Mechanics of Breathing

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Mechanics of Breathing

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chapter 86 (Section XII - The Lung)

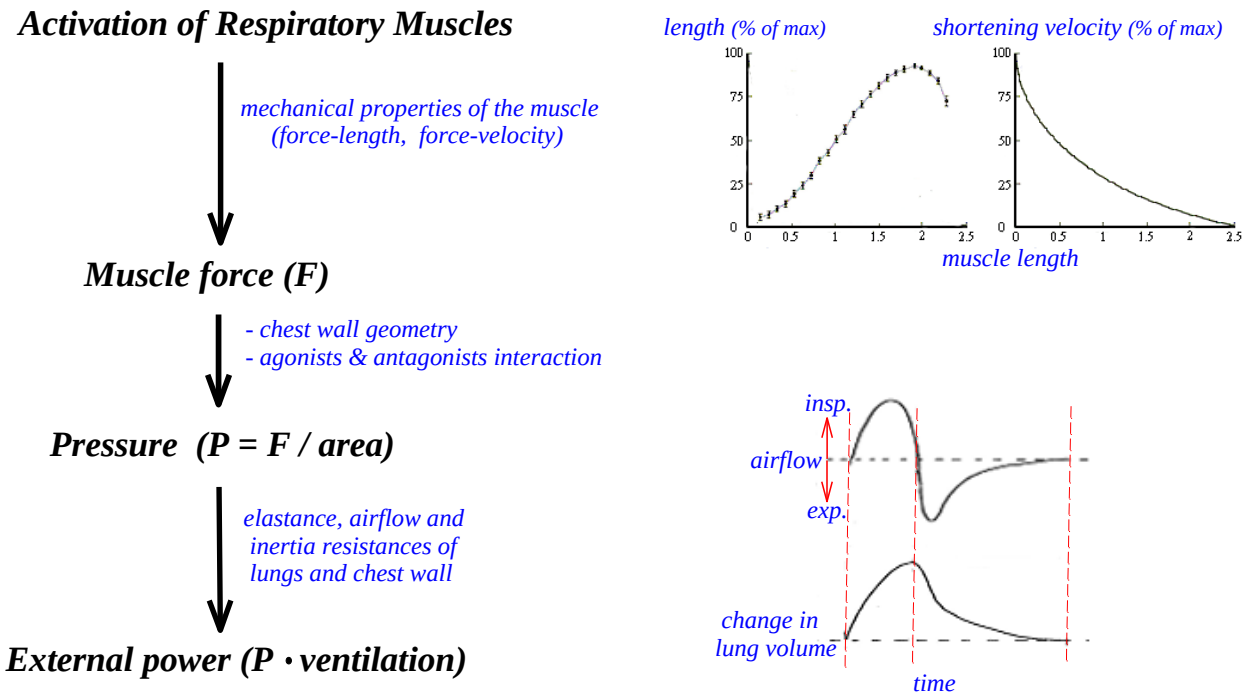

Figure 71-1. Schematic summary of the processes involved in the translation of muscle activation into ventilation. At right, top, typical muscle length-force and length-velocity relationships, bottom, the pneumotachographic (time-airflow) and spirometric (time-volume) recordings.

