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Cost-effectiveness of myocardial perfusion imaging: A summary of the currently available literature

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EXECUTIVE SUMMARY

This literature review presents evidence that myocardial perfusion imaging (MPI), single photon emission computed tomography (SPECT), is cost-effective when compared with other diagnostic modalities. This is particularly the case with respect to the patient who appears by clinical criteria to be at intermediate risk, in which SPECT can accurately both diagnose and risk stratify for coronary artery disease (CAD). By diagnosing and then stratifying risk, SPECT can efficiently distinguish patients with CAD who are most likely to benefit from cardiac catheterization and revascularization from those for whom medical therapy alone is likely to be the best initial strategy. Standard measures of this cost-effectiveness used in analyses include cost per correct diagnosis, cost per quality-adjusted life-years, and cost per event identified.

Studies comparing SPECT with stress electrocardiogram (ECG) in intermediate-risk patients indicate that SPECT is more cost-effective mostly because it is more accurate. Of the 10 published cost-effectiveness analyses comparing these 2 diagnostic modalities, 7 favored the SPECT-guided testing approach. Although SPECT is more expensive as an initial diagnostic strategy, the extra cost is justified by conventional cost-effectiveness criteria. These studies indicate that SPECT costs between $5417 and $20,550 per correct diagnosis of significant CAD. More importantly, the cost per quality-adjusted life-year is estimated at $38,000 to $40,316. These values are below the conventionally accepted threshold for economic efficiency (set at less than $50,000 per life-year saved). This is in contrast to stress ECG, which has a cost per quality-adjusted life-year above the accepted threshold. The greater accuracy and sensitivity of SPECT in the detection of prognostically important coronary pathology makes it possible to avoid costly false-negative diagnoses and their associated downstream economic and health consequences, such as result from potentially avoidable acute coronary syndromes or myocardial infarctions. In patients with normal SPECT studies, the annual risk of myocardial infarction or cardiac death is approximately 1%. Data derived from actual observation demonstrate that, in practice, patients who have normal stress ECGs are often referred for further costly testing, including cardiac catheterization. In contrast, the excellent negative predictive value of a normal SPECT study is a strong deterrent to additional confirmatory testing. In patients with normal SPECT studies, only 1% undergo downstream coronary angiography.

The strategy of using initial SPECT studies is also cost-effective in the intermediate-risk patient when compared with the diagnostic strategy of initial cardiac catheterization. The highly favorable prognostic value of a negative or a low-risk SPECT study in this situation makes it possible to avoid costly and unnecessary cardiac catheterization and revascularization procedures. This has been demonstrated in important large observational database studies including the multicenter Economics of Noninvasive Diagnosis (END) registry in the United States and the multicenter Economics of Myocardial Perfusion Imaging in Europe (EMPIRE) study from Europe. Both studies showed that a diagnostic strategy beginning with SPECT and using catheterization only in patients with provocable ischemia on a SPECT study resulted in a 30% to 41% savings when compared with a strategy of initial cardiac catheterization in all patients. Savings were in part due to the fact that patients with low to moderate risk on SPECT studies could be treated with medical therapy, avoiding the costs associated with catheterization and revascularization with equivalent health outcomes.

Comparison of the cost-effectiveness of SPECT with stress echocardiography is complex. Less relevant, high-

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quality data are available. The initial cost of stress echocardiography is less. However, by using a hypothetical case analysis of an intermediate risk patient, the incremental cost-effectiveness ratios (ICERs) of SPECT and stress echocardiography were found to be in a similar range: $41,900 for stress echocardiography and $54,800 for SPECT, with both modalities compared with stress ECG. These analyses were in part based on SPECT methods (planar thallium data) that are outdated, limiting the relevance of the cost comparison. Concern has been raised about the false-positive rate of SPECT studies. However, a recent evaluation by the Agency for Health-Related Quality reported that the false-positive rate was similar for stress echocardiography and SPECT imaging. An analysis by Lee et al indicated that the lower occurrence of false-negative tests with SPECT balanced the greater initial expense of this procedure relative to stress echocardiography in patients with an intermediate-risk pretest probability of coronary artery disease ($\geq$ 30%). The conclusion from the data available is that the techniques have similar cost-effectiveness, and that the choice between them should be guided by local expertise. In addition, patient risk profile and concerns might be important in this decision, with higher risk and/or concern favoring SPECT because of the excellent prognosis of a normal SPECT, and because this negative predictive value has been demonstrated to help reduce the need for further testing.

