Study objective: To assess the potential health and cost effects of initial testing with sputum cytology to diagnose lung cancer.

Design: Cost-effectiveness analysis.

Data sources: Surveillance Epidemiology and End Results (SEER) program; cost data from Northern California Kaiser Permanente Hospitals and Universities of Stanford and Iowa; National Center for Health Statistics; and a MEDLINE search.

Interventions: The use of sputum cytologies preceding other tests (ie, fine-needle aspiration, bronchoscopy, thoracotomy) in patients with suspected lung cancer.

Main outcome measures: Mortality associated with testing and initial surgical treatment (eg, performance of thoracotomy to remove a local-stage, centrally located cancer), cost of testing and initial treatment, life expectancy, lifetime cost of medical care, and cost-effectiveness.

Results: In central lesions, sputum cytology as the first test was the dominant strategy because it both lowers medical-care costs ($2,516 per patient) and lowers the mortality risk (19 deaths in 100,000 patients) of the evaluation without adversely affecting long-term survival. In peripheral lesions, sputum cytology costs less than $25,000 per year of life saved if the pretest probability of cancer exceeds 50%. The estimated annual savings of adopting sputum cytology as the first test for diagnosing lung cancer in the United States is at least $30 million.

Conclusions: Experience in regional centers indicates that sputum cytologic testing is infrequently ordered before implementing invasive diagnostic techniques, even in patients with central lung masses. The study findings suggest that sputum cytology as the first test in suspected lung cancer is likely to be cost saving without adversely affecting patient outcomes.

(CHEST 1997; 112:937-45)

Key words: cost-effectiveness; diagnostic testing; pulmonary lesions

Abbreviations: FNA=fine-needle aspiration

More than 170,000 patients are diagnosed as having lung cancer in the United States each year.1 In the process of diagnosing lung cancer, most patients have chest radiographs that reveal pulmonary lesions suggesting the presence of a cancer. To obtain a pathologic diagnosis, patients often undergo additional testing, such as bronchoscopy, fine-needle aspiration (FNA), thoracotomy/thoracoscopy, and, less commonly, sputum cytology.2-5

Patterns of testing for lung cancer in the United States changed significantly in the past 30 to 40 years.4 Before the 1960s, sputum cytology was considered the best initial test in the diagnostic evaluation of patients with chest radiographs suggesting a cancer diagnosis.2-4 Though data on usage rates of sputa cytologic tests are not generally available, at the University of Iowa and Stanford University, approximately 15% of patients with suspected lung cancer undergo sputum cytologic testing and <5% undergo multiple sputum cytologic tests. Bronchoscopy and FNA have replaced sputum cytologic testing in the initial evaluation of pulmonary lesions, in part, because of these tests’ higher probability of diagnosing cancer when cancer is present.2-15 While other tests provide, on average, greater diagnostic accuracy than sputum cytology, they also have the disadvantages
of greater risks of morbidity and mortality and being more costly per test.2-4

To our knowledge, clinical outcomes and the cost of alternative testing strategies in patients with suspected lung cancer have never been assessed in a controlled trial. In particular, there is no direct comparison of testing strategies that use sputum cytology as an initial inexpensive and safe—albeit less accurate—procedure to testing strategies that do not use sputum cytology. Additional evidence on the potential advantages and disadvantages of sputum cytology is warranted. Decision analysis has been shown to be particularly well suited to summarizing existing data for deciding whether to alter clinical practice or if further examination of clinical practice, eg, in a randomized trial, is warranted.

This article assesses the costs and clinical outcomes associated with sputum cytology as the initial test in patients with pulmonary lesions seen on chest radiographs (sputa strategies) compared to testing strategies that do not use sputa (nonsputa strategies). Specifically, we compared sputa to nonsputa strategies on the following: (1) mortality of testing and initial surgical treatment (eg, performance of a thoracoscopy to remove a local-stage centrally located cancer); (2) cost of testing and initial surgical treatment; (3) life expectancy; and (4) lifetime cost of medical care. We also estimate the cost of sputa and nonsputa strategies per added year of life saved in patients with suspected lung cancer.