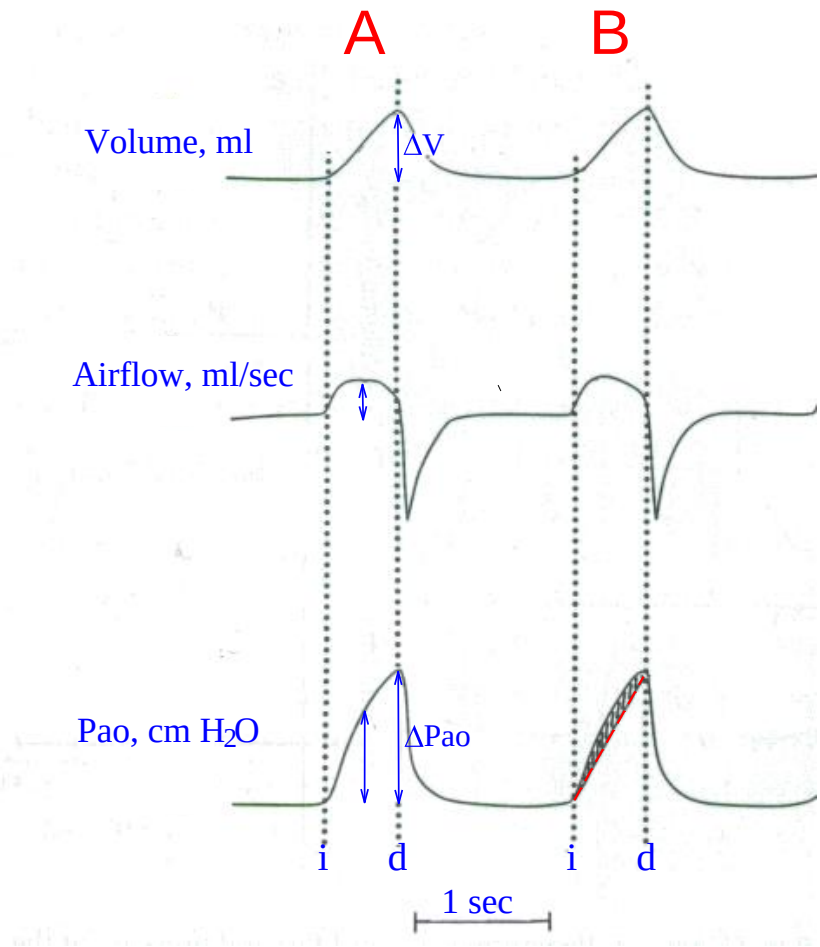

Figure 71-2. Semi-schematic drawing of the changes in lung volume, airflow and pressure at the airway opening (Pao), with the most common recording units, that can be observed in an intubated infant during mechanical ventilation. The dashed line labelled i and d indicate the onset of, respectively, inflation and deflation. Pao at end-deflation is usually a few cm H_2O higher than zero. The compliance of the respiratory system is measured 'dynamically', at end-inflation, as $\Delta V/\Delta Pao$. The resistance of the respiratory system can be measured by various analytical procedures, for example at mid lung volume, when airflow is high (A), or as average inflation by planimetry (B). Further details are in text.

