

One method of infant pulmonary function testing is measurement of passive expiratory mechanics. To obtain a passive expiratory curve, a mask with pneumotachometer is placed over the mouth and nose of the infant. This can be done with or without mild sedation. At end inspiration, a shutter or balloon occludes the mask flow for 100 ms, triggering the Hering-Breuer reflex, which is an apneic pause in response to the occlusion. The lungs then passively empty. As shown in Figure 2-A, there is an initial spike of expiratory flow, which represents emptying of the upper airway. This is followed by a linear decay in flow, the slope of which represents the **negative reciprocal of the** expiratory time constant (τ). To calculate τ , a line is drawn from the beginning of the linear decay to where the flow falls off (points C to D in Fig 2-A). In this case, the slope is

$$(130 \text{ ml/sec} - 50 \text{ ml/sec}) \div (24 \text{ ml} - 62 \text{ ml}) = -2.10 \text{ sec}^{-1}$$

$$\tau = -\frac{1}{-2.10} = 0.475 \text{ sec}$$

Calculating the slope from point C to point E would yield 0.331 s, (choice A is incorrect). Calculating the slope from point B to point E would yield 0.161 s, (choice D is incorrect). Finally the slope from point B to point C is 0.043 (choice C is incorrect).

The rate at which the lungs empty is affected by respiratory system compliance (CRS) and airway resistance (R). These two factors can be combined into a single measure called τ , where

$$\tau = R \times CRS$$

Note that τ has units of seconds. In the setting of increased airway resistance (eg, asthma), τ is high, and the lung takes longer to empty. Similarly, in diseases where the elastic recoil of the lung has been lost (eg, emphysema), compliance will be high and τ will again be elevated.

Passive expiratory flow volume curves can be used to calculate τ in infants. With this method, the lungs are modeled as a single compartment system, with all of the elastic forces represented as a single air sac and all of the resistive forces as a single airway. In this model, the volume in the lungs as a function of time can be expressed as

$$V(t) = V_0 e^{-t/\tau}$$

Where $V(t)$ is the volume at any time point in expiration, and V_0 is the volume at end inspiration. Since flow (V') is the derivative of volume, it follows that

$$V' = \frac{dV}{dt} = -\frac{1}{\tau} \times V_0 e^{-t/\tau}$$

Solving for τ yields

$$\tau = -\frac{V}{V'}$$

Where $-\frac{V}{V'}$ is **the negative reciprocal of the** slope of the flow-volume curve. By measuring mouth pressure just before the occlusion (PMO), compliance can be calculated by

$$Crs = \frac{\Delta V}{P_{mo}}$$

Where change on volume (ΔV) is the expired volume (points A to E). Resistance can then be calculated by

$$R = \frac{\tau}{Crs}$$