**Materials and Methods**

Figure 1 shows the decision model of the evaluation of a reference-case male patient age 50 years with suspected lung cancer. The patient has no history of cancer. We consider two scenarios characteristic of patients presenting with lung lesions: (1) a patient with a smaller lesion (<2 cm) seen in the center of the lung (central-lesion case), and (2) a patient with a moderately sized lesion (≥3 cm) seen at the periphery of the lung (peripheral-lesion case). We assume there is no clinical or radiographic evidence of extrapulmonary disease. Additional sensitivity analyses assess variations in the reference-case assumptions.

**Diagnostic Strategies**

In both scenarios, the patient may have an initial sputum cytology test or proceed directly to other diagnostic tests. If a cancer diagnosis is made on any test, no further testing for a pathologic diagnosis will be performed and a pathologic diagnosis of cancer is followed by a staging procedure (ie, CT scan or mediastinoscopy). The model also considers two bronchoscopy options, depending on whether transbronchial needle aspiration is used as a staging procedure at the time of a diagnostic bronchoscopy.16-19 If the transbronchial needle aspiration reveals cancer in the mediastinum, we assume that staging has been completed, else we assume that another staging procedure, such as CT scanning, will be done.20 We did not include consideration of positron emission tomography as a staging procedure in this case.

![Decision Tree](image)

**Figure 1.** Decision tree showing sequence of tests and treatments for patient with central or peripheral lesion seen on chest radiograph.
Data Sources

Life expectancies were derived from published reports of the Surveillance Epidemiology and End Results Program and the National Center for Health Statistics.23-29 The Surveillance Epidemiology and End Results data form a population-based tumor registry that is used to estimate mortality rates in this population. Cost of medical care was obtained from the Northern California Kaiser Permanente Hospitals. Test-associated costs were calculated from costs obtained from the billing offices of Stanford University and the University of Iowa. These costs include both the procedural and a pathology cost. Test characteristics, such as sensitivity, specificity, complication rates, and morbidity rates, were based on a MEDLINE search for literature published between 1980 and 1995.

Outcome Measures

For each case scenario and testing strategy, we estimate the mortality associated with testing, mortality associated with initial treatment (ie, thoracotomy for local-stage, centrally located cancers), cost of medical care of testing and initial treatment, life expectancy, and lifetime cost of medical care. Mortality of testing and initial treatment are estimated as the cumulative probability of death associated with continuing to be tested until a pathologic diagnosis is made and a definitive initial treatment is provided or the patient has a fatal complication. The cost of testing and initial treatment includes all expenses associated with the testing procedures, test complications, staging, staging complications, initial treatment, and treatment complications. Life expectancy is estimated for each stage (local, regional, and distant) based on published reports.33 Total cost of medical care includes the cost of testing plus the expenses associated with all testing, initial treatment, and follow-up care. Besides estimating the mean of all measures when input variables are assigned their reference-case values, as described in the next section, we also estimate the standard deviation of these measures as the input values were varied at random over a uniform distribution across the range of permissible reference-case values.

Assumptions

In the following sections, we describe the pretest probability of cancer for each scenario, estimated life expectancies as a function of diagnosis and stage, test characteristics (sensitivity and specificity), and cost of testing and treatment (Table 2).

Probability of Cancer, by Scenario and Staging: After pathologic and staging tests, all cancers are classified according to site of origin (primary or metastatic), stage (local, regional, distant), and pathologic tumor type (small cell, non-small cell). Local-stage cancers are removed by thoracotomy or thoracotomy. The probability of the stage of cancer following surgery reflects the accuracy of the staging procedure in correctly classifying cancers as local stage. Staging for most patients consists of a thoracic CT scan.

