Preoperative Spirometry and Laparotomy*

Blowing Away Dollars

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Study Objective: Increasing evidence indicates that routine preoperative diagnostic spirometry (pulmonary function tests [PFTs]) before elective abdominal surgery does not predict individual risk of postoperative pulmonary complications and is overutilized. This economic evaluation estimates potential savings from reduced use of preoperative PFTs.

Design: Analyses of (1) real costs (resource consumption to perform tests) and (2) reimbursements (expenditures for charges) by third-party payers.

Setting: University-affiliated public and Veterans Affairs hospitals.

Patients: Adults undergoing elective abdominal operations.

Measurements and results: Average real cost of PFTs was $19.07 (95% confidence interval [CI], $18.53 to $19.61), based on a time and motion study. Average reimbursement expenditure by third-party payers for PFTs was $85 (range, $33 to $150; 95% CI, $68 to $103), based on Medicare payment of $52 and a survey of nine urban US hospitals with a spectrum of bed sizes and teaching status. Estimates from published literature included the following: (1) annual number of major abdominal operations, 3.5 million; and (2) proportion of PFTs not meeting current guidelines, 39% (95% CI, 0.31 to 0.47). Local data were used when estimates were not available in the literature: (1) proportion of laparotomies that are elective, 76% (95% CI, 0.73 to 0.79); and (2) frequency of PFTs before laparotomy, 69% (95% CI, 0.54 to 0.84). Estimated annual national real costs for preoperative PFTs are $25 million to $45 million. If use of PFTs were reduced by our estimate for the proportion of PFTs not meeting current guidelines, potential annual national cost savings would be $7,925,411 to $21,406,707. National reimbursement expenditures by third-party payers range from more than $90 million to more than $235 million. If use were reduced, potential annual savings in reimbursements would be $29,084,076 to $111,345,440. Potential savings to Medicare approach $8 million to $20 million annually.

Conclusion: Reduced use of PFTs before elective abdominal surgery could generate substantial savings. Current evidence indicates reduced use would not compromise patients’ outcomes.

(CHEST 1997; 111:1536-41)

Key words: economics; preoperative care; pulmonary complications; pulmonary function testing; surgery/operative

Abbreviations: ACP=American College of Physicians; ALMD=Audie L. Murphy Division, South Texas Veterans Health Care System; AO=annual number of abdominal operations; C$_{np}$=annual costs; CI=confidence interval; CPFT=real cost of spirometry/PFTs per testing; DC=direct cost; E=proportion of abdominal operations that are elective; MD=physician cost; OC=overhead cost; PFTs=pulmonary function testing; Preop PFT=frequency of PFTs before elective abdominal surgery; Reimb=reimbursement expenditures by third-party payers; Reimb$_{ann}$=annual reimbursement expenditures by third-party payers

The approximately 3.5 million elective abdominal operations performed annually in the United States are associated with a relatively high risk of pulmonary complications.1-3 Many clinicians routinely order pulmonary function testing (PFT) or spirometry before these procedures to assess risk. However, a growing body of evidence indicates that spirometry predicts pulmonary operative risk poorly in individual patients.4-10

In a systematic review of the evidence regarding spirometry before abdominal operations, its predictive value was unproved.4 Studies suffered from significant methodologic flaws and many preceded current technologies in supportive care. Methodologic problems included poor standardization and definition of postoperative pulmonary complications, inadequate blinding of observers, selection bias,
retrospective design, inadequate control for interventions, and reporting of clinically unimportant complications such as microatelectasis. A more recent review indicates that this literature continues to suffer from similar methodologic problems and concludes that routine spirometry does not appear to identify patients likely to develop significant complications after upper abdominal surgery. These authors conclude that "until convincing prospective studies conclude otherwise, there is no strong evidence for performing routine screening pulmonary function tests before abdominal surgery in patients who are asymptomatic nonsmokers." 6

Recent evidence corroborates this approach. Lawrence et al10 evaluated spirometry's predictive value in patients undergoing elective abdominal operations using nested case-control design, explicit criteria for pulmonary complications, and assessment of postoperative complications that was blinded to preoperative pulmonary status. Preoperative clinical factors independently associated with pulmonary complications included abnormal results of lung examination or chest radiograph, the Goldman cardiac risk index, and overall comorbid disease burden. Neither individual spirometric variables nor degree of obstructive lung disease was associated with complications on univariate or multivariable analysis.

