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6. Transfer factor (TLCO) and the anatomy of the lung

The core of this chapter considers the transfer factor (TLCO), and its two components, KCO and VA. These three indices are measured together in a single breath test. The TLCO measures the integrity of the gas exchanging part of the lung, the acinus. It is unique in being a window on the pulmonary microcirculation. It helps to think of the TLCO as a measure
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of the anatomy of the acinus, and PaO₂ and PaCO₂ as measuring physiologically—determined differences between acini.

Derivation of the TLCO. Multiplication of the rate constant, kCO (units of s⁻¹ or min⁻¹) and the alveolar volume, VA (mL), gives CO uptake (VTCO) in mL min⁻¹ if all lung gas were 100% CO (as if PCO = Pb*) where Pb* is barometric pressure within the lung (Pb – water vapour pressure at 37°C):

\[ kCO \times VA = VTCO \] .......................... [5]

\[ VTCO / Pb* = CO \text{ uptake per unit PCO} = TLCO \] .......... [6]

\[ TLCO = [kCO \times VA] / Pb* \] .......................... [7]

\[ TL / VA = kCO / Pb* = KCO \] .......................... [8]

KCO is the transfer factor per unit alveolar volume (TL/VA), but it is not the transfer factor corrected for lung volume, because KCO is actually a rate constant, normalised to barometric pressure (Pb*). The KCO is better regarded as the transfer factor per alveolus (or per acinus), representing the efficiency of the alveolar uptake of CO.

CO AND HELIUM ANALYSIS IN THE SINGLE BREATH TLCO

Figure 6.5 Concentrations of the test gases (carbon monoxide (CO) and helium (He)) plotted against breath hold time for the single breath TLCO manoeuvre illustrating the origin and calculation of the two components (the slope [kCO] and VA) from which the TLCO is derived. See text.
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MODEL AND ANALYSIS OF BRONCHIAL AND ALVEOLAR EXHALED NO

Figure 6.8  A. Schematic diagram of NO bronchial flux during expiratory flow with NO addition shown to mixed expired (Fi), alveolar (FALV), and intrabronchial (Fib) locations at different generations (gen). Inset is bronchial wall and lumen with NO diffusing capacity of bronchial wall (Dbw) and overall bronchial flux (Jbr).  B. Plot of NO output ($\dot{V}_{LNO}$) ($= \dot{V}E \times F_{NO}$) versus expiratory flow (at 120, 225, 375 mL s$^{-1}$) in a normal and asthmatic subject. Slope and intercept differentiate alveolar and bronchial NO. Adapted from Lehtimaki.29

7.5 Learning Points

• the acinus (Weibel’s generations 15–23), the “effective” gas exchange unit, is ventilated by convection and molecular diffusion.
• TLCO measures the gas exchange surface area, comprising the alveolo–capillary membranes (DM) and red cells with Hb ($\theta . Vc$).
• TLCO is the product of $kCO$, the rate of alveolar CO uptake, and VA (alveolar volume “seen” by inhaled CO). $KCO \sim TL/VA = kCO/Pb^*$. These relationships are the basis of clinical interpretation.
• TLNO measures, in effect, the DM part of the transfer process.
• Exhaled NO is a measure of bronchial (and acinar) inflammation.