Life Expectancies: Table 2 shows life expectancies based on whether the patient has cancer, whether the cancer is primary or metastatic to the lung, the pathologic type of cancer (small cell and non-small cell), the cancer stage (local, regional, distant), and treatment (surgery or no surgery).33 The stage-specific life expectancies in Table 2 represent life expectancies for patients with small cell carcinoma and non-small cell carcinoma, weighted by the probability of these diagnoses.30 The life expectancy of patients with local-stage small cell carcinoma is based on the patient receiving adjuvant therapy in addition to surgery.

Test Characteristics: For each test in a patients with a central lesion, Table 3 (top) shows the assumptions of true-positive rate (sensitivity),7-9,11,13-15,33 true-negative rate (specificity),7-9,11,13-15,33 mortality rate of testing and initial treatment, test-related nonfatal complication rate, cost of tests, and cost of treating nonfatal complications. All nonfatal complications do not require treatment. In addition, there are several types of complications for each test. The values in Table 3 represent averages of complication types and costs of those treatable complications. Table 3 (bottom) shows assumptions for similar variables in patients with peripheral lesions.

Sputa tests consist of three to five consecutive early morning deep-cough samples.7-4 Ten percent of patients will be unable to produce a sputum sample sufficient to make a diagnosis.7-4,34 FNA procedures are performed using a percutaneous, transthoracic technique under CT scan or fluoroscopic guidance.1,2,10,30,32-40 Diagnostic accuracy of FNA generally depends more on lesion size than on location;13,40 thus, the true-positive rate of FNA is higher for the relatively larger peripheral lesion than for the smaller central lesion with FNA. The rate of pneumothorax varies between 15% and 25%;15,40 thus, the nonfatal all-cause complication rate was assumed equal to 15%.

Table 1—Possible Sequence of Tests Assessed in a Central Lesion Case and a Peripheral Lesion Case

<table>
<thead>
<tr>
<th>Strategy Name</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central lesion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T Thoracoscopy</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>BT Bronchoscopy</td>
<td>Thoracoscopy</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>FT FNA</td>
<td>Thoracoscopy</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>BFT Bronchoscopy FNA</td>
<td>Thoracoscopy</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>BFE Bronchoscopy FNA</td>
<td>Expectant management</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Peripheral lesion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T Thoracoscopy</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>FT FNA</td>
<td>Thoracoscop</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>FBT FNA</td>
<td>Bronchoscopy</td>
<td>Thoracoscopy</td>
<td>—</td>
</tr>
<tr>
<td>FBE FNA</td>
<td>Bronchoscopy Expectant management</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*0.4 = thoracotomy; BT = bronchoscop plus thoracoscopy; FT = FNA plus thoracoscopy; BFT = bronchoscopy plus FNA; BFE = bronchoscopy plus FNA plus expectant management; FBT = FNA plus bronchoscopy plus thoracoscopy; FBE = FNA plus bronchoscopy plus expectant management.

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Bronchoscopy costs included those of biopsy and brush, wash, and, if done, transbronchial needle aspiration. Because central lesions are more easily visualized than peripheral lesions with bronchoscopy, the sensitivity of bronchoscopy for central lesions is higher than for peripheral lesions.6 Published mortality rates for bronchoscopy vary between 0.01% and 0.5%;12 we selected a base-case mortality rate of 0.1%. Nonfatal complication rates vary in the literature between 0.8% and 25%;12 the all-cause nonfatal complication was assumed to be 15%. The cost of the expectant management includes the cost of chest radiographs performed at intervals of 3 to 6 weeks.