Despite accumulating evidence that it is not uniformly helpful in gauging risk, spirometry appears overutilized. One study found that, in a large urban academic medical hospital, 40% of preoperative spirometry did not meet current guidelines for preoperative testing.5,6,11,12 Therefore, this economic evaluation estimates potential savings from reduced, more targeted use of preoperative PFTs.

**Materials and Methods**

This study was approved by the Institutional Review Board at the University of Texas Health Science Center at San Antonio and the Research and Development Committee, Audie L. Murphy Division, South Texas Veterans Health Care System (ALMD).

We measured potential savings in two ways: real costs (due to resource consumption to perform tests) and reimbursements (or charges) by third-party payers for testing.

**Real Cost of PFTs**

Real cost of diagnostic spirometry, or PFTs, per individual patient was measured by the following equation: (1) CPFT = DC + MD + OC, where CPFT = average total real cost of PFT per patient; DC = direct cost of PFT; MD = physician cost; and OC = overhead cost of PFT.

All calculations used 1991 dollars. Only the cost of diagnostic spirometry was measured; lung volumes, bronchodilator testing, and arterial blood gases were not included. Direct costs were calculated for the ALMD of the South Texas Veterans Health Care System. The ALMD is a 650-bed acute-care hospital affiliated with the University of Texas Health Science Center at San Antonio.

DCs of spirometry, or PFTs, were those associated with personnel time, maintenance, testing materials or supplies, laboratory space, and equipment. From both a detailed prospective log for 2 weeks and the PFT Laboratory's register for 6 months (1,077 PFTs), preoperative PFTs comprised approximately 30% of total spirometric tests performed at ALMD. This estimate agrees with previous studies in which 25% of 5,875 PFTs and 31% of 441 screening spirometries were preoperative tests.7,11

Average personnel time spent per spirometric testing for an individual patient was measured using a time and motion study that documented technician time required to do spirometric testing in each of 35 patients. The sample size of 35 was based on the rule of thumb that minimum sample size required to estimate a mean is ≥30 when the population is large and normally distributed, and variance (eg, SD) is unknown.13

Average daily down time in the laboratory (ie, time when no spirometric tests were conducted but personnel were engaged in record keeping, administrative, or other related tasks) was estimated and 30% was proportionally allocated to the cost of preoperative spirometry. Cost for personnel time spent on machine maintenance and replacement of supplies as well as for cleaning supplies, disposables, printer paper, and writing supplies was also estimated, and 30% was allocated to the cost of spirometry.

The cost of space was calculated by attributing a rental value to the amount of square footage used for PFTs. Some might question including a cost that would be fixed regardless of the volume of spirometric testing. We included it because the proportion attributed to preoperative spirometry compared with other reasons for spirometric testing would vary as the proportion of preoperative tests varies. The average annual rent for available commercial space within a mile of ALMD was $126 per square foot. This total was then divided by the number of spirometric tests per week. Capital costs were allocated based on an annual depreciation rate of 10% for equipment costing $36,500 in 1991. The resulting annual capital cost of $3,650 was then divided by the average number of spirometric tests per year. The costs of all these components (personnel, maintenance, materials, laboratory space, and equipment) were then added together for total direct cost of spirometric testing.

Estimated MD was based on self-reports of time required for both a fellow and an attending physician to read four batches of 30 tests (120 individual patients). Average estimated physician reading time was 55 s per test. Because PFTs in this university-affiliated hospital are read by fellows in pulmonary medicine and reviewed by an attending physician, the average time for both fellows and physicians to read the tests was used. Total estimated MD was based on the average salary and fringe benefits of these physicians ($80,000 per year in 1991 dollars). This is a conservative estimate of MD because it was based on academic salaries rather than salaries in the private sector.

OC of spirometric testing was the proportion of administrative costs or OCs attributed to the PFT Laboratory at ALMD. An overhead rate of 15% was obtained from ALMD Fiscal Services and applied to direct spirometric and physician costs. DC, MD, and OC were summed for an average total real cost of spirometry per individual patient-testing episode.

