

Title: AIRWAY CLOSURE IN ANESTHETIZED CHILDREN

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In an often quoted study from 1972 Mansell and co-workers reported that closing capacity (CC) was close to functional residual capacity (FRC) in awake children 6-8 years of age and postulated that airway closure probably occurs during normal tidal breathing in younger children¹. During anesthesia, which reduces FRC, one would therefore expect airway closure to occur above FRC. To study this we measured CC and FRC in healthy infants and children.

Methods. 24 children, 4 months-14 years of age (median 52 months), were studied prior to surgery. Informed consent was obtained from the parents and the study was approved by the local Human Studies Committee. Monitoring was with ECG, blood pressure, pulse oximetry, and end-tidal $p\text{CO}_2$. Anesthesia was induced with i v thiopental and maintained with 1% halothane in air-oxygen ($\text{FiO}_2=0.6$, $\text{ET-CO}_2=35\pm 4.5$ mmHg). The patients were paralyzed with vecuronium and the trachea was intubated with a cuffed endotracheal tube. FRC was measured with a multiple breath tracer gas washout technique². Airway closure was measured by the bolus method using SF_6 as tracer gas: The lungs were deflated to a tracheal pressure of -20 cmH_2O , the bolus (0.5 ml $\text{SF}_6/100$ ml FRC) injected into the airway, the lungs inflated to $+20$ cmH_2O (=P-insuffl), and then again deflated to -20 cmH_2O . The maneuver was done by means of a super syringe using low flow rates (<0.2 l/s). To study the effects of different insufflation volumes on airway closure, an insufflation pressure of 30 cmH_2O was also tested in eleven of the patients. Airway flow and expired SF_6 concentration were measured by a pneumotachograph and an infrared SF_6 detector placed close to the tracheal tube. During expiration the SF_6 concentration was recorded against expired gas volume. The obtained closing volume curves were analysed in random order by two independent observers and the mean results were used. The start of airway closure was taken to be the point where a consistent rise in gas concentration commenced (phase IV). Data are presented as means \pm SD.

Results. 20/24 FRC and 29/35 CC measurements were done in duplicate. The coefficient of variation was $2.4\pm 2.1\%$ for the FRC measurements and $5.9\pm 7.5\%$ for the CC measurements. The obtained closing volume curve was usually of good quality, one recording is shown in fig 1. The results of FRC and CC measurements are summarized in figures 2 and 3. 30 cmH_2O insufflation pressure increased CC by $9.9\pm 7.2\%$ ($\beta < 0.01$ as compared to CC obtained with P-insuffl = 20 cmH_2O) and in four patients this resulted in airway closure above FRC (fig 3). In two patients no phase IV could be identified with an insufflation pressure of $+20$ cmH_2O .

Discussion. There are, to our knowledge, no previous studies of airway closure in children less than 6 years of age. We found no greater tendency for airway closure in the younger children. Airway closure within the tidal volume does not seem to be a general phenomenon in anesthetized children.

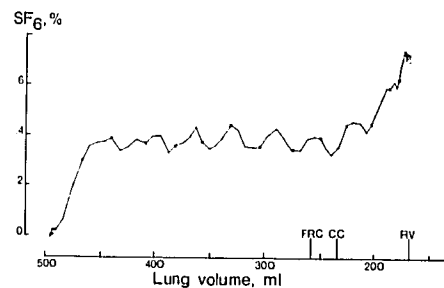


Fig 1. Closing volume curve in a 2 year old child. The crosses in the tracing are 0.4 s apart. Note cardiac oscillations (heart rate = 110/min).

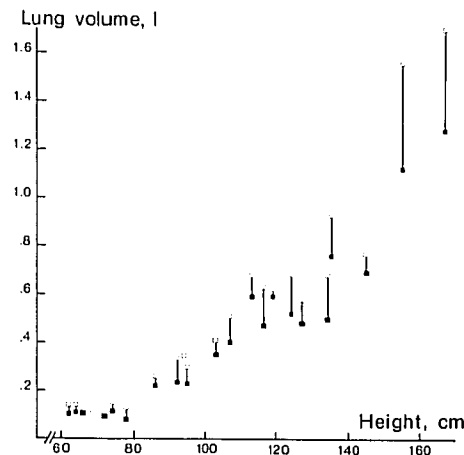


Fig 2. FRC (\square) and CC (\blacksquare) vs height. P-insuffl during CC measurements was $+20$ cmH_2O .

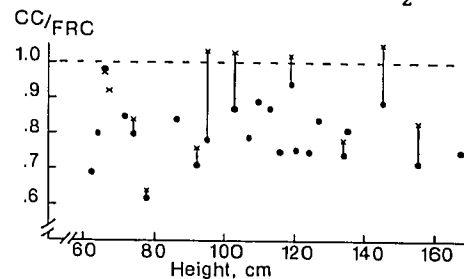


Fig 3. CC/FRC vs height. \bullet = P-insuffl $+20$ cmH_2O . \times = P-insuffl $+30$ cmH_2O .

References.

- Mansell A, Bryan C, Levison H: Airway closure in children. *J Appl Physiol* 33:711-714, 1972
- Jonmarker C, Jansson L, Jonson B, Larsson A, Werner O: Measurement of functional residual capacity by sulfur hexafluoride washout. *Anesthesiology* 63:89-95, 1985