Besides making a pathologic diagnosis, thoracoscopy or thoracotomy can be used to remove the lesion.33,39 Assuming tissue is obtained, the sensitivity and specificity of pathologic diagnosis with these procedures are effectively 100%. In practice, however, the diagnostic accuracy of these procedures is less accurate because of inadequacies in tissue sampling.33,39,41 All local-stage cancers are assumed to be excised. In a patient with a nonneoplastic lesion, a pathologic diagnosis of "benign" is made and no further testing is necessary. If a cancer diagnosis is made by a test other than thoracoscopy/thoracotomy and the patient has local-stage cancer or the test is a false-positive, we assume that thoracoscopy/thoracotomy was used as definitive treatment.42

We included in the sequence of test strategies "expectant management" to account for the approximately 5% of patients in whom none of the prior tests established a pathologic diagnosis and the clinical probability of cancer with the lesion is deemed insufficient to warrant more invasive testing.43-45 Expectant management consists of regularly scheduled chest radiographs (eg, every 3 to 6 weeks) to monitor changes in the size and appearance of the lesion that may indicate a cancer diagnosis.45 Some experts may use longer intervals; however, the assumption of a shorter interval testing period is conservative in that it predominantly favors nonprotocol strategies. Our analysis also considers the tradeoff with expectant management of avoiding the risks and costs of more invasive testing balanced against the risks and costs of a delay in making a diagnosis of cancer, particularly in patients with local-stage cancer.39,45

**Costs of Medical Care:** The cost of medical care is categorized as initial care (first 6 months, not including costs related to testing, or surgical complications), continuing care (yearly costs after initial care costs), and terminal care (6 months prior to death).40 These costs represent those derived from patient billing records, and include both total hospital discharge and home health-care costs. The cost of treating nonfatal complications is an average reported in the Kaiser data taken across all the possible complications, weighted by the probability of the complication. The relatively higher cost of initial care for local disease results from additional hospital costs of excising the tumor, whereas patients with regional or distant disease have other costs associated with outpatient care, including chemotherapy. Life expectancies and costs are discounted at a fixed annual discount rate of 3%;46 and costs are reported in 1995 US dollars.

**RESULTS**

We describe separately findings for the central- and peripheral-lesion cases.

**Central Lesions**

Table 4 (top) shows, for a patient with a central lesion, mortality associated with testing and initial treatment, cost of medical care of testing and initial treatment, life expectancy, and lifetime cost of medical care. Mortality of testing and initial treatment at its lowest is 3.6 deaths per 1,000 patients for sputa-bronchoscopy-FNA-expectant management and, at its highest, is 6.1 deaths per 1,000 patients for FNA-bronchoscopy-thoracoscopy. Sputa-bronchoscopy-FNA-expectant management results in 19 fewer deaths per 100,000 patients compared to the nonsputa strategy of bronchoscopy-FNA-expectant management. The cost of testing and initial treatment is $5,120 for sputa-bronchoscopy-FNA-expectant management and $11,217 for thoracoscopy. Sputa-bronchoscopy-FNA-expectant management costs $330 lower than the nonsputa strategy of bronchoscopy-FNA-expectant management. Life expectancy is 9.85 years for sputa-bronchoscopy-FNA-expectant management and 9.57 years for thoracoscopy, a difference of 114 days. Lifetime cost of medical care is $24,561 for sputa-bronchoscopy-FNA-expectant management and $33,984 for thoracoscopy.

**Cost Per Life-Year Saved:** Table 5 (bottom) shows...
differences in life expectancies and lifetime cost of medical care between strategies that vary in only whether sputa examination is used as an initial test before further testing or treatment. In all five comparisons, initial sputa examination results in equivalent or longer life expectancy (range = 0 to 107 days) and lower lifetime medical costs (range = $−151 to $−2,516). The slightly longer life expectancy associated with sputa strategies primarily reflects sputa sparing some patients the additional testing and mortality associated with more invasive testing.

