Sputum Color: Potential Implications for Clinical Practice

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BACKGROUND: Respiratory infections with sputum production are a major reason for physician visits, diagnostic testing, and antibiotic prescription in the United States. We sought to determine whether the simple characteristic of sputum color provides information that impacts resource utilization such as laboratory testing and prescription of antibiotics. METHODS: Out-patient sputum samples submitted to the microbiology laboratory for routine analysis were assigned to one of 8 color categories (green, yellow-green, rust, yellow, red, cream, white, and clear), based on a key made from paint chip color samples. Subsequent Gram stain and culture results were compared to sputum color. RESULTS: Of 289 consecutive samples, 144 (50%) met standard Gram-stain criteria for being acceptable lower-respiratory-tract specimens. In the acceptable Gram-stain group, 60 samples had a predominant organism on Gram stain, and the culture yielded a consistent result in 42 samples (15% of the 289 total specimens). Yield at each level of analysis differed greatly by color. The yield from sputum colors green, yellow-green, yellow, and rust was much higher than the yield from cream, white, or clear. CONCLUSIONS: If out-patient sputum is cream, white, or clear, the yield from bacteriologic analysis is extremely low. This information can reduce laboratory processing costs and help minimize unnecessary antibiotic prescription. *Key word: respiratory, infection, sputum color, antibiotics, laboratory, prescription, microbiology, Gram stain, predominant organism, bacteria.* [Respir Care 2008;53(4):450–454.

Introduction

Cough is one of the most common symptoms for which medical evaluation is sought, accounting for approximately 30 million physician visits annually in the United States.[1] Most acute cough syndromes are due to colds, upper-respiratory-tract infections, or acute bronchitis. Despite the fact that multiple randomized trials have demonstrated that antibiotics provide no benefit for the treatment of these illnesses,[2] a majority of these patients are prescribed antibiotics.[3] Because a large proportion of the total antibiotic prescriptions by ambulatory physicians in the United States are for colds, upper-respiratory-tract infections, and bronchitis,[4] minimizing the unnecessary prescription of antibiotics for respiratory illness is an important aspect of controlling the emergence of antibiotic-resistant bacteria.[3]

The presence of sputum production may prompt patients to request antibiotic therapy. Many patients believe that antibiotics are effective for acute respiratory infections if purulence is present.[5] Physician beliefs may be similar. Evidence-based guidelines for the identification of clinically important infection in patients with uncomplicated acute cough illness have minimized the role of sputum characteristics.[6] Nonetheless, productive cough, especially with purulent sputum, correlates with antibiotic prescription in acute respiratory infections.[2,7]

One strategy for limiting or targeting antibiotic prescription is to send sputum for microbiologic analysis, either to demonstrate to the patient that a substantial infection is not present or to identify an organism when antibiotic treatment is deemed necessary. Sending specimens from all patients with productive cough, however, would be costly. To increase the efficiency of this approach we sought to determine whether the simple char-

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acteristic of sputum color can predict the results of sputum analysis. If color correlates with sputum Gram stain and culture results, we reasoned that sputum color could discriminate which specimens to send for microbiologic testing and allow physicians to counsel patients regarding the likelihood of important respiratory infection.

Methods

Over a 10 month period, consecutive sputum samples from out-patients were categorized by color when they were submitted to the microbiology laboratory for Gram stain and culture. Each sample was assigned one of 8 color choices by the accepting microbiology technician, using a standard color key. The key was a sheet of paper to which paint chip color samples (Pittsburgh Paints, Pittsburgh, Pennsylvania) were attached and numbered 1 through 8. The colors and paint chip number were white (Pittsburgh Paints number 2537), cream (2484), yellow (2251), yellow-green (3362), green (4452), rust (4252), red (7157), and clear. The corresponding color number was recorded by the technician in a log kept separate from the sample during subsequent processing.

