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ORIGINAL ARTICLE

Sputum colour for diagnosis of a bacterial infection in patients with acute cough

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Abstract

Objective. Sputum colour plays an important role in the disease concepts for acute cough, both in the patients' and the doctors' view. However, it is unclear whether the sputum colour can be used for diagnosis of a bacterial infection. *Design.* Cross-sectional study. *Setting.* A total of 42 GP practices in Düsseldorf, Germany. *Subjects.* Sputum samples obtained from 241 patients suffering from an episode of acute cough seeing their doctor within a routine consultation. *Main outcome measures.* Relation of sputum colour and microbiological proof of bacterial infection defined as positive culture and at least a moderate number of leucocytes per low magnification field. *Results.* In 28 samples (12%) a bacterial infection was proven. Yellowish or greenish colour of the sputum sample and bacterial infection showed a significant correlation ($p = 0.014$, Fisher's exact test). The sensitivity of yellowish or greenish sputum used as a test for a bacterial infection was 0.79 (95% CI 0.63–0.94); the specificity was 0.46 (95% CI 0.038–0.53). The positive likelihood-ratio (+LR) was 1.46 (95% CI 1.17-1.85). *Conclusions.* The sputum colour of patients with acute cough and no underlying chronic lung disease does not imply therapeutic consequences such as prescription of antibiotics.

Key Words: *Acute cough, bacterial infection, diagnostic test, family practice, general practice, respiratory tract infection, sputum colour*

Whether a certain diagnostic approach can contribute to rational decisions is of great interest within the specific context of primary care. Thus the evaluation of possible diagnostic options in pulmonary diseases [1,2], including respiratory tract infections [3], has become a focus of primary care research.

Acute cough as the key feature of acute respiratory tract infections is one of the commonest conditions managed in primary care. Despite scientific evidence, general practitioners still frequently prescribe antibiotics for the treatment of these conditions [4–6]. Explanations for the over-prescribing of antibiotics vary from efforts to protect patients from complicated courses of disease to assumed patient expectations as well as inadequate knowledge of physicians [5,7,8].

Discoloured sputum (or respiratory discharge) is commonly interpreted by both patients and physicians as a clinical sign for the presence of bacterial infection [9,10]. Thus in patients with acute respiratory infections yellowish and greenish sputum as well as certain non-specific symptoms such as fatigue are strong predictors for antibiotic prescribing in primary care [4,11,12]. So far there has been no evidence that discoloured sputum is correlated with a bacterial aetiology of acute respiratory infections in otherwise healthy adults. We analysed sputum samples of regular patients visiting their GP due to an episode of acute cough to determine whether sputum colour predicts the presence of bacterial infection – defined as typical growth of bacteria in sputum cultures and microscopic proof

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Discoloured sputum in patients with acute respiratory infections may lead to the prescription of antibiotics.

- This study investigates the correlation of discoloured sputum in patients with acute cough and a bacterial aetiology.
- The findings imply that the colour of sputum or discharge cannot be used to differentiate between viral and bacterial infections in otherwise healthy adults.
- The colour of sputum should not be used to make a decision on whether to prescribe an antibiotic within this group of patients.

of at least moderate numbers of leukocytes in sputum sample.

Material and methods

Study design

Cross-sectional study including otherwise healthy patients from a general practice setting in Germany with an onset of acute cough.

Study population

All 536 GPs from the Düsseldorf region were invited by letter to participate in the study. We offered free of charge microbiological sputum testing for all their patients within a two-week period. No other incentives were offered. A total of 42 GPs agreed to participate. According to the inclusion criteria, patients had to be 16 years of age or older, they had to be seen for the first time within an episode of cough, and should not have had another episode of cough during the previous eight weeks. A cough already lasting longer than three weeks, underlying chronic lung diseases such as asthma, COPD (Chronic Obstructive Pulmonary Disease), immune deficiency, or malignant diseases were exclusion criteria. Participating GPs were visited in their practices and were instructed by AA and CB how to collect sputum samples. We used a simple sputum sample technique that included a mouthwash with water and the instruction for the patient to breathe deeply, to hold his/her breath, and then to cough [13]. We did not use techniques like saline nebulisation to stimulate expectoration.

Each GP then collected sputum samples during a two-week period from all eligible patients suffering from acute productive cough and stored the samples at $+4^{\circ}$C. Samples were collected twice a day by a courier service and were taken to the microbiological laboratory of the University Hospital Düsseldorf where they where tested by CB and WD.

Testing and instruments

Participants and GPs received a self-administered questionnaire covering several domains such as basic sociodemographic information and medical history.

Rating of sputum colour. All sputum samples were rated for their colour by one researcher (CB) using a standardized colour reference table. Colours were printed on a reference card using the following CMYK process colours: Colourless 0,0,0,0, yellowish 6,0,42,0, and greenish 18,0,43,0.

Definition of bacterial infection

A quantitative sputum culture was performed, and a bacterial infection was considered only when the germ was isolated at concentrations $>10(6)$ cfu ($>10(5)$ for Streptococcus pneumoniae) in samples with <10 epithelial cells and >25 leukocytes per low magnification field ($\times 100$).