Peripheral Lesions

Table 5 (top) shows, for patients with a peripheral lesion, mortality associated with testing and initial treatment with thoracoscopy, cost of medical care of testing and initial treatment, life expectancy, and life-
time cost of medical care. The mortality of testing and initial treatment at its lowest is 3.4 deaths per 1,000 patients for sputa-FNA-bronchoscopy-expectant management compared to, at its highest, 6.1 deaths per 1,000 patients for FNA-bronchoscopy-thoracotomy. Sputa-FNA-bronchoscopy-expectant management results in four fewer deaths per 100,000 patients compared to the nonsputa strategy of FNA-bronchoscopy-expectant management. The cost of testing and initial treatment is $5,047 for sputa-FNA-bronchoscopy-expectant management and $11,236 for thoracotomy. Life expectancy was 9.783 years for sputa-FNA-bronchoscopy-expectant management and 9.778 years for FNA-bronchoscopy-expectant management, a difference of 1.8 days. Lifetime cost of medical care is $24,322 for sputa-FNA-bronchoscopy-expectant management and $35,099 for thoracotomy.

Cost Per Life-Year Saved: Table 5 (bottom) shows differences in life expectancies and lifetime cost of medical care between strategies that vary in only whether sputa examination is used as an initial test before further testing or treatment (eg, sputa-FNA-bronchoscopy-expectant management vs just FNA-bronchoscopy-expectant management). Each of the sputa strategies provides a life expectancy equivalent to or longer than the comparable nonsputa strategies (range = 0 to 1.8 days). In only the comparison of sputa testing preceding FNA-bronchoscopy-expectant management is there an added lifetime cost to the sputa strategy, equal to $138. In this least favorable comparison to sputa on the basis of cost, initial sputa examination costs $27,600 per year of life saved. In the other three comparisons, initial sputa examination results in lower medical cost and equivalent or longer life expectancy.

Sensitivity Analysis

Table 6 shows the effect of varying the pretest probability of cancer on the difference in life expectancy, difference in lifetime cost of medical care, and cost-effectiveness in the central- and peripheral-lesion cases. The comparison is shown only between the testing strategies that were least favorable to sputa. For instance, in peripheral lesions, the comparison is between using and not using sputa examination before FNA-bronchoscopy-expectant management. In central lesions, the comparison is between using and not using sputa examination before bronchoscopy-FNA-expectant management. In both scenarios, sputa testing increases life expectancy as the probability of cancer increases. Sputa testing costs less per life-year saved in

Table 5—Peripheral Lesion Case, Outcomes and Costs*

<table>
<thead>
<tr>
<th>Test Strategy</th>
<th>Mortality of Testing and Initial Treatment (per 1,000 Patients)</th>
<th>Mortality of Testing and Initial Treatment, (per 1,000 Patients)</th>
<th>Life Expectancy, yr</th>
<th>Lifetime Cost of Medical Care, $</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strategy</td>
<td>Mean (SD)</td>
<td>Strategy</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>1</td>
<td>SFBE</td>
<td>3.4 (1.0)</td>
<td>SFBE</td>
<td>5,047 (35)</td>
</tr>
<tr>
<td>2</td>
<td>FBE</td>
<td>3.5 (1.0)</td>
<td>FBE</td>
<td>5,064 (36)</td>
</tr>
<tr>
<td>3</td>
<td>T</td>
<td>5.0 (1.0)</td>
<td>SFT</td>
<td>9,470 (48)</td>
</tr>
<tr>
<td>4</td>
<td>ST</td>
<td>5.0 (1.0)</td>
<td>SFBT</td>
<td>9,810 (49)</td>
</tr>
<tr>
<td>5</td>
<td>SFT</td>
<td>5.5 (1.0)</td>
<td>FT</td>
<td>9,916 (46)</td>
</tr>
<tr>
<td>6</td>
<td>FT</td>
<td>5.5 (1.0)</td>
<td>FBT</td>
<td>10,286 (53)</td>
</tr>
<tr>
<td>7</td>
<td>SFBT</td>
<td>6.0 (1.0)</td>
<td>ST</td>
<td>10,803 (43)</td>
</tr>
<tr>
<td>8</td>
<td>FBT</td>
<td>6.1 (1.0)</td>
<td>T</td>
<td>11,236 (43)</td>
</tr>
</tbody>
</table>