Sputum Gram stains and culture were performed on each specimen via standard technique. A sample was believed to represent lower-respiratory-tract secretions and defined as "acceptable" when the Gram stain had both < 10 squamous epithelial cells and ≥ 25 polymorphonuclear white blood cells per high-power field. On Gram stain an organism was deemed "predominant" if it was in a quantity at least as great as the mixed respiratory flora. The subsequent culture result was defined as correlating with the Gram stain if the organism(s) identified on culture was/were consistent with the morphology of the predominant organism(s) seen on Gram stain.

The most recent medical record note for each patient from whom sputum was submitted was reviewed by the investigators to determine which samples were obtained from a patient taking an antibiotic of any kind.

Descriptive statistics and sensitivity/specificity testing were used for data analysis. The study was approved by the institutional review board of Virginia Mason Medical Center and was deemed exempt with regard to the requirement for informed consent.

Results

A total of 289 sputum samples were analyzed (Fig. 1). Of these, 50% (144/289) were of acceptable quality and thought to be from the lower respiratory tract. Among the acceptable samples, 42% (60/144) demonstrated a predominant organism on Gram stain. Subsequent culture identified an organism consistent with that seen on Gram stain

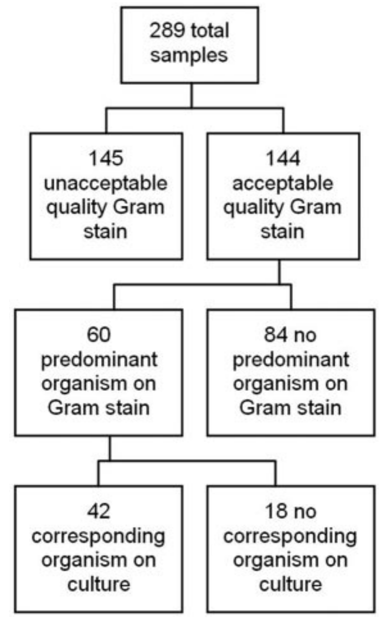

Fig. 1. Flow chart of the analysis of 289 out-patient sputum samples.

in 70% (42/60). The yield of a maximally informative result from all samples was therefore 15% (42/289).

The distribution of sputum colors is shown in Table 1. Cream, yellow, and yellow-green were the most common, accounting for 75% (217/289) of all samples. Colors in which more than half of the samples demonstrated an acceptable Gram stain were green, yellow-green, yellow, and rust (see Table 1 and Fig. 2). The overall yield of a subsequent predominant organism on Gram stain with corresponding culture from this group of colors was 24% (35/135). This compares to a 5% yield (7/144) from the color group that included clear, white, cream, and red. Positive and negative predictive values for each color and level of analysis are also listed in Table 1.

Color did not correlate with specific bacteria. For example, among 30 acceptable-quality sputum samples that grew *Haemophilus influenzae*, 12 were yellow-green, 11 yellow, 4 cream, 1 white (3%), 1 green (3%), and 1 rust. Among the 12 acceptable specimens that grew *Moraxella catarrhalis*, 4 were yellow-green, 3 yellow, 2 rust, 2 clear, and 1 cream. Traditional descriptions of sputum colors for some specific organisms versus their prevalence in this study are listed in Table 2.

With regard to current antibiotic therapy, 62% (180/289) of the patients were not taking an antibiotic at the time sputum was obtained, 20% (58/289) were taking an antibiotic, and antibiotic status could not be determined in 18% of cases (51/289). Among those with acceptable-quality versus unacceptable-quality Gram stains, antibiotic therapy was absent in 62% (90/144) versus 63% (91/145), present in 19% (28/144) versus

