Sputum gram's stain in community-acquired pneumococcal pneumonia: a meta-analysis

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Authors' objectives
To evaluate the sensitivity and specificity of the sputum Gram's stain in community-acquired pneumococcal pneumonia (CAPP). In addition, to determine whether a variation in test characteristics was related to factors such as the stain interpreter, the definition of a positive Gram's stain, or control for antibiotic use before testing.

Searching
MEDLINE was searched from 1966 to 1993 for English language articles, using the keywords 'sputum', 'Gram's stain' and 'pneumonia'. The bibliographies of retrieved articles were also examined.

Study selection

Study designs of evaluations included in the review
No inclusion criteria relating to the study design were specified. Prospective studies and a retrospective chart review were included.

Specific interventions included in the review
Studies evaluating the sputum Gram's stain in CAPP were eligible for inclusion. No detailed inclusion criteria relating to the index test were specified. A positive Gram's stain was defined as an average of greater than 10 organisms of proper pneumococcal structure per oil immersion field, greater than 50% of organisms on the slide of proper structure, or when either of these two criteria were met.

Reference standard test against which the new test was compared
The included studies were required to use an independent reference standard to confirm the diagnosis. No detailed inclusion criteria relating to the reference standard were specified. The reference standards included sputum culture, culture of transtracheal aspirate, culture of bronchial aspirate, or a combination reference standard in which the result was deemed positive if one or more of several tests were positive. Blood culture was used as a reference standard in one study in which all the patients had bacteremia.

Participants included in the review
Studies of patients with community-acquired pneumonia were eligible for inclusion.

Outcomes assessed in the review
The included studies were required to report sufficient data for the generation of 2x2 contingency tables. The outcome measures reported by the review were sensitivity and specificity.

How were decisions on the relevance of primary studies made?
Three reviewers, who were blinded to the study authors and journal of publication, judged whether the articles met the inclusion criteria.

Assessment of study quality
The following criteria were used to assess quality: whether the inclusion and exclusion criteria were explicit; whether intra- and inter-observer variability was assessed; the training of the test interpreter; whether the assessment of characteristics of the Gram's stain test was a specific objective of the study; and the general clarity of the study. Three reviewers, who were blinded to the study authors and journal of publication, assessed the quality of each study using their own criteria for scoring.

Data extraction
The authors did not state how the data were extracted for the review, or how many reviewers performed the data extraction. Information was collected on the reference standard, blinding, stain interpreter, control for antibiotic use, and definition of a positive test.

**Methods of synthesis**

How were the studies combined?
A summary receiver operating characteristic (ROC) curve was estimated using the method of Moses et al. (see Other Publications of Related Interest). Several studies reported results using different standards or interpreters for the same patient set. The summary ROC curve was therefore estimated using weighted linear regression, with each sample of patients represented equally.

How were differences between studies investigated?
The summary ROC curve for the relevant range was calculated by excluding those studies with a sensitivity or specificity below 50%. The influence of study blinding, antibiotic use, Gram's stain definition, stain interpreter and study size were explored by including them in the summary ROC model.

**Results of the review**

Twelve articles with a total of 1,322 patients were included: 11 prospective studies and one retrospective chart review.

The sensitivity ranged from 15% (specificity 98%) to 100% (specificity 67%) and the specificity from 11% (sensitivity 96%) to 100% (sensitivity 67%). In 7 of the 12 studies, the sputum Gram's stain had a sensitivity of less than 70%, meaning that nearly a third of patients with evidence of pneumococcal pneumonia had a false-negative Gram's stain. The sensitivities remained poor even where an expert (an infectious disease or pulmonary specialist) interpreted the stain. When a laboratory technician (the likely interpreter in a hospital setting) reviewed the stain, the sensitivity was always below 70%. Sputum culture was the most common reference standard (10 out of 17 estimations).

Study size, blinding, the definition of a positive test, and control for antibiotic use were not statistically related to the test characteristics. There was a trend (P=0.07) for interpreter level of training to be positively associated with diagnostic accuracy, but this was not statistically significant.

**Authors’ conclusions**

No single estimation of sensitivity and specificity can be made regarding the sputum Gram's stain in CAPP. The test characteristics vary dramatically depending on several factors. Thus, the sputum Gram's stain may be misleading and its use may even be hazardous, especially if its interpreter is not well trained according to specific guidelines. Further studies may help clarify the role of the sputum Gram's stain in CAPP.

**CRD commentary**

The review addressed a clear question with appropriately defined inclusion criteria. The review methods and details of the included primary studies were well described, and the data analysis was appropriate and clear. Relevant studies may have been missed since the search was restricted to MEDLINE and no attempt was made to identify unpublished studies. No assessment of publication bias was reported. The authors’ conclusions follow from the data presented.

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

Practice: The authors recommended that practitioners who elect to use this test to guide therapy be taught a specific definition for positive Gram’s stain; an average of greater than 10 organisms of the proper pneumococcal structure per oil immersion field in purulent sputum may be a reasonable choice. Competence, not only at recognising specific bacterial types, but also at adhering to a specific definition should be tested.

Research: The authors did not state any implications for further research.
Bibliographic details

PubMedID
8987424

Other publications of related interest

Indexing Status
Subject indexing assigned by NLM

MeSH
Community-Acquired Infections /diagnosis; Evaluation Studies as Topic; False Positive Reactions; Humans; Pneumonia, Pneumococcal /diagnosis; Sensitivity and Specificity; Sputum /microbiology

AccessionNumber
11996001908

Date bibliographic record published
30/04/2004

Date abstract record published
30/04/2004

Record Status
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.