Between Test Strategies^

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Difference in Life Expectancy, d</th>
<th>Difference in Lifetime Costs of Medical Care, $</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFBE vs FBE</td>
<td>1.8 (2.7)</td>
<td>137 (154)</td>
<td></td>
</tr>
<tr>
<td>SFT vs FT</td>
<td>0.4 (2.7)</td>
<td>-140 (148)</td>
<td></td>
</tr>
<tr>
<td>SFBT vs FBT</td>
<td>-0.4 (2.7)</td>
<td>-118 (148)</td>
<td></td>
</tr>
<tr>
<td>ST vs T</td>
<td>0.0 (2.8)</td>
<td>-2,201 (157)</td>
<td></td>
</tr>
</tbody>
</table>

^See Table 4 for explanation of abbreviations.

1Sputa strategy minus nonsputa strategy.

2Cost-effectiveness estimate not needed because sputa strategy prolongs life expectancy and is less costly.

*Those that differ in only whether sputa examination is performed as an initial test.
patients presenting with central lesions and is less costly for selected patients with peripheral lesions; in particular, in patients whose probability of cancer is \( >50\% \). The conclusions regarding the lower cost and better survival, especially in patients with central lesions, remained stable to variation in other reference-case assumptions.

### Discussion

This study suggests that sputum cytology could be used to a greater extent in the evaluation of suspected lung cancer, particularly in patients with central lesions, to reduce the cost of the initial evaluation without adversely affecting test-related mortality or life expectancy. Notably, in patients presenting with a central lesion where the pretest probability of cancer is \( >50\% \), sputa strategies lower medical-care costs and may prolong survival by reducing the need to proceed to riskier/costlier testing strategies. In patients presenting with a peripheral lesion, where the pretest probability of cancer is estimated to be \( \geq 50\% \), the cost per life-year saved with sputa strategies is \( <25,000 \). Adopting sputum cytology as the first test for patients with a centrally located lung lesion seen on chest radiographs has the potential to provide substantial medical-care savings in the United States. At least 200,000 patients with suspected lung cancer (=fraction of central lesions \( 60\% \) \times number of lung cancers/year \( 170,000 \)/\( \div \) pretest probability of cancer \( 50\% \)) would be eligible for sputum cytology as an initial test. The potential savings in testing costs alone with adoption of sputum cytology equals at least \$30 million each year (\( >200,000 \times \$150 \) savings per test per patient). Relatively few diagnostic strategies introduced into medicine during the 1980s and 1990s have been shown to offer such a potential advantage to both prolonging survival and lowering medical-care costs. The savings may be underestimated because this study conservatively applied estimates of the accuracy of sputum cytology, and risks of morbidity and mortality of invasive tests, to the lower ranges of those reported in the literature.

The decision to use sputum cytology may depend on the patient’s and clinician’s beliefs about the effects of testing strategy on quality of life. Besides reducing the mortality risk of more invasive procedures, the sputa strategies also help patients avoid the need for tests that are uncomfortable. In contrast, the performance of up to six sputa cytologic tests may delay establishing a diagnosis by a week or more.\(^{47}\) Depending on the patient’s attitudes—e.g., the patient’s anxiety about knowing the diagnosis outweighs the patient’s fear of and discomfort with invasive procedures—nonsputa strategies may result in a higher “quality-adjusted” life expectancy even though the sputa strategies result in longer life expectancy. Thus, clinical decisions at the bedside may need to be tailored to patients individual attitudes about the risks and benefits of invasive procedures to diagnosis lung cancer.

The assumptions incorporated into the model, of necessity simplified the clinical decision, depicting dominant practice options in our institutions. Practices at other institutions may vary, only giving greater salience to the need for a systematic evaluation of diagnostic options for patients with suspected lung cancer. For example, incorporating FNA with bronchoscopy for both diagnosis and staging\(^{16-19}\) may be a cost-effective option when compared to surgical mediastinal exploration.\(^{18}\) However, some investigators have raised concerns about the yield of using transbronchial needle aspiration alone as a staging procedure,\(^{30}\) and have suggested that it should be accompanied by CT scanning. Our findings suggest that first doing bronchoscopy with or without FNA results in higher costs than doing sputum cytologic

*See Table 4 for explanation of abbreviations.