**Estimated Reimbursement Expenditures by Third-Party Payers**

Estimates for reimbursement expenditures (Reimb) were based on a telephone survey of nine urban hospitals across regions of the United States, representing a spectrum of bed sizes and teaching affiliations (Table 1). These included the following:

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**Table 1**

<table>
<thead>
<tr>
<th>Hospital Region</th>
<th>Size (Beds)</th>
<th>Teaching Affiliation</th>
<th>Reimb Expenditures</th>
<th>OC Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>750</td>
<td>Yes</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>Midwest</td>
<td>600</td>
<td>No</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>Southwest</td>
<td>1,000</td>
<td>Yes</td>
<td>50%</td>
<td>40%</td>
</tr>
</tbody>
</table>

**Real vs. Reimb**

These estimates were based on the equation: (2) CPFT = RC = CPFT × Reimb, where CPFT = real total cost of spirometry per patient; RC = reimbursed total cost of spirometry per patient; and Reimb = estimated reimbursement per test. The average ratio of real to reimbursed cost was calculated as 1.2.

**Cost Reduction**

Potential cost savings through reduced, more targeted use of preoperative PFTs were estimated as 30% of the difference between PFTs and PFTs, attributable to 30% preoperative spirometry. The average patient was estimated to save $36 per PFT, for an estimated total savings of $10,080 per year at the South Texas Veterans Health Care System.
New York City-Columbia Presbyterian Hospital; Chicago-Rush Presbyterian Hospital; Houston-St. Luke's Episcopal Hospital; San Antonio-St. Luke's Lutheran Hospital; University Hospital; Methodist Hospital; Santa Rosa Hospital; Albuquerque-Lovelace Hospital; and San Francisco-San Francisco General Hospital.

Reimbursement for spirometry ranged from $33 to $150 (mean=$85; 95% confidence interval [CI], $67.66 to $102.34; Table 1). For simplicity, the lower and upper bounds of the CI interval were rounded off to $68 and $102, respectively (Tables 2 and 3). The Medicare reimbursement rate was estimated from the 1991 Medicare allowable charge of total relative value unit×31,001. Using the current procedural terminology code of 94060 and total relative value unit of 1.69, the allowable charge for Medicare is $52.39 (Table 1).

Estimated Annual Real Costs and Reimbursement Expenditures

We estimated annual costs for preoperative spirometry with the following equation: (2) $C_{ann}=A\times E\times PreOp\ PFT\times C_{PFT}$, where $C_{ann}$=annual costs; AO=annual number of abdominal operations; E=proportion of abdominal operations that are elective; PreOp PFT=frequency of preoperative PFTs before elective abdominal surgery; and $C_{PFT}$=average real cost of PFTs from equation 1.

To estimate annual reimbursement expenditures for preoperative spirometry, we used the following equation: (3) $Reimb_{ann}=A\times E\times PreOp\ PFT\times Reimb$, where $Reimb_{ann}$=annual charges or reimbursements by third-party payers; AO, E, and PreOp PFT are the same as in equation 2; and Reimb=charge, or reimbursement, for PreOp PFT.

Approximately 3,597,000 major abdominal operations are done annually, per the National Hospital Discharge Survey for 1993, using ICD-9-CM (International Classification of Diseases, 9th Revision, Clinical Modification) procedure codes (Table 1). For simplicity, we rounded this number down to 3.5 million (Tables 2 and 3). We specifically excluded laparoscopic cholecystectomies and diagnostic or endoscopic procedures; the exact codes used for the estimate are available from the authors on request. The annual number of abdominal operations in patients 65 years or older was 1,229,000, also estimated from the 1993 National Hospital Discharge Survey (Table 1).

We could not identify estimates from published literature for two additional variables: (1) proportion of abdominal operations that are elective and (2) frequency of PFTs before elective abdominal operations. We therefore collected data to estimate these variables and calculated 95% CIs. To assess the proportion of abdominal operations that are elective, we reviewed the computerized registry of all general surgical procedures at our two university-affiliated teaching hospitals for 1994. In 1994, at ALMD and University Hospital, a 560-bed public hospital, 546 of 717 (76%; 95% CI, 0.73 to 0.79) abdominal operations were elective (Table 1). The estimate for frequency of PFTs before elective abdominal operations was based on (1) review of preoperative screening procedures and logs of operations and spirometry.