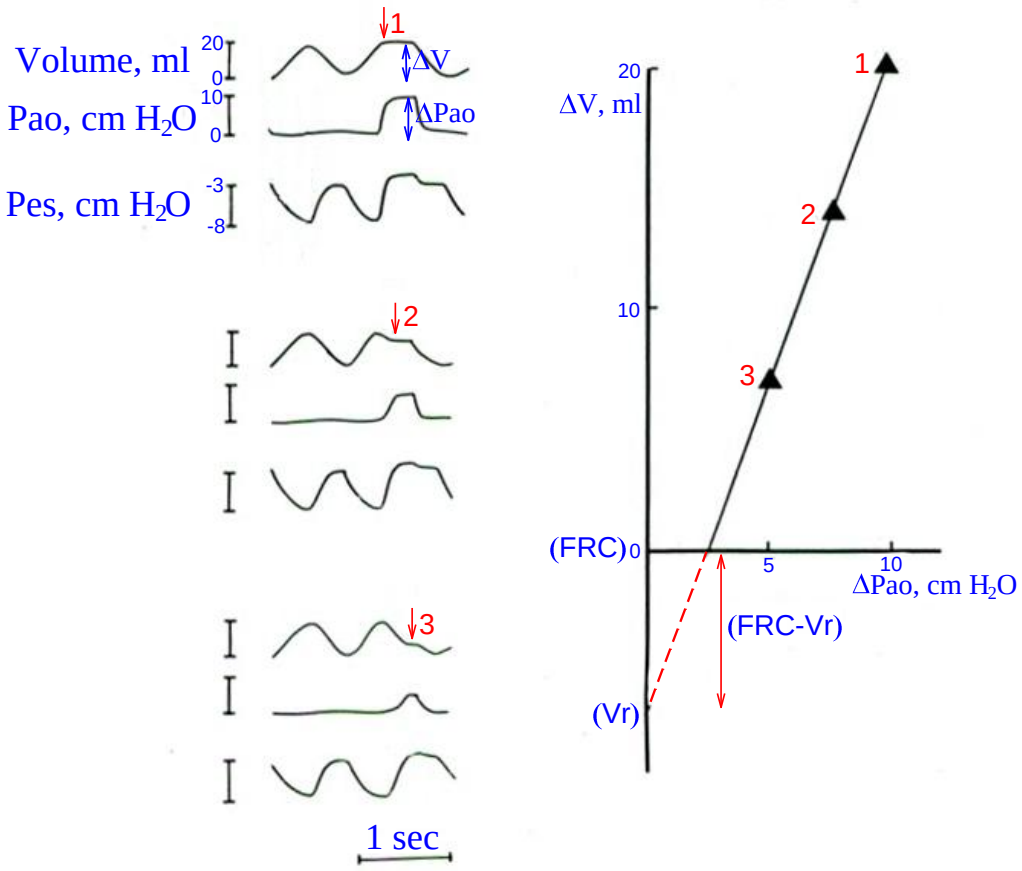

Figure 71-3. Semi-schematic representation of the changes in lung volume (ΔV_T), pressure measured at the mouth (Pao) and esophageal pressure (Pes) in a spontaneously breathing infant. In each of the three examples indicated, from top to bottom, the recordings start with a breathing cycle followed by an occlusion of the airways made by the investigator. At 1, the occlusion is at end-inspiration; at 2, in the first third of expiration; at 3, in the second half of expiration. The corresponding Pao-V points are plotted in the diagram at right; the slope of the linear regression represents the compliance of the respiratory system (Crs) and the intercept on the y-axis represents the difference between the end-expiratory level and the resting volume (FRC-Vr difference). Although only three data points are represented, many more data points through the whole V_T range are desirable to improve the accuracy of the linear regression.