1Cost-effectiveness estimate not needed because sputa prolongs life expectancy and is less costly.

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### Table 6—As a Function of the Pretest Probability of Cancer, Differences in Lifetime Expectancy and Costs Between Test Strategies

<table>
<thead>
<tr>
<th>Probability of Cancer</th>
<th>Peripheral Lesions (SFBE* Minus FBE)</th>
<th>Central Lesions (SBFE Minus BFE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difference in Life Expectancy, d</td>
<td>Difference in Lifetime Costs, $</td>
</tr>
<tr>
<td>0.1</td>
<td>0.208</td>
<td>264</td>
</tr>
<tr>
<td>0.3</td>
<td>1.045</td>
<td>200</td>
</tr>
<tr>
<td>0.5</td>
<td>2.166</td>
<td>138</td>
</tr>
<tr>
<td>0.7</td>
<td>2.651</td>
<td>21</td>
</tr>
<tr>
<td>0.9</td>
<td>4.995</td>
<td>2</td>
</tr>
</tbody>
</table>

*SBFE = sputum bronchoscopic examination; FBE = fiberoptic bronchoscopy; SFBE = sputum fiberoptic bronchoscopy.

The decision to use sputum cytology may depend on the patient's and clinician's beliefs about the effects of testing strategy on quality of life. Besides reducing the mortality risk of more invasive procedures, the sputa strategies also help patients avoid the need for tests that are uncomfortable. In contrast, the performance of up to six sputa cytologic tests may delay establishing a diagnosis by a week or more. Depending on the patient's attitudes—e.g., the patient's anxiety about knowing the diagnosis outweighs the patient's fear of and discomfort with invasive procedures—nonsputa strategies may result in a higher "quality-adjusted" life expectancy even though the sputa strategies result in longer life expectancy. Thus, clinical decisions at the bedside may need to be tailored to patients individual attitudes about the risks and benefits of invasive procedures to diagnosis lung cancer.

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tests first, followed by a staging procedure if cytology tests reveal a cancer diagnosis or the next diagnostic procedure if cytologic tests do not reveal a cancer diagnosis.

Our findings indicate, at a minimum, there should be a reconsideration of the appropriateness of sputum cytology in the diagnostic evaluation of patients with suspected lung cancer. Decision-analytic methods are particularly useful methods for assessing whether the cost of further evaluation of a clinical strategy—ie, in a randomized clinical trial—is justified by the potential benefits.48 However, some clinicians may view results based on a decision analysis skeptically, particularly because the published literature on the safety and efficacy of tests to diagnose the etiology of lung lesions may be out of date with today's procedures or reflect practices at selected (eg, academic) medical centers instead of practice in the community. Because the incidence of test-related mortality is so low, a study to assess the differential effect of testing strategies on this outcome would be prohibitively expensive. To allay concerns, however, a study could assess the effect of sputa vs nonsputa strategies on the number of more costly tests (eg, bronchoscopy, FNA, thoracotomy) that were avoided, the differential cost of testing, and the diagnostic accuracy of different strategies; in particular, did any patients undergoing sputa testing have a significant delay in the diagnosis of a treatable lung cancer?

CONCLUSIONS

Health provider organizations, clinicians, and patients are seeking to lower the cost of medical care while maintaining high-quality care. For the many thousands of patients each year who undergo diagnostic evaluation of suspected lung cancer—particularly those patients presenting with centrally located lung lesions—the addition of sputa examination as an initial test shows significant promise in lowering the costs of testing and initial treatment, lowering the lifetime costs of medical care, lowering the risk of death from testing and initial treatment, and thus modestly improving life expectancy.

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