Statistical analysis

After testing for correlation of sputum colour and proof of bacterial infection we calculated sensitivity, specificity, and positive and negative likelihood ratio with their confidence intervals. As the sputum colour is mainly used to clinically confirm a diagnosis of bacterial infection [4], we were particularly interested in the positive likelihood ratio of yellowish and greenish sputum. The likelihood ratio of a positive test would indicate how likely it is that a yellowish or greenish sputum will be found among people with a bacterial infection compared with those without.

Results

From December 2001 to March 2002 sputum samples were taken in 36 GP practices. Some six GPs did not collect any sputum sample within the study period. Sputum samples from 241 patients were investigated. Patients were between 16 and 82 years of age (mean 43), and 61% of the study participants were females. Patients had been suffering from cough for eight days (mean) when visiting their GP (1–21 days). Some 10 patients reported comorbidities (cardiovascular diseases $n=4$, gastrointestinal diseases $n=3$, diabetes $n=1$, asymptomatic polycythemia vera $n=1$, major depression $n=1$). In 28 samples (12%) a bacterial infection (as per definition) was proven. Typical pathogens like Streptococcus pneumoniae ($n=9$), Haemophilus

Influenzae (n = 5), Haemophilus Parainfluenzae (n = 5), and Moraxella catarrhalis (n = 4) were isolated in these samples. A detailed report on pathogens and resistances has been published elsewhere [14]. Table I shows a contingency table for bacterial infection/no bacterial infection and yellowish or greenish sputum/colourless sputum sample. We found a bacterial infection significantly more often in yellowish or greenish sputum samples (Pearson's $\chi^2(1) = 6.32$, $p = 0.012$). The sensitivity of and yellowish or greenish sputum used as a test for a bacterial infection was 0.79 (95% CI 0.63–0.94); the specificity was 0.46 (95% CI 0.038–0.53). The positive likelihood ratio (+LR) was 1.46 (95% CI 1.17–1.85) indicating a minimal increase in the likelihood of a bacterial infection for discoloured sputum samples. The positive predictive value (PPV) was 0.16 (95% CI 0.13–0.18).

Discussion

Our results suggest that yellowish or greenish sputum is only a very weak diagnostic marker for a bacterial infection. Although a statically significant relationship between sputum colour and a bacterial infection exists, it cannot be used to confirm the suspicion of a bacterial bronchitis or to base the decision on for or against antibiotic therapy.

Strengths and limitations

Our study is mainly limited by the microbiological reference standard used. The "classic" microbiological definition for a bacterial infection has its limitations as it can only indirectly prove a bacterial infection. Furthermore the simple sputum sample technique that was used may have led to an underdetection of bacterial infections. However, only a much more complicated combination of several diagnostic procedures including PCR could hypothetically have resulted in relevantly better diagnostic accuracy. Instead of using a certain cut-off level and a colour reference-card as done, an analysis of the relationship between the intensity of the sputum colour and the concentration of germs may have given a more differentiated view. Only 36 of the 536 invited GPs contributed to the study; however, we do not believe that our study was subject to an unintentional selection bias. First, the units of analysis were patients with acute cough and GP-related data such as diagnostic procedures or individual treatment patterns were not part of our research question. Second, the sputum samples analysed in our study can be traced back to clearly defined inclusion criteria such as the first visit within an episode of acute cough without underlying chronic lung diseases such as asthma, COPD, immunodeficiency, or malignant diseases. Therefore it is unlikely that the number of practices or any other GP-related issues could have influenced the results of our microbiological analyses. Other limitations of our study are largely related to the limited information collected on the individual patients from whom the samples were obtained. Additional information on co-medication and comorbidities might have provided helpful insights into the aetiology of our acute cough patients. However, in this study we did not focus on the causality of acute cough but on the relationship between sputum colour and the presence of a bacterial infection.

Table I. Sputum colour and microbiological proof of bacterial infection

	Bacterial infection	No bacterial infection	Totals
Yellowish or greenish sputum sample	22 (16.2%)	114 (83.8%)	136 (100%)
Colourless sputum sample	6 (5.7%)	99 (94.3%)	105 (100%)
Totals	28 (11.6%)	213 (88.4%)	241

The strength of our study is our representative and unbiased sample of otherwise healthy patients typical of the routine consultation in general practice. As GPs were also allowed to send in sputum samples of patients not matching the inclusion criteria to be examined free of charge (n = 16) we avoided a preselection of patients by the GPs.

Relationship to other studies

Robertson discovered in 1955 that green sputum colour is caused by crystallized peroxidase. Since this enzyme is released by leukocytes that are part of the general immune response, discoloured sputum colour can be due to a variety of aetiologies. Therefore, yellowish or green sputum may be a normal feature in patients with viral bronchitis. Also, sputum production in viral airway infections may be clear, white, or even tinged with blood [15]. It has been shown that a yellowish or greenish sputum colour is often related to the bacterial load of patients suffering from COPD exacerbation [16,17] or patients hospitalized due to respiratory conditions [18]. In otherwise healthy patients only indirect evidence showed that yellowish or greenish sputum did not influence outcomes with or without antibiotic therapy [19]. However, few studies have specifically examined the role of sputum colour in primary care patients without chronic respiratory diseases, although these patients are the most prevalent in general practice. In everyday practice only

sputum samples of problematic patients will be sent in for microbiological investigation. In a recent study, Johnson et al. examined such 289 consecutive outpatient samples sent in by primary care physicians, finding that the bacterial yield from sputum colours green, yellow-green, yellow, and rust was higher than the yield from cream, white, or clear samples [20].

