

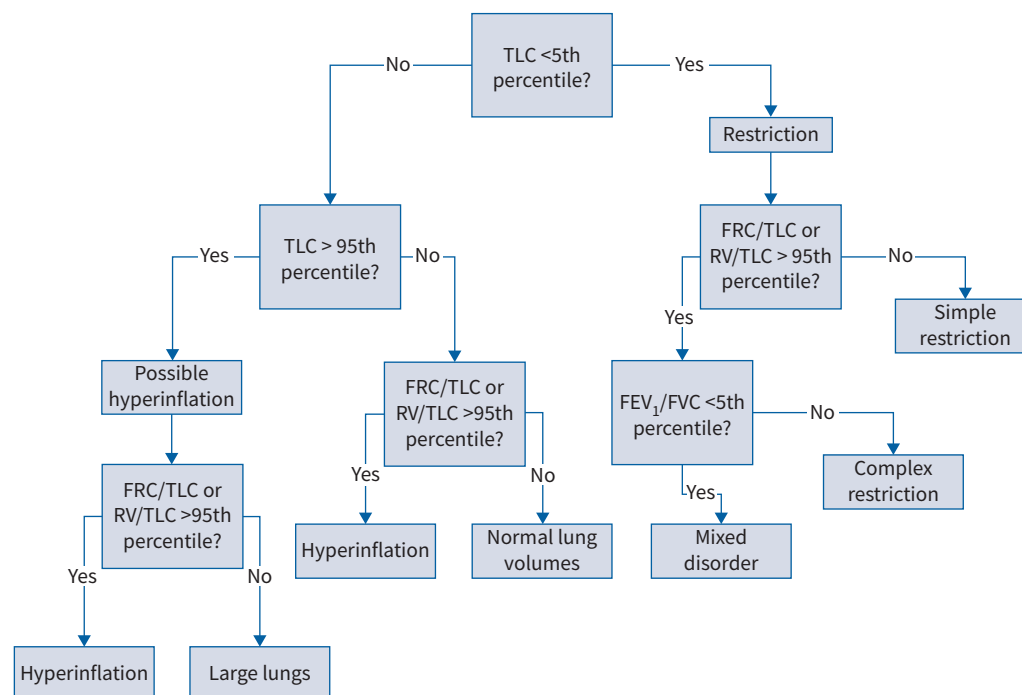


FIGURE 10 Approach to interpretation of lung volumes. Beginning with total lung capacity (TLC), determine whether restriction is present based on whether TLC is low (right side of figure). If restriction is present, then assess the relative size of functional residual capacity (FRC) or residual volume (RV) to the TLC: if FRC/TLC or RV/TLC are elevated, then determine if there is airflow obstruction based on the forced expiratory volume in 1 s (FEV₁)/forced vital capacity (FVC) ratio. If obstruction is present, then this is a mixed disorder, but if not present, then it may be a form of “complex restriction”, which implicates more than one process occurring to lower FVC out of proportion to the reduction in TLC. Obesity or neuromuscular disease are common causes of complex restriction. If the FRC/TLC and RV/TLC ratios are normal in the setting of reduced TLC, then simple restriction is present. If TLC is normal, ruling out restriction (left side of figure), then the next step is to determine if lung volumes are overall normal, or the individual has large lungs, or they may be hyperinflated, by following the pathways indicated. Note that hyperinflation may occur with TLC, FRC and RV, or may occur with FRC or RV alone; in the former situation, the rise in TLC indicates loss of elastic recoil, so is likely due to emphysema, whereas in the latter situation, the increase in FRC or RV without increase in TLC may be seen in chronic bronchitis or asthma.

an increase in RV or RV/TLC due to premature airway closure and air trapping. With progression, lung hyperinflation and air trapping are reflected by increases in FRC or FRC/TLC and often in TLC. An increased FRC/TLC indicates a reduced IC, which is a hallmark of COPD and closely associated with reduced exercise tolerance and dyspnoea [150]. Note that an increased RV/TLC may also be seen with muscle weakness or suboptimal effort and in some restrictive processes when TLC is reduced proportionally more than RV (table 5) [151, 152].

Restrictive impairments

A reduction in lung volumes defines a restrictive ventilatory impairment and is classically characterised by a reduction in TLC below the LLN (5th percentile) (figure 10 and table 7). A typical example is shown in figure 9g. The presence of a restrictive impairment may be suspected from spirometry alone when FVC is reduced, FEV₁/FVC is normal or increased and the flow–volume curve shows a convex pattern (reflecting high elastic recoil). However, a reduced FVC by itself does not prove a restrictive ventilatory impairment. Indeed, it is associated with a low TLC less than half the time [153, 154]. Conversely, in adults, a normal FVC and FEV₁/FVC are highly reliable at ruling out restriction as measured by low TLC [153]. Note that a high PEF with normal FEV₁ may be seen in early interstitial lung disease before restriction limits FVC [155].

In most restrictive disease processes, FEV₁, FVC and TLC are typically reduced in roughly the same proportion; this pattern is known as “simple restriction”. However, some individuals present with a