Exercise: Paper critique of 'A radiographic method for assessing lung area in neonates'

In this exercise we will look a shortened version of a paper on the measurement of the lungs of babies. The original paper can be found in *The British Journal of Radiology*, 1999; **72**: 335-338. We have cut out all the references and most of the details of the measurement method.

A radiographic method for assessing lung area in neonates

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Abstract. The aim of this study was to determine whether computer assisted analysis of lung area on the chest radiograph reliably predicted lung volume in neonates. Anteroposterior chest radiographs taken for clinical purposes were scanned and analysed using a Power Macintosh computer with a Wacom A5 Ultra Pad and NIH image software. The cardiac, mediastinal and thymic densities and areas of perihilar and lobar consolidation were subtracted from the thoracic area to give the lung area. This was compared with lung volume, assessed by measurement of functional residual capacity (FRC), within 1 h of the chest radiograph being performed. 50 infants, median gestational age 30 weeks (range 243) were studied. Their median lung area was 11.23 cm^2 (range 0.82--28.53) and lung volume 28 ml (range 3-103). The intraobserver and interobserver coefficients of repeatability of lung area were 1.0 cm^2 and 1.06 cm^2, respectively. Lung area correlated significantly with FRC ($r = 0.60$, $p<0.0001$). It is concluded that computer assisted analysis of the chest radiograph lung area is a reliable method of assessing lung volume in neonates.

Assessment of lung volume can assist in determining the severity of an infant's lung disease and the appropriateness of the respiratory support level applied. An abnormally low lung volume could indicate either severe disease or too low a level of respiratory support. Lung volume can be measured on the neonatal intensive care unit (NICU) using a helium gas dilution technique, but this method is not routinely available. Lung volume is therefore usually determined by subjectively assessing the size of the lungs as seen on a chest radiograph. However, computer assisted analysis can provide an objective assessment of the lung area. The aim of this study was to determine if the lung area so calculated was a reliable indicator of lung volume in neonates receiving intensive care.

Method

Infants were eligible for entry into the study if their routine lung volume measurements (see below) were performed within 1 h of a chest radiograph being obtained for clinical purposes. All chest radiographs were in the anteroposterior (AP) projection and taken at end inspiration.

To determine the repeatability of the measurements, the first 20 radiographs were assessed independently by two observers (interobserver variation) and by the first observer on two separate occasions (intraobserver variation). Lung volume was assessed by measurement of functional residual capacity (FRC) using a helium gas dilution technique and specially designed infant circuit (total volume 95 ml). FRC was estimated twice in each infant on each occasion. The FRC was expressed as the mean of the paired measurements and related to body weight. The coefficients of repeatability of FRC in ventilated and non-ventilated infants were 5.7 ml kg^{-1} and 3.9 ml kg^{-1}, respectively.

Patients

50 infants were studied with a median gestational age of 30 weeks (range 24-42), birthweight of 1236 g (range 486-4316) and post-natal age of 1 day (range 1-30). Their diagnoses were respiratory distress syndrome (RDS) (n = 11), prematurity and mild respiratory distress (n = 14), infection (n = 7), transient tachypnoea of the newborn (TTN) (n = 5), chronic lung disease (CLD) (n = 3), hypoplastic lungs (n = 3), surgical

conditions (n = 5) and meconium aspiration syndrome (n = 2). 30 infants were ventilator-dependent at the time of the study. Routine lung function measurements in the neonatal intensive care unit have been approved by King's College Hospital Ethics Committee. Some measurements were made as part of a randomized trial which assessed the impact of fluid input on the development of CLD; parents gave written consent for their infant to take part in that trial.

Analysis

The repeatability of two assessments of the chest radiographs by two independent observers or the same observer on two occasions was determined according to the method of Bland and Altman. The difference between the lung areas was calculated for each subject. The sum of these differences squared was divided by the number of subjects, the square root of the results being the standard deviation (SD) of the differences. Twice this SD gave the co-efficient of repeatability, which is greater than 95% of the differences. A Spearman's correlation coefficient was calculated to assess the relationship between the lung areas and FRCs.

