± 10 cmH₂O. Airways resistance measurements should not be done at the same time as plethysmographic lung volumes due to specific panting maneuvers used and their influence on end-expiratory lung volume. Nose clips should be in place throughout the maneuvers, and cheeks should be supported with both hands at least during the panting maneuver. After closing the door and allowing an appropriate period of time for thermal equilibration (no less than 20s), the participant should breathe through the mouthpiece in a relaxed manner until the end-expiratory volume is constant for at least 3 breaths before activating the shutter closure.

The preferred sequence of maneuvers after the shutter closure is maximal exhalation to RV (to obtain ERV), followed by maximal inhalation to TLC (to obtain VC). A series of 3-5 technically satisfactory panting maneuvers, followed by coupled ERV maneuvers, should be recorded. The participant may take a tidal breath or two after the shutter closure if dyspnea precludes an immediate ERV maneuver. Dyspnea is sometimes lessened by allowing a slightly larger than average tidal breath before exhalation to residual volume. If the thoracic gas volume measured during the shutter closure is displaced from the average end-expiratory volume prior to the shutter closure, the FRC volume marker should be adjusted manually (if not automatically adjusted by the software) to the end-expiratory volume. If the TGV is adjusted to FRC pleth automatically, visual verification of this correction is indicated. Three FRC values within 5% of one another should be averaged, and the average value reported as FRC. The technically satisfactory ERV values that are coupled to the selected FRC measurements are averaged, and subtracted from the average FRC value to obtain RV. The single largest technically acceptable VC value is added to the RV to obtain TLC.

See diagram on next page



If the participant is unable to perform the maneuvers in the preferred sequence, an acceptable alternative is to perform linked IC maneuvers after the shutter closure, followed by a slow expiratory VC maneuver. For this sequence the average of technically acceptable linked ICs is added to the mean FRC to obtain TLC, and the largest slow expiratory VC is subtracted from TLC to obtain RV. It also is acceptable to obtain measurements of VC (either inspiratory VC or slow expiratory VC) separately from the linked FRC-IC maneuvers or the linked FRC-ERV maneuvers if the participant is unable to perform the entire sequence with good efforts. If this is case, indicate the unlinked status of the vital capacity used to calculate TLC or RV in the COMMENTS section of your PFT report.

52.4 Data Submission

Please submit the following documentation. This will allow the quality of the measurements to be assessed and assigned in the database. As the information required to rate each testing session requires assessment of the individual efforts, we recommend a screenshot at the time of completion of each effort be taken and submitted.

- Volume-time tracing showing tidal breathing before shutter closure, shutter closure and lung subdivisions measured after shutter opening. This allows assessment of stability of the assigned FRC level, patency of the shutter during the maneuver and the linking of all components of the lung volumes. This should be clearly labeled with effort number.
- TGV loops scaled to allow the entire loop to be visualized, clearly labeled with effort number.
- Data table showing TGV, FRCpleth, ERV, IC, VC, RV and TLC, clearly labeled with effort number.

Technician comments should summarize the technical acceptability of the testing session including any problems encountered.