Table 1. Sputum Sample Data

Sputum Color (*n*)	Acceptable Gram stain			Acceptable Gram Stain Plus Predominant Organism on Gram Stain			Acceptable Gram Stain Plus Predominant Organism on Gram Stain Plus Corresponding Culture		
	n	Positive Predictive Value (%)	Negative Predictive Value (%)	*n*	Positive Predictive Value (%)	Negative Predictive Value (%)	*n*	Positive Predictive Value (%)	Negative Predictive Value (%)
Green (3)	3 of 3	100	51	3 of 3	100	80	2 of 3	67	86
Yellow-green (54)	37 of 54	69	54	20 of 54	37	83	18 of 54	33	90
Rust (13)	8 of 13	67	51	4 of 13	31	80	3 of 13	23	86
Yellow (75)	44 of 75	59	53	18 of 75	24	80	12 of 75	16	86
Red (2)	1 of 2	50	50	0 of 2	0	79	0 of 2	0	92
Cream (88)	39 of 88	44	48	9 of 88	10	75	4 of 88	5	81
White (25)	6 of 25	24	48	2 of 25	8	78	1 of 25	4	84
Clear (29)	6 of 29	21	47	4 of 29	14	78	2 of 29	7	85

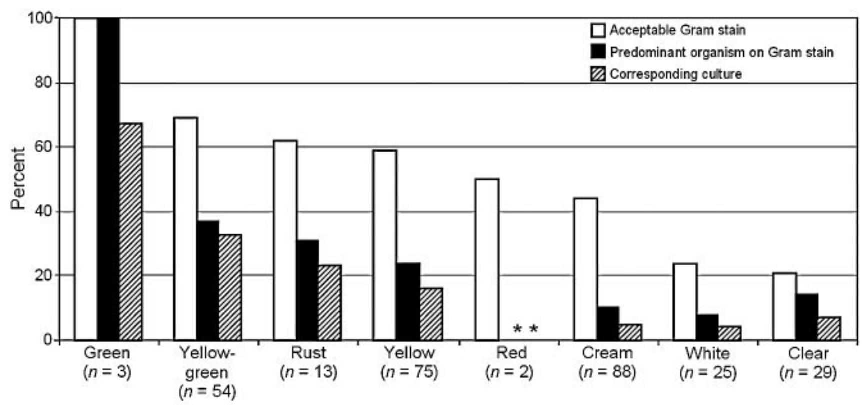

Fig. 2. Categorization of 289 sputum samples into 8 color categories and 3 subcategories: (1) acceptable Gram stain, (2) predominant organism on that Gram stain, and (3) culture result corresponded to the morphology of the organism seen on the Gram stain. * There were zero red samples in the subcategories predominant organism on Gram stain and corresponding culture.

20% (29/145), and unknown in 18% (26/144) versus 17% (25/145). Among the patients with an acceptable quality Gram stain, a predominant organism on stain, and a correlating culture, 64% (27/42) were not on antibiotics, 17% (7/42) were taking an antibiotic, and antibiotic status was unknown in 19% (8/42).

Discussion

The presence of sputum, especially when discolored, is commonly interpreted by both patients and physicians to represent the presence of bacterial infection and an indication for antibiotic treatment. In reality, purulence primarily occurs when inflammatory cells or sloughed mucosal epithelial cells are present, and it can result from either viral or bacterial infection.[8,9] As this study demonstrates, sputum color is most useful to maximize the likelihood that a sputum specimen will yield useful information on microbiologic analysis.

Few prior studies have specifically examined the role of sputum color. In a study of in-patients at a veterans hospital, yellow was the only sputum color that correlated with good or fair quality on Gram stain of the specimen.[10] In a study of patients who presented with exacerbations of moderate-to-severe chronic obstructive pulmonary disease, sputum samples were categorized by color and then compared to culture results.[11] Gram-positive organisms were isolated more frequently from white-gray sputum, and Gram-negative organisms were most frequently from yellow sputum. The importance of these findings is difficult to interpret, however, because that study did not indicate whether the cultured organisms correlated with the Gram stain findings. Since sputum cultures in every color category yielded an average of more than one organism per specimen, it is probable that more than just the predominant organism(s) on Gram stain were reported. The importance of correlating culture results with Gram-stain findings has long been emphasized.[12]

Table 2. Sputum Colors of Specific Organisms Grown From Acceptable-Quality Specimens, as Compared to Traditional Descriptions of Sputum Produced by Those Organisms