### Table 1—Estimates for Variables Used in Analyses

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real cost of spirometry per testing*</td>
<td>$19.07</td>
<td>$18.53 –$19.61</td>
</tr>
<tr>
<td>Estimated annual No. of abdominal operations†</td>
<td>3,397,000</td>
<td></td>
</tr>
<tr>
<td>Estimated annual No. (%) of abdominal operations in patients ≥65 years old†</td>
<td>1,229,000 (34)</td>
<td></td>
</tr>
<tr>
<td>Percent of abdominal operations that are elective†</td>
<td>76</td>
<td>73 –79</td>
</tr>
<tr>
<td>Frequency of spirometry before elective abdominal operations, %</td>
<td>69</td>
<td>54 –84</td>
</tr>
<tr>
<td>Average reimbursement expenditure by third-party payers, for spirometry†</td>
<td>$85</td>
<td>$67.66 –$102.34</td>
</tr>
<tr>
<td>1991 Medicare reimbursement for spirometry</td>
<td>$52</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Proportion of preoperative spirometry not meeting current guidelines, %</td>
<td>39</td>
<td>31 –47</td>
</tr>
</tbody>
</table>

*From time and motion study at a university-affiliated Veterans Affairs hospital.
†From National Hospital Discharge Survey for 1993.
‡From 1994 data for university-affiliated Veterans Affairs and public hospitals in San Antonio.
§Estimated from six San Antonio hospitals, range of 25 to 100%.
‖From survey of nine hospitals across the United States, range of $33 to $150.

### Table 2—Cost of Spirometry

<table>
<thead>
<tr>
<th>Equation</th>
<th>Variables</th>
<th>Estimate</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Real cost of spirometry per testing</td>
<td>$C_{PFT}$</td>
<td>19.07</td>
<td></td>
</tr>
<tr>
<td>Equation 1:</td>
<td>$C_{ann}$</td>
<td>AO+E×PreOp PFT×$C_{PFT}$</td>
<td>15.90</td>
</tr>
<tr>
<td>B. Annual real cost of preoperative spirometry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation 2:</td>
<td>$C_{ann}$</td>
<td>AO</td>
<td>E</td>
</tr>
<tr>
<td>Est:</td>
<td>$35,001,078</td>
<td>3.5 million</td>
<td>76%</td>
</tr>
<tr>
<td>Min*:</td>
<td>$25,565,841</td>
<td>3.5 million</td>
<td>73%</td>
</tr>
<tr>
<td>Max*:</td>
<td>$45,546,186</td>
<td>3.5 million</td>
<td>79%</td>
</tr>
<tr>
<td>C. Annual reimbursement expenditures by third-party payers for preoperative spirometry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation 3:</td>
<td>$Reimb_{ann}$</td>
<td>AO</td>
<td>E</td>
</tr>
<tr>
<td>Est:</td>
<td>$156,009,000</td>
<td>3.5 million</td>
<td>76%</td>
</tr>
<tr>
<td>Min*:</td>
<td>$93,819,600</td>
<td>3.5 million</td>
<td>73%</td>
</tr>
<tr>
<td>Max*:</td>
<td>$236,903,200</td>
<td>3.5 million</td>
<td>79%</td>
</tr>
</tbody>
</table>

*Minimum estimates (Min) used lower bounds of confidence limits for each variable; maximum estimates (Max) used upper bounds of confidence limits for each variable. Est = estimate.
Table 3—Potential Savings With Reduced Use of Preoperative Spirometry

<table>
<thead>
<tr>
<th></th>
<th>AO</th>
<th>E</th>
<th>Preop PFT</th>
<th>CFPT</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Potential savings in real costs</strong></td>
<td>$13,650,420</td>
<td>3.5 million</td>
<td>$69</td>
<td>$19.07</td>
<td>39%</td>
<td></td>
</tr>
<tr>
<td><strong>Est:</strong></td>
<td>$7,925,411</td>
<td>3.5 million</td>
<td>$54</td>
<td>$18.53</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td><strong>Min:</strong></td>
<td>$21,406,707</td>
<td>3.5 million</td>
<td>$84</td>
<td>$19.61</td>
<td>47%</td>
<td></td>
</tr>
<tr>
<td><strong>Max:</strong></td>
<td>$111,345,440</td>
<td>3.5 million</td>
<td>$102</td>
<td>$19.61</td>
<td>47%</td>
<td></td>
</tr>
</tbody>
</table>

*Minimum estimates (Min) used lower bounds of confidence limits for each variable; maximum estimates (Max) used upper bounds of confidence limits for each variable. Est = estimates.