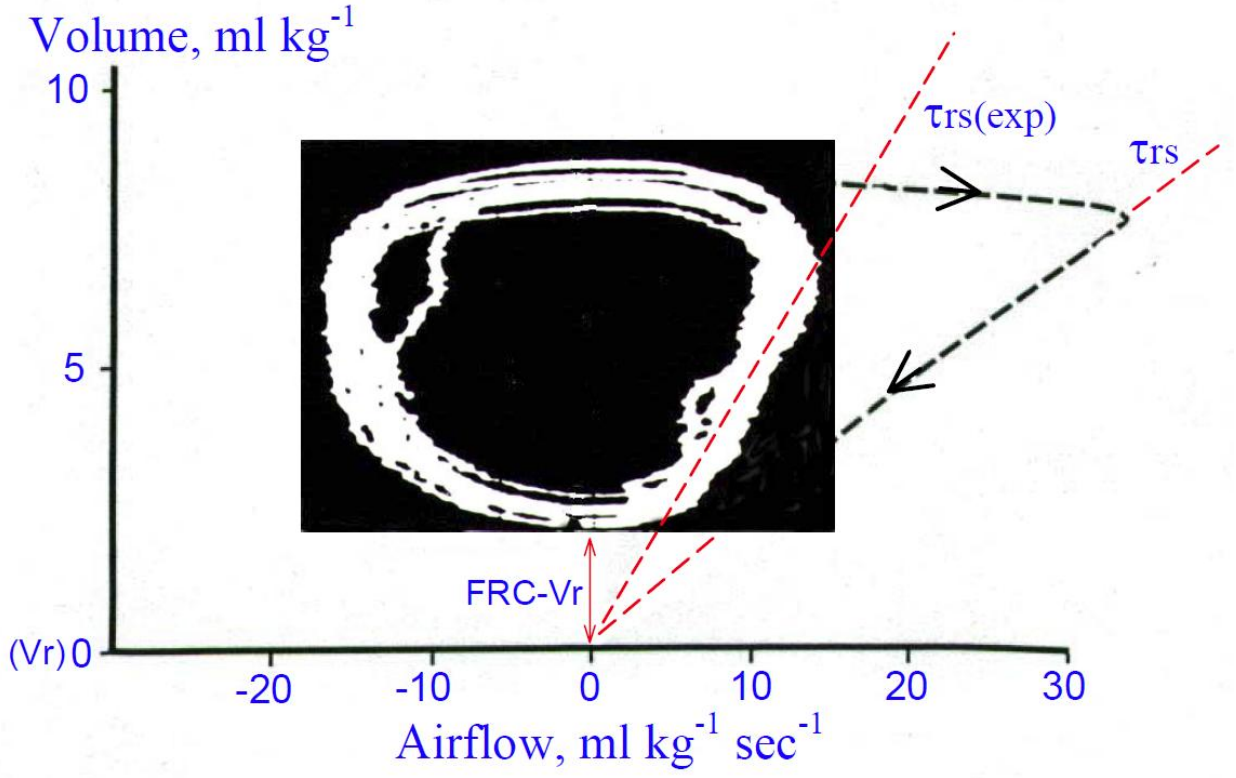

Figure 71-4. Infant, spontaneously breathing. Respiratory airflow and volume are continuously recorded on the x- and y-axes; inspirations are at left with negative flows and expirations are at right with positive flows (superimposed white oscilloscope tracings on the black background). Eventually, at end-inspiration, the airways are briefly occluded by the investigator (end-inspiratory occlusion); following release of the occlusion (arrowed dashed black line), the slope of the deflation flow-volume curve represents the passive time constant of the respiratory system (τrs). Usually, during resting breathing, the expiratory flow-volume curve is at the left of the passive curve, indicating that the expiratory time constant τrs(exp) exceeds τrs. The extrapolation to zero flow of the linear portion of the expiratory flow-volume relationships permits to compute the volume difference between the end-expiratory volume (FRC) and the resting volume of the respiratory system (Vr).