Organism (*n*)	Traditional Description of Sputum Color	Sputum Colors Found in the Present Study
Klebsiella pneumoniae (2)	Red "currant jelly"	Red 0
		Yellow-green 2
Streptococcus pneumoniae (6)	Rusty	Rust 0
		Yellow-green 4
		Yellow 1
		Cream 1
Pseudomonas aeruginosa (9)	Green	Green 1
		Yellow-green 4
		Yellow 3
		Rust 1

Sputum color has also been used to determine the need for antibiotic therapy in exacerbations of chronic obstructive pulmonary disease. In one study, samples were divided into "mucoid" (opaque or milky color) versus "purulent" (various shades of green).[13] Sputum cultures were more likely to grow bacteria when purulent and were thought to indicate the need for antibiotic treatment.

This study presents several important findings. First, there was a clear relationship between sputum color and acceptability of the Gram-stain quality (see Fig. 2). The Gram stain is recommended as a means of grading sputum adequacy on the basis of presence of epithelial cells (which represent oropharyngeal contamination) and polymorphonuclear white blood cells (which represent lower-respiratory-tract inflammation). Several guidelines have been proposed for evaluating Gram-stain quality, with different combinations and cutoffs, but none is considered clearly superior.[14] In the present study more than half of the specimens with yellow, green, or rust colors demonstrated acceptable Gram stains, according to the criteria chosen (see Fig. 2). Conversely, white or clear specimens were acceptable less than 25% of the time.

Second, the association between color and microbiologic findings was even more striking. One presumably sends sputum to the laboratory to determine the presence/absence and identities of organisms. A predominant organism was seen on an acceptable Gram stain in only 10% of the cream, white, or clear specimens, and a corresponding bacterial species was grown on subsequent culture in only a fraction of those cases. Many microbiology laboratories do not proceed with sputum culture if the Gram stain is of unacceptable quality. Since cream, white, or clear sputum specimens accounted for half of the samples in this study, substantial cost savings could be achieved by educating physicians about the rare utility of cream, white, or clear sputum specimens, and by encouraging physicians not to submit those samples for analysis unless there is a high suspicion of bacterial infection. Alternatively, since the clinician may be responding to the patient's report and may not actually see the sputum color, laboratories could limit processing of such samples in the same way they do with unacceptable Gram stains. Further, if the sputum is cream, white, or clear there should be other evidence to support the clinical likelihood of substantial infection before prescribing antibiotics.

Third, we saw no relationship between the yield of sputum analysis and current antibiotic use. Patients who were taking an antibiotic were as likely as those not on antibiotics to produce sputum of acceptable Gram-stain quality, to demonstrate a predominant organism on stain, and to yield a corresponding culture. Though this suggests that a clinician should not be dissuaded from analyzing sputum from a patient taking an antibiotic if suspicion of infection is sufficiently high, it also raises the question of patient compliance with out-patient antibiotic therapy.

Limitations

Limitations of the present study relate largely to the lack of information collected about the individual patients from whom the samples were obtained. Disease processes that were responsible for their sputum production are unknown. It is possible, for example, that sputum characteristics differ between those suffering from conditions such as bronchitis, pneumonia, asthma, cystic fibrosis, and bronchiectasis. In addition, no attempt was made to correlate the specific antibiotics being taken with the culture results. If the cultures yielded organisms that should have been sensitive to the antibiotic the patient was taking, the clinician would consider the possibility of medication noncompliance. Finally, in conditions with chronic lower-respiratory-tract colonization and sputum production, such as cystic fibrosis, the clinical utility of information gained from a high-quality sputum sample is sometimes difficult to interpret.

Conclusions

Objective assessment of out-patient sputum color has the potential to (1) yield substantial cost savings by eliminating the processing of low-yield specimens and (2) reduce unnecessary antibiotic prescription when there is not more clinical evidence of bacterial infection than cream, white, or clear sputum. It will be necessary to test these concepts prospectively in a defined patient population to determine the clinical utility of sputum color grading.

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