



Comparison between two methods for estimating pneumothorax size from chest X-rays

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Received 6 September 2005; accepted 28 November 2005

KEYWORDS

Pneumothorax;
Size;
Rhea method

Summary

Aim: To compare the estimated size of spontaneous pneumothoraces using the established Rhea inter-pleural distances method with the CT-derived Collins method. **Method:** Adult patients with spontaneous pneumothorax treated conservatively were identified from the ED databases. X-rays were reviewed independently by two researchers and measured according to the methods described by Rhea and Collins. Estimates of size derived by the two methods were compared using bias plot analysis techniques.

Results: A total of 156 X-rays in 57 patients were identified. A total of 82% were male with a median age of 22 years. Pneumothoraces varied in size from 4% to 88%. The average difference between methods was 4% (Collins method estimating larger size) with 95% limits of agreement –3.8% to 11.7%. Agreement was very close for small pneumothoraces but deteriorated with increasing pneumothorax size (Collins methods estimated larger pneumothorax size).

Conclusion: The Rhea method for estimating pneumothorax size is acceptably accurate for smaller pneumothoraces but may significantly under-estimate the size of larger pneumothoraces.

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Introduction

It is commonly held that size of pneumothorax is an important determinant of therapy.^{1–3} However ‘best guess’ estimation of pneumothorax size is inaccurate and is inconsistent between observers.⁴

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The most commonly used objective method for estimating pneumothorax size is the Rhea method.⁵ This method uses the average of the interpleural distances measured in centimetres at the apex, midpoint of the upper half of the lung and midpoint of the lower half of the lung on an erect chest X-ray to estimate pneumothorax size in percent using a nomogram (Fig. 1). This method is based on a method described by Barnhard et al.⁶ for estimating lung volumes based on mathematical assumptions that the thoracic volume can be approximated by treating the lung as a stack of five elliptical cylindroids. Recently more sophisticated methods for estimating the volume of a pneumothorax have been developed using helical computerised tomography (CT).⁷ From this Collins et al.⁷ have derived a formula using interpleural distances on erect X-ray to estimate pneumothorax size.

The aim of this study is to compare the estimated size of spontaneous pneumothoraces using the established Rhea inter-pleural distances method with the CT-derived Collins method.

Methods

This retrospective study was conducted at Western Hospital in Footscray, Australia (annual emergency

department (ED) census 32,000) and the Accident and Emergency Medicine Academic Unit, Chinese University of Hong Kong, Prince of Wales Hospital, Hong Kong (annual ED census 160,000).

We identified adult patients with spontaneous pneumothorax treated conservatively from ED patient management databases. Hong Kong patients presented between February 2002 and August 2004 and Australian patients between August 1994 and November 2004. These dates reflect the availability of searchable databases at the study centres. The study was approved by the relevant institutional ethics committees at both sites.

Medical records were reviewed to confirm that the pneumothorax was of the spontaneous type. X-rays were reviewed independently by two researchers and measured according to the methods described by Rhea et al.⁵ and Collins et al.⁷ The average of the measurements by the two observers was taken as the 'true' measurement and used in calculation of pneumothorax size using the two methods of estimation. Expiratory films were preferred but if none was available, inspiratory films were included.

The primary outcome of interest was agreement between pneumothorax size (as percent) between the two methods.

Data was analysed using bias plot (Bland–Altman) analysis.

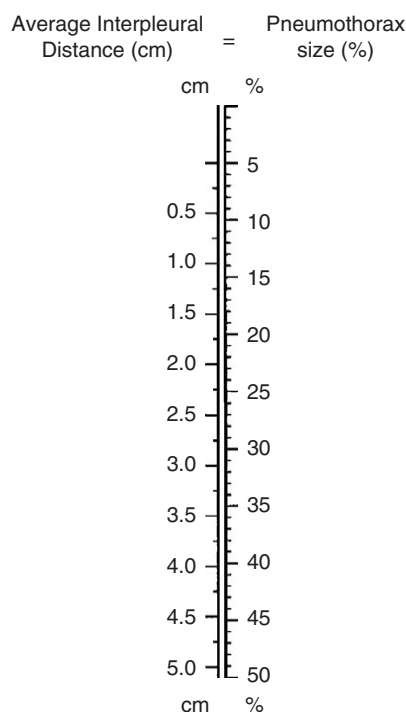


Figure 1 Prediction of pneumothorax size from average interpleural distance. Reproduced with permission from Rhea et al.⁵

Results

A total of 156 X-rays in 57 patients were identified. A total of 82% were male, with a median age of 22 years. Pneumothoraces varied in size from 4% to 88% (Collins method estimation).

The average difference between methods was 4% (Collins method estimating larger size) with 95% limits of agreement -3.8% to 11.7% . Agreement was very close for small pneumothoraces but deteriorated with increasing pneumothorax size (Collins methods estimated larger pneumothorax size) (Figs. 2 and 3).