**Sensitivity Analyses**

Sensitivity analyses were based on the upper and lower bounds of the confidence limits for the different variables (Table 1). We conservatively used the upper and lower bounds of the 95% CIs (54 to 84%) for the frequency of PFTs before elective abdominal operations and the average charge, or reimbursement, for PFTs, rather than the more disparate range actually found in the local survey.

**Results**

**Real Cost of Spirometry per Testing**

From direct observation using a time and motion study, spirometric testing required an average of 8 min per test. Time spent waiting for computerized results added an additional 5 min but was not included in personnel costs. Assuming that testing is performed by a technician with an annual salary of $27,862 (the salary rate with benefits for laboratory technicians at ALMD), personnel cost was $10.05 per test.

An estimated 5 h/wk were spent on maintenance tasks, including machine calibration, hose and machine cleaning, replacement of disposables such as mouthpieces and noseclips, and changing of chart and computer paper. Total weekly maintenance costs were calculated and divided by the average number of spirometric tests per week for a maintenance cost of $1.44 per test. The remaining DC components (supplies, space, and capital) were each estimated at $1.50 per test. Per test, total DC of preoperative PFT was $15.99, total MD was $0.59, and OC was $2.49 (Table 2). After DC, MD, and OC were substituted into equation 1, average total real cost of preoperative PFT (CPFT) was $19.07 per test (95% CI, 18.53 to 19.61; Tables 1 and 2).

**Potential Savings**

Table 3 summarizes our calculations. If 39% (95% CI, 31 to 47%) of the annual number of PFTs do not
meet current guidelines, then 427,707 to 1,091,622 tests may not be clinically indicated (ie, [0.31 × 1,379,700 tests] to [0.47 × 2,322,600 tests]). Using equation 2, the lower bound estimates for all variables, and if unindicated tests were not performed, the estimated potential minimum national real cost savings is almost $8 million annually ($7,925,411). Substituting the upper bounds of estimates for all variables, the estimated potential maximum national real cost savings is about $21 million ($21,406,707). The range for potential annual savings in reimbursement expenditures by third-party payers, using minimum and maximum estimates for all variables, is approximately $29 million to over $111 million. Potential annual savings in Medicare reimbursements range from $7,809,685 to $19,932,393.

**DISCUSSION**

Increasing evidence indicates that routine preoperative spirometry does not accurately predict the risk of postoperative pulmonary complications in individual patients.\(^4\)\(^-\)\(^10\) Other factors, such as comorbid diseases and lung disease sufficiently severe to result in abnormal results of physical examination or radiography may be more important in operative risk.\(^7\)\(^-\)\(^10\) Despite the accumulating evidence, physicians appear to overuse preoperative spirometry for preoperative risk assessment and substantial resources may be wasted. With reduced use, potential annual savings in real costs are $8 to $21 million. Potential savings in reimbursements by third-party payers are $29 million to over $111 million, including Medicare savings of $8 to $20 million.

The primary limitation of this analysis is imprecision in estimated variables. Real cost of spirometry may vary across institutions but such variations would not likely change the thrust of these findings. Although unlikely, even if actual costs at other institutions were 50% less than the estimated figure of $19.07 used in this study, minimum annual potential savings in real costs alone would still be $4,078,156 if testing were reduced.

We recognize that the small samples for estimating reimbursement expenditures and frequency with which diagnostic spirometry is obtained before elective abdominal operations may lead to some inaccuracy. Instability in estimates for some variables is reflected in their wide CIs (eg, frequency of PFT before elective abdominal surgery). Nevertheless, sensitivity analyses using the lower bounds for estimates for all variables indicate that substantial resources are consumed by preoperative spirometry, without clear return in accurate clinical prediction of operative pulmonary risk.