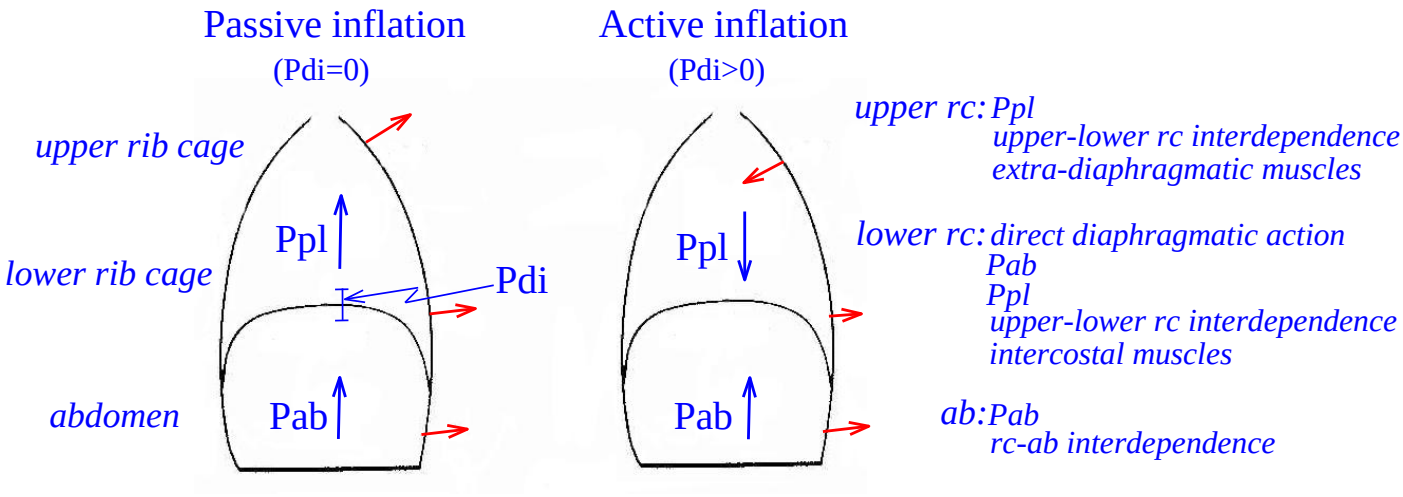

Figure 71-5. Schema of the pressures applied to the chest wall and its components rib cage (rc) and abdomen (ab) during passive inflation (*left*) and spontaneous (active) inspiration (*right*) in a normal newborn infant. Arrows in blue indicate the changes in pleural (Ppl) and abdominal (Pab) pressures. Pdi is trans-diaphragmatic pressure, equal to Pab-Ppl. Arrows in red indicate the expected direction of motion in passive and active conditions, when Pdi is, respectively, zero or positive. At extreme right, summary of pressures and forces responsible for the motion of upper rc, lower rc, and ab during spontaneous inspiration; the resulting motion is the net effect of all these factors.

