Airway narrowing, smooth muscle force and wall compliance at low and high mechanical strains

T.K. Ansell,[1] P.K. McFawn,[1] H.W. Mitchell[1] and P.B. Noble,[1,2] [1]School of Biomedical, Biomolecular and Chemical Sciences, University of Western Australia, Crawley, WA 6009, Australia and [2]School of Women's and Infants' Health, University of Western Australia, Crawley, WA 6009, Australia.

In a normally inflated lung, airways are maintained under constant mechanical strain due to distending forces applied by the lung parenchyma. In obstructive disease (*e.g.* asthma) the magnitude of airway strain may be reduced due to mechanical 'uncoupling' or alternatively increased due to dynamic hyperinflation. While several studies have characterized the effect of mechanical strain in isolated airway smooth (ASM) strip preparations *in vitro*, the effect of mechanical strain on the intact airway wall has not been well studied.

Aim: To determine the effect of high and low mechanical strains on airway function

Methods: Whole bronchial segments were dissected from pig lungs and maintained in organ bath chambers. Mechanical strain on airways was controlled by modifying transmural pressure (P_{tm}). Airways were initially equilibrated to 5 cmH_2O P_{tm}, approximating the mechanical environment present at functional residual capacity in vivo. P_{tm} was subsequently increased to 25 cmH_2O or decreased to −5 cmH_2O for 1 h, and then returned to 5 cmH_2O for a further 1 h. Two recording systems were used on different groups of airways: (i) pressure controlled, where airways were allowed to narrow against a fixed pressure, and by which specific wall compliance was measured from volume changes to a 5 cmH_2O cyclical pressure change; (ii) volume controlled, where airways contracted against a fixed lumen volume and the resultant increases in pressure were recorded as an index of ASM force. The desired pressure and volume conditions were applied by a servo controlled syringe pump.

Results: Increasing P_{tm} to 25 cmH_2O produced an immediate expansion in airway volume of ~25% and a reduction in wall compliance of 69.3 ±1.8% (n=6, $P<0.001$, paired t-test). Increased P_{tm} attenuated airway narrowing by 15.8 ±4.2% (n=6, $P<0.05$) and ASM force by 20.8 ±3.4% (n=5, $P<0.05$). Maintaining P_{tm} at 25 cmH_2O for 1 h produced a further fall in narrowing ($P<0.05$, ANOVA) but did not affect ASM force or wall compliance. Decreasing P_{tm} to −5cmH_2O produced an immediate reduction in airway volume of ~30% and an increase in wall compliance of 30.2 ±2.6% (n=6, $P<0.001$). Reduced P_{tm} attenuated airway narrowing by 19.5 ±3.8% (n=6, $P<0.001$) and force by 20.0 ±2.7% (n=5, $P<0.001$). Maintaining P_{tm} at −5 cmH_2O for 1 h produced a further decrease in airway narrowing (n=6, $P<0.01$) and ASM force (n=5, *P*p<0.001), and an increase in wall compliance (n=6, $P<0.01$). In all cases upon return to P_{tm} of 5 cmH_2O airway narrowing, ASM force and compliance were restored to the pre-strain levels in <20 min.

Conclusions: The findings suggest that changes in mechanical strain above or below that expected to occur in the normal healthy lung, and favor reduced airway narrowing and ASM force production. In comparison, increases in mechanical strain favor reduced airway wall compliance while lower strains may increase wall compliance. Acute changes in mechanical strain have no long lasting impact on airway wall properties.