Diagnosis of pneumothorax by radiography and ultrasonography: a meta-analysis

Ding W, Shen Y, Yang J, He X, Zhang M

CRD summary
This review concluded that bedside ultrasound performed by clinicians had higher sensitivity and similar specificity to chest X-ray for diagnosing pneumothorax. Potential for missed studies, lack of duplication of the entire review process and use of less robust analytical methods to derive pooled estimates of accuracy from heterogeneous studies mean that the conclusions should be treated with caution.

Authors' objectives
To compare anterior-posterior chest radiography (X-ray) with transthoracic ultrasonography for the diagnosis of pneumothorax.

Searching
MEDLINE, EMBASE and The Cochrane Library were searched to October 2010 for studies published in English; the search strategy was reported. Related links for results of the database search were viewed. Bibliographies of retrieved articles were scanned.

Study selection
Diagnostic accuracy studies that evaluated chest X-ray and/or ultrasonography for the detection of pneumothorax, where there is a clear definition of a positive test, were eligible for inclusion. Acceptable gold standards included computed tomography (CT) and a composite of clinical presentation and escape/aspiration of intrapleural air on drainage. Studies had to report sufficient data to construct 2x2 tables of test performance. Most of the studies were conducted in patients who had suffered trauma. Where reported, ultrasound operators varied; emergency physicians and radiologists were most commonly used.

Two reviewers independently selected studies for the review; disagreements were resolved by consensus.

Assessment of study quality
Study quality was assessed using an adapted version of the 14-point QUADAS tool; four criteria were omitted (representative patient spectrum, progression bias, clinical review bias, reporting of uninterpretable/intermediate results).

The authors did not state how many reviewers performed the quality assessment.

Data extraction
Data were extracted to construct 2x2 tables of test performance and sensitivity, specificity and the diagnostic odds ratio (DOR) were calculated with 95% confidence intervals (CI). The authors assumed independence of the left and right sides of the chest so data were extracted on a per hemithorax basis rather than per patient. Where a single biopsy was conducted, the patient was considered to have a single hemithorax.

The authors did not state how many reviewers extracted data.

Methods of synthesis
Pooled estimates of sensitivity, specificity and DOR with 95% CI were calculated using a random-effects model. Heterogeneity was assessed using the Q and I² statistics. Summary receiver operating characteristic (SROC) curves were produced using the Moses-Littenberg model. Threshold effect was investigated using Spearman's correlation. Meta-regression was used to investigate the impact of the direction of data collection, patient population, blinding, diagnostic criteria used and the operator.

Results of the review
Twenty studies met the inclusion criteria (7,569 participants, range 41 to 1,684). Fourteen studies were prospective, two were retrospective and the direction of data collection was not reported in four studies. All 20 studies clearly described...
their inclusion criteria, used an appropriate reference standard and adequately described the index and reference standard tests. Seventeen studies avoided partial verification bias, 15 avoided differential verification bias and 19 avoided incorporation bias. Thirteen studies blinded interpreters of the index test and six blinded interpreters of the reference standard.

For ultrasonography (15 studies), overall sensitivity was 88% (95% CI 85% to 91%; I²=91%), specificity was 99% (95% CI 98% to 99%; I² 75%) and DOR was 993.1 (95% CI 333.5 to 2,937.4; I² 70%).

For X-ray (19 studies), overall sensitivity was 52% (95% CI 49% to 55%; I²=91%), specificity was 100% (95% CI 100% to 100%; I²=51%) and DOR was 304.8 (95% CI 121.9 to 761.9; I²=55%).

Of the covariates included in a meta-regression, the ultrasonography operator was strongly associated with accuracy. When the analysis was restricted to clinicians other than radiologists, sensitivity was 90% (95% CI 87% to 93%) and specificity was 99% (95% CI 98% to 99%); both analyses had significant heterogeneity.

**Authors’ conclusions**
Bedside ultrasonography performed by clinicians had a higher sensitivity and similar specificity compared with chest X-ray in the diagnosis of pneumothorax. The accuracy of ultrasonography depended on the skill of the operators.

**CRD commentary**
The review addressed a clear research question with reproducible inclusion criteria. Several relevant sources were searched but inclusion was restricted to studies published in English. Diagnostic filters were used during the search so additional studies may have been missed. Study selection was conducted in duplicate; it was unclear whether similar methods to reduce error and bias were employed during the data extraction and quality assessment processes. Study quality was assessed using appropriate criteria and the results were published in full in an online appendix along with the study details and further analytical results but this was not freely accessible.

The pooled estimates of diagnostic accuracy were derived from frequentist meta-analytical techniques using clinically heterogeneous studies. Therefore, the reliability and generalisability of these pooled results is unclear. The SROC model used has limitations and more robust models from which summary estimates of sensitivity and specificity can be derived were available. Some of the implications for practice stated are not based on research conducted during this review.

Given the limitations of the review, the conclusions should be treated with caution.

**Implications of the review for practice and research**

**Research:** The authors did not state any implications for practice.

**Practice:** The authors stated that despite its simplicity, security and portability, ultrasonography had limitations and may not be appropriate for patients with subcutaneous emphysema, adhesion of pleura, thoracic dressings, pleural calcifications or skin injury. The authors stated that bedside ultrasonography appeared to be an attractive alternative to bedside chest X-ray, especially in the emergency department, intensive care unit and other clinical situations where radiography was not available, and it had potential to play a major role in the diagnosis of acute respiratory failure.

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