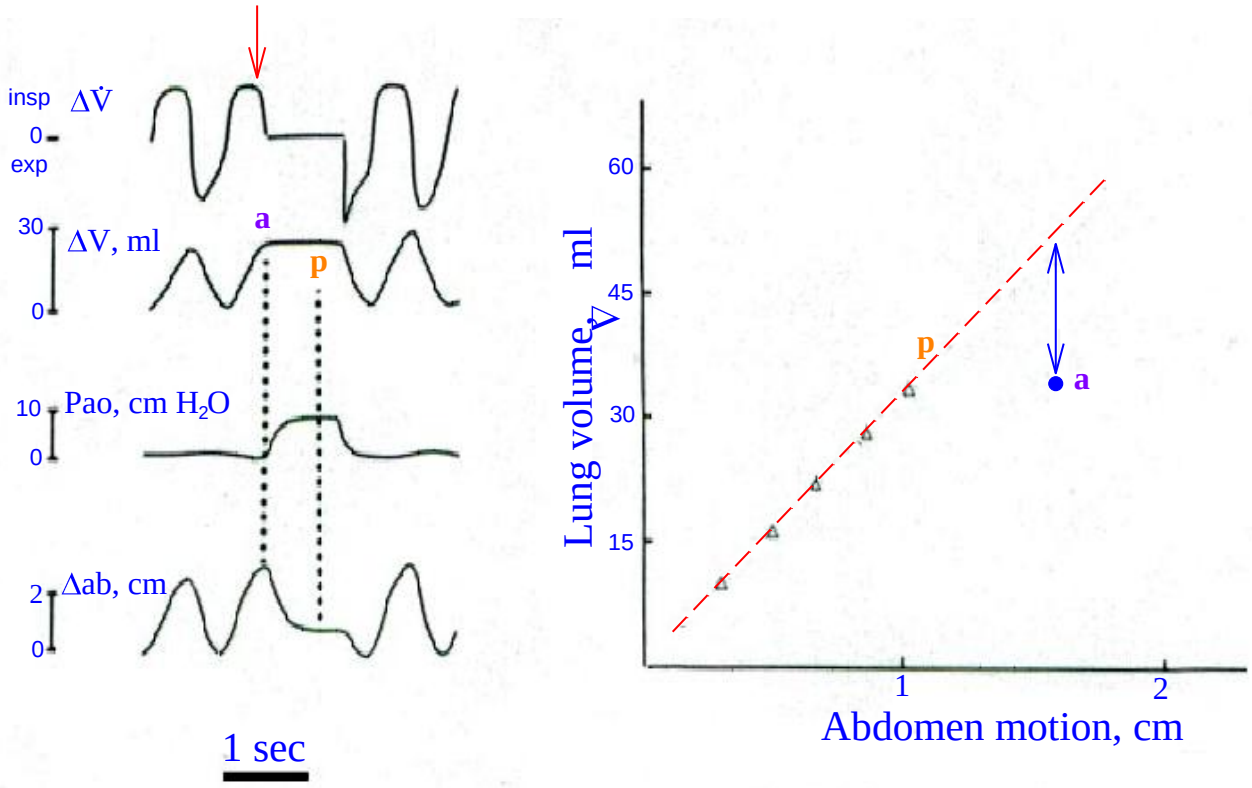

Figure 71-6. Schematic representation (from *top* to *bottom*) of the changes in respiratory airflow ($\dot{V}$), lung volume (V), pressure at the airway opening (Pao) and motion of the abdominal wall (ab) in a spontaneously breathing infant. At *arrow* (end-inspiration, first dotted line), the investigator briefly occludes the infant's airways; the occurrence of muscle relaxation is shown by the plateau of Pao (p, second dotted line). The active (*a*, *solid circle*) and passive (*p*) ab-V data points are plotted at *right.* The passive relationship *(open triangles)* is obtained by multiple occlusions at different lung volumes during expiration. The vertical distance between *a* and the passive curve (*blue double-end arrow)* indicates the volume loss because of distortion.

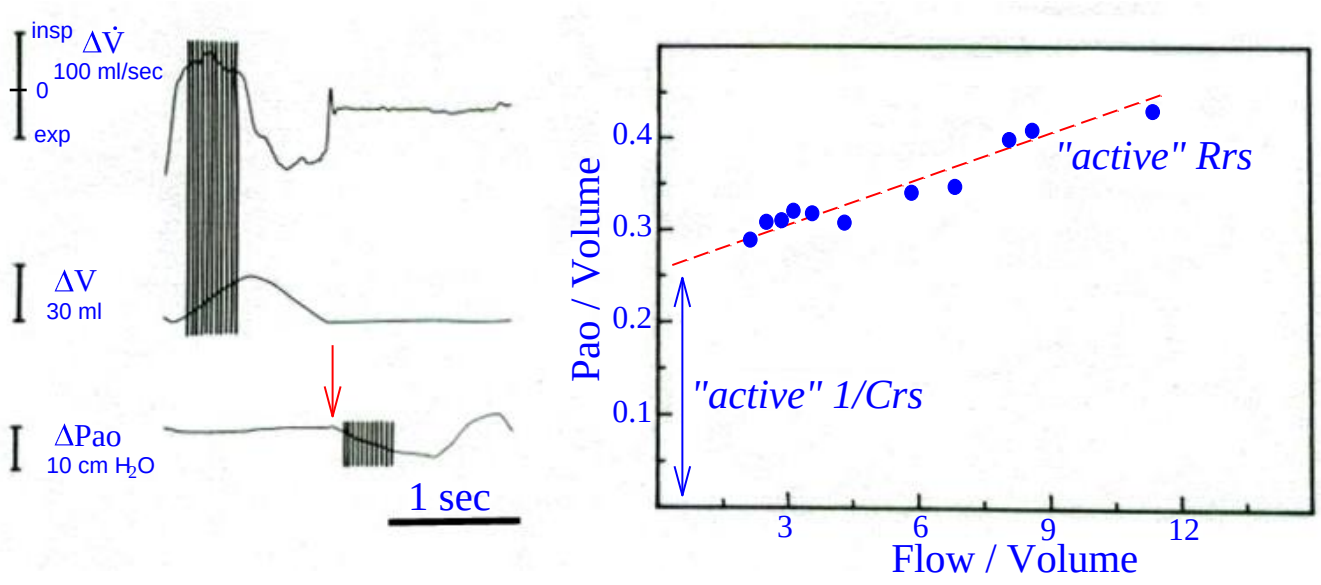

Figure 71-7. *Left*, newborn infant, spontaneously breathing. From top to bottom, records of respiratory airflow ($\dot{V}$), tidal volume (V) and mouth pressure (Pao). At the time indicated by the *arrow*, the investigator occludes the infant's airways; then, the infant makes an inspiratory effort, as shown by the drop in Pao with no changes in V. The vertical parallel lines indicate iso-time measurements of Pao (from the onset of the effort), and of $\dot{V}$ and V (from the onset of the preceding breath). *Right*, The iso-time Pao/V-$\dot{V}$/V points are plotted; from the linear regression through the data points, the slope and the reciprocal of the intercept represent, respectively, the active resistance and active compliance of the respiratory system.