Discussion

Management guidelines and contemporary texts advise that the size of a pneumothorax is an important determinant of therapy.^{1–3} Some base size cut-offs on maximal inter-pleural distance at the apex (MID) as a surrogate for calculation/estimation of size^{1,2} while others recommend more

formal estimation of size.³ The most commonly used objective method for estimating pneumothorax size is the Rhea method.⁵ This method uses the average of the interpleural distances (AID) measured in centimetres at the apex, midpoint of the upper half of the lung and midpoint of the lower

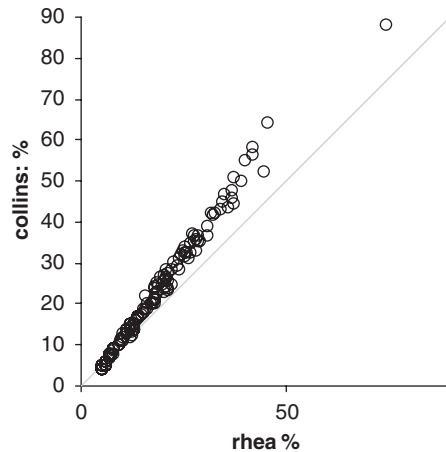


Figure 2 Comparison of pneumothorax size estimation using the Collins and Rhea methods.

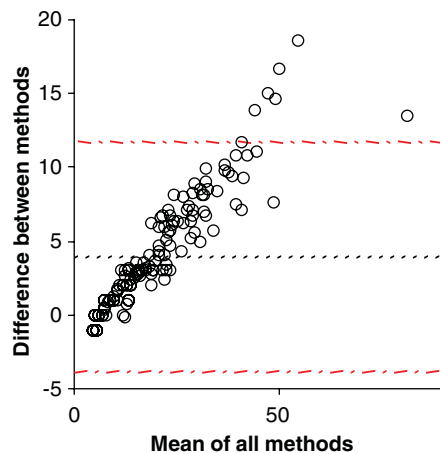


Figure 3 Bias plot of agreement between pneumothorax size estimated by the Collins and Rhea methods.

half of the lung on an erect chest X-ray to estimate pneumothorax size in percent by using a nomogram. AID was shown to correlate more closely with pneumothorax size (calculated using the Barnhard method⁶) than MID ($r = 0.94$ vs. $r = 0.87$).⁵ The accuracy of methods based on chest X-ray parameters has been questioned.⁸ Recently, the advent of CT volumetrics allowed Collins et al. to derive a new formula using that technology which showed very good correlation with measured volume ($r = 0.96$).⁷

Our study shows that for small pneumothoraces agreement between these methods is very good. However as pneumothorax size increases, agreement deteriorates with the Rhea method underestimating size compared to the Collins method. The most likely reasons for this difference are the relatively small samples used to derive both methods (20 each) and the methods used to derive them. In particular, the Rhea method is based on the assumption that the hemi-thoracic volume can be approximated by five elliptical cylindroids and calculated using diameters measured on a chest X-ray, whereas the CT volumetric methods calculate volumes, using more direct measurements and smaller intervals; thus better approximating true shape and volume. Therefore the CT-derived method is more likely to be accurate.

The clinical implication of this finding is that the Collins method should probably replace the Rhea method for estimation of pneumothorax size. Collins formula is however cumbersome ($\% = 4.2 + (4.7 \times (\text{sum of interpleural distances}))$), but could be converted easily to a table showing size estimates for various interpleural distance sums (Table 1).

Our study has some limitations that should be considered when interpreting the results. It is a retrospective cohort with all the well-known limitations of retrospective data collection. Patient identification was from ED databases that are open to miscoding, so eligible cases may have been

Table 1 Table of calculated pneumothorax sizes using Collins' formula.

Sum of interpleural distances (cm)	Estimated % pneumothorax	Sum of interpleural distances (cm)	Estimated % pneumothorax
1	8.9	9	46.5
2	13.6	10	51.2
3	18.3	11	55.9
4	23	12	60.6
5	27.7	13	65.3
6	32.4	14	70
7	37.1	15	74.7
8	41.8	16	79.4

missed. The sample includes a relatively small number of patients from two ethnic groups. Both of the methods compared in this study have not been validated.

Conclusion

The Rhea method for estimating pneumothorax size is acceptably accurate for smaller pneumothoraces but may significantly under-estimate the size of larger pneumothoraces. The Collins method may be a more accurate alternative, especially for larger pneumothoraces.

Acknowledgements

The authors would like to thank the staff of the Radiology Departments of both hospitals, Miss Cecily Leung, Dr. Stewart Chan and Professor Timothy Rainer (Hong Kong) for their advice and support and Mrs. Megan Clooney (Australia) for assistance with case screening.

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