Results

Interobserver and intraobserver repeatability

The mean lung area calculated by the first observer was 11.8 cm^2 (SD ±4.8) and of the second was 11.7 cm^2 (SD ±4.9). The mean difference between observers was 0.07 cm^2 (range -0.83 to 1.15) (Figure 1). The interobserver coefficient of repeatability was 1.06 cm^2. The first observer re-evaluated the radiographs, the mean lung area calculated on the second occasion was 11.69 cm 2 (SD±4.66). The mean difference between the two calculations was 0.1 cm^2 (range –1.07 to 0.94). The intraobserver co-efficient of repeatability was 1.0 cm^2.

Comparison of lung area with FRC

The median lung area of the 50 infants was 11.23 cm^2 (range 0.82—28.53) and their median FRC was 28 ml (3—103). Lung area correlated significantly with lung volume (r = 0.60, p<0.001).

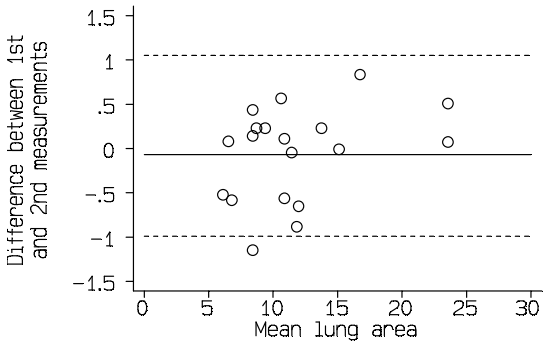

Figure 1. The difference in lung areas between the measurements made by two observers related to the mean lung area. Differences in an individual's results are plotted against the individual's mean lung area on the chest radiograph (i.e. the mean of the lung areas recorded by the two observers). Two data points are overlapping.

Discussion

Lung volume has been assessed using the chest radiograph appearance by a number of techniques. Simple assumptions have been made about the cross-sectional shape of the chest or an ellipsoidal method has been employed. Planimetry was used initially, but has been superseded by computerized analysis. A good correlation was found between both the FRC and total lung capacity (TLC) and the radiograph "lung volume", calculated as the sum of the areas of the AP projection of the left plus the right lung and the lateral projection of both lungs. However, this method has an important limitation in that lateral chest radiographs are rarely available on neonates receiving intensive care. Fortunately, results from a preliminary study suggested that the AP projection of the lung alone could be used to estimate lung volume in infants. Those findings were subsequently confirmed and the lung area measured by planimetry found to correlate closely with both thoracic gas volume (TGV) (r = 0.9) and FRC (r = 0.72) respectively. Using computerized assisted analysis of the AP projection of the lung only, we have also found a significant correlation between the radiographic lung area and FRC.

Computerized assessment of the lung area from an AP chest radiograph can be performed very rapidly. However, it is important to be aware of possible sources of error. The infant must lie supine without lateral rotation. A prominent thymus will enlarge the cardiomediastinal silhouette, making the lung boundaries difficult to

trace. The chest radiograph should be taken at a standard point in the respiratory cycle. If the exposure is taken at the beginning of inspiration, rather than the end, an error equal to the tidal volume could be introduced and result in an underestimate of 15% of the lung volume. In this study, the radiographers followed a standard policy of obtaining chest radiographs at end inspiration and this was done under routine clinical conditions. Nevertheless, computer assisted analysis of the lung area correlated significantly with lung volume measurements using a helium gas dilution technique in infants with a variety of respiratory diseases. The areas for calculation were all obtained by drawing them manually, a previous study having shown that this technique correlates highly (r = 0.98) with an automated method. As computer assisted analysis of the lung area on the chest radiograph is simple and rapid to perform, its application is recommended in settings where lung volume assessment by helium gas dilution has been found useful.

Questions

1. What is the coefficient of repeatability? How can the intraobserver coefficient of repeatability of 1.0 cm^2 be interpreted?
2. What is the purpose of the figure?
3. What can we deduce about the effect of using a different observer to measure lung area?
4. Why did the authors use the Spearman rank correlation coefficient?
5. What are the problems with this approach?
6. Why would the 95% limits of agreement method not be possible here?
7. What other analysis might be preferable to that used?
8. The authors' conclusion was that 'computer assisted analysis of the chest radiograph lung area is a reliable method of assessing lung volume in neonates.' Is this supported by the results?