Implications for practice

Our study confirms that the colour of sputum or discharge cannot be used in the consultation with otherwise healthy adult patients suffering from acute cough to differentiate between viral and bacterial infections. Thus it should not be used to make a decision on the choice of therapy and especially not on whether to prescribe an antibiotic.

Implications for further research

Despite the fact that sputum colour as a solitary test cannot be recommended for routine use it may have a role in complex diagnostic algorithms. Even when not useful in an otherwise healthy low-risk population it may help to ameliorate diagnostic accuracy in special patient subgroups. Thus the assessment of sputum colour may be considered for future diagnostic and epidemiological studies on respiratory tract infection.

Competing interests

There are no competing interests.

Ethical approval

Not required.

References

[1] Medbø A, Melbye H. What role may symptoms play in the diagnosis of airflow limitation? Scand J Prim Health Care 2008;26:92–8.
[2] Stratelis G, Fransson SG, Schmekel B, Jakobsson P, Mölstad S. High prevalence of emphysema and its association with BMI: A study of smokers with normal spirometry. Scand J Prim Health Care 2008;26:241–7.
[3] Lindbæk M, Høiby EA, Lermark G, Steinsholt IM, Hjortdahl P. Which is the best method to trace group A streptococci in sore throat patients: Culture or GAS antigen test? Scand J Prim Health Care 2004;22:233–8.
[4] Fischer T, Fischer S, Kochen MM, Hummers-Pradier E. Influence of patient symptoms and physical findings on general practitioners' treatment of respiratory tract infections: A direct observation study. BMC Fam Pract 2005;6:6.
[5] Gonzales R, Steiner JF, Sande MA. Antibiotic prescribing for adults with colds, upper respiratory tract infections, and bronchitis by ambulatory care physicians. JAMA 1997;278: 901–4.
[6] Little P, Rumsby K, Kelly J, Watson L, Moore M, Warner G, et al. Information leaflet and antibiotic prescribing strategies for acute lower respiratory tract infection: A randomized controlled trial. JAMA 2005;293:3029–35.
[7] Himmel W, Lippert-Urbanke E, Kochen MM. Are patients more satisfied when they receive a prescription? The effect of patient expectations in general practice. Scand J Prim Health Care 1997;15:118–22.
[8] Butler CC, Rollnick S, Pill R, Maggs-Rapport F, Stott N. Understanding the culture of prescribing: Qualitative study of general practitioners' and patients' perceptions of antibiotics for sore throats. BMJ 1998;317:637–42.
[9] Mainous AG, Zoorob RJ, Oler MJ, Haynes DM. Patient knowledge of upper respiratory infections: Implications for antibiotic expectations and unnecessary utilization. J Fam Pract 1997;45:75–83.
[10] Wilm S, Knauf A, Kreilkamp R, Schlegel U, Altiner A. The doctor, his patient and the sputum. Z Allg Med 2006;82: 260–7.
[11] Cals JW, Boumans D, Lardinois RJ, Gonzales R, Hopstaken RM, Butler CC, et al. Public beliefs on antibiotics and respiratory tract infections: An internet-based questionnaire study. Br J Gen Pract 2007;57:942–7.
[12] Coenen S, Michiels B, van Royen P, et al. Antibiotics for coughing in general practice: A questionnaire study to quantify and condense the reasons for prescribing. BMC Fam Pract 2002;3:16.
[13] Munden J, Eggenberger T, Wittig P, editors. Handbook of primary care procedures. Philadelphia: Lippincott Williams & Wilkins, 2003. p. 419–21.
[14] Bormann C, Däubener W, Abholz H-H, Altiner A. Bacterial pathogens and resistances in 232 patients with acute productive cough. Z Allg Med 2003;79:193.
[15] Knutson D, Braun C. Diagnosis and management of acute bronchitis. Am Fam Physician 2002;65:2039–44.
[16] Stockley RA, O'Brien C, Pye A, Hill SL. Relationship of sputum color to nature and outpatient management of acute exacerbations of COPD. Chest 2000;117:1638–45.
[17] Allegra L, Blasi F, Diano P, Cosentini R, Tarsia P, Confalonieri M, et al. Sputum color as a marker of acute bacterial exacerbations of chronic obstructive pulmonary disease. Respir Med 2005;99:742–7.
[18] Flournoy DJ, Davidson LJ. Sputum quality: Can you tell by looking? Am J Infect Control 1993;21:64–9.
[19] Stott NC, West RR. Randomised controlled trial of antibiotics in patients with cough and purulent sputum. BMJ 1976;4:556–9.
[20] Johnson AL, Hampson DF, Hampson NB. Sputum color: Potential implications for clinical practice 2008;53:450–4.