The frequency of routine PFTs before elective abdominal operations is particularly difficult to estimate. Our estimate of 69% was based on a local survey and the range was wide: PFTs were obtained before 25 to 100% of elective abdominal operations. Our most detailed data are for ALMD, where approximately 47% of patients undergoing elective, nonlaparoscopic abdominal operations have preoperative spirometric testing.\(^14\) However, these patients are typically older, long-term smokers with a high prevalence of COPD. The prevalence of preoperative PFTs in community hospitals may be lower. Even so, if as few as 25% of patients undergoing elective abdominal surgery have preoperative PFTs, minimum annual cost savings would still be $2,367,207 if use were reduced by as little as 20%. With a 25% prevalence of screening preoperative PFTs and a 20% reduction in use, minimum annual savings in reimbursements would be $6,643,000 for Medicare and $8,687,000 for other payers.

Clinicians may overestimate spirometry’s ability to predict individual operative risk for several reasons. First, earlier studies suggesting that spirometry predicts complications preceded modern supportive care technology and were often substantially flawed.\(^4\)\(^,\)\(^6\) Recent evidence indicates that even for patients with severe obstructive lung disease, current supportive care may render the risk of noncardiac surgery relatively acceptable.\(^7\)\(^-\)\(^8\) Second, it is erroneous to assume that spirometry’s excellent diagnostic performance for obstructive lung disease translates into good predictive performance for postoperative pulmonary complications in individual patients. Third, in contrast to preoperative cardiac risk assessment, clinicians’ ability to assess pulmonary operative risk is limited.\(^14\) Cardiac operative risk has been more intensely and rigorously studied than pulmonary risk.\(^14\) Compared with cardiac risk assessment, the clinician has fewer tools for estimating pulmonary operative risk and may subsequently be overly dependent on spirometry.

Beyond currently available evidence, more valid assessment of the efficacy of preoperative spirometry would require either (1) a randomized trial of preoperative spirometry or (2) a prospective cohort study of a wide spectrum of patients with pulmonary risk factors (eg, known pulmonary disease, smoking history, abnormal results of pulmonary examination) who all receive preoperative spirometry. In either design, the strategy for identifying postoperative complications should include (1) uniform prospective surveillance for all patients, (2) explicit objective criteria, and (3) blinding to preoperative pulmonary status.

Meanwhile, the current level of evidence suggests that routine spirometry is not helpful and wastes resources. Reduced use of spirometry targeted to
patient subgroups could improve risk assessment and result in substantial savings. Patients with good functional status and normal results of physical examination may not benefit from routine preoperative spirometry. Subgroups who might benefit include patients with extensive smoking histories, pulmonary disease on examination who have never had diagnostic spirometry to quantitate level of disease, or patients in whom especially severe disease is suspected. This rationale is supported by recent work showing that moderate obstructive lung disease can be reliably diagnosed on the basis of history and results of physical examination.15,16

More limited use of spirometry raises the issue of cost savings at the expense of postoperative pneumonia due to missed airway obstruction. However, we lack the key information to compare these two “costs.” To fully cost a potentially preventable pneumonia due to missed airflow obstruction because spirometry was not done, we need evidence that knowing about the airflow obstruction would have prevented the pneumonia. Currently available data do not suggest that (1) routine spirometry accurately predicts and prevents postoperative pneumonia or (2) that reduced use of spirometry would compromise patients’ outcomes.

In conclusion, these results suggest that substantial resources may be currently wasted on clinically unindicated preoperative spirometry. While the temptation may exist to consider expenditures in the millions relatively small compared with other components of health-care expenditures, in reality we cannot escape the basic tenets of health economics with such a justification. These tenets are simple. Resources for health care are not unlimited. Therefore, choices must be made in how limited resources will be used. All such decisions come with opportunity costs: resources spent on one alternative are then unavailable for other, perhaps more clinically important interventions.17

ACKNOWLEDGMENT: We thank Amiram Gafni, DSc, for carefully reviewing the manuscript and providing many constructive comments.

REFERENCES
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