In summary, evidence is convincing that, for the intermediate-risk patient, initial investigation with SPECT studies is a cost-efficient approach. In special populations including emergency-department (ED) patients, diabetic patients, and women, there is additional information indicating the cost effectiveness of SPECT. For low-risk patients, a cost-effective strategy appears to be stress ECG, with the selective use of SPECT for a patient whose initial test is abnormal. For high-risk patients, cardiac catheterization is in most analyses found to be the most effective diagnostic approach. However, some believe that initial SPECT studies are nevertheless indicated even in stable patients with a high probability of coronary disease because these studies can provide additional data to help direct the most effective use of revascularization therapy.

BACKGROUND ON COST-EFFECTIVENESS ANALYSIS

Over the last decade, there has been a movement in medicine toward requiring a sufficient evidence base to justify the cost of any procedure or therapy. This movement of evidence-based medicine began as a result of dramatic increases in the costs of health care that far outpaced inflation and encumbered greater percentages of our gross domestic product. Detailed analysis of health care costs over the past few decades has shown tremendous growth in the use of medical procedures. Recent updates from the American Heart Association (AHA) show that, of the nearly $50 billion spent on professional and hospital services, the growth in diagnostic procedures has been dramatic.[1] Since 1979, cardiac catheterization rates have increased 389%. Dramatic growth is not solely for invasive procedures, but also, since 1998, the rates for myocardial perfusion SPECT have increased from 10% to 30% per year in both the United States and Europe.[2] From the epidemiologic evidence, a portion of the recent dramatic declines in cardiovascular disease mortality has been, in part, a result of patient-management strategies that focus on early and effective diagnosis of CAD. However, dramatic growth in use rates has led health care policy analysts to question the rationale and consider strategies to constrain further diagnostic test growth.

Cost-effectiveness analysis (CEA) is an analytical approach that integrates a test's clinical effectiveness with its economic value.[3,4] In this era of limited resources, the calculation of marginal or incremental cost-effectiveness provides a rational means to balance health care quality and clinical value in terms of the best outcome at a reasonable price. Gated SPECT imaging has been used to evaluate whether its use is worth the additional cost when compared with other diagnostic test modalities. According to the US Preventive Services Taskforce, CEA is defined as an incremental comparison of the cost per life-year saved. In cardiovascular medicine, disease-specific CEA has also been defined as the cost per correct disease classification or the cost per event detected. Thus, the global equation that can be applied for any CEA is Δ cost/Δ outcome. In this manner, a CEA relates the economic resources consumed to the benefits attained.

The purpose of this statement is twofold: (1) to provide a synopsis of available economic data on the value of myocardial perfusion SPECT and (2) to identify additional guidelines and other reviews available on the subject, such as the recent exhaustive technology assessment published by the National Institute of Clinical Excellence (NICE) in the United Kingdom.[2,5] This report will focus on the comparative costs for an array of diagnostic procedures and a synthesis of available evidence concerning the cost-effectiveness of myocardial perfusion SPECT as compared with exercise ECG, echocardiography, and invasive coronary angiography.

METHODS

Circulation, *American Journal of Cardiology*, *Journal of Nuclear Cardiology*, *Journal of the American Society of Echocardiography*, *Journal of the American College of Cardiology*, and *Journal of Nuclear Medicine* were surveyed for articles relating to topics on cost-effectiveness and MPI or SPECT imaging, by using conventional search engines such as PubMed and OVID. Two journals, *Journal*

of Nuclear Cardiology and *Journal of the American Society of Echocardiography*, were surveyed from 1996 to 2004; the rest were surveyed from 1993 to 2004. This survey was supplemented by references in several recent review articles. Special mention is made here of a recent publication from the United Kingdom National Health Service Health Technology Assessment Programme that presents a systematic review of the effectiveness and cost-effectiveness of myocardial perfusion SPECT.[5]

Data quality

In general, the quality of economic analysis, including myocardial perfusion SPECT, is heterogeneous. A few are complex mathematical analyses, with multiple assumptions. Most studies are decision (or simulation) models, and a few represent observational cohorts comprising clinically mixed populations. In the NICE evaluation of myocardial perfusion SPECT, 22 economic evaluations were used to evaluate the CEA of SPECT.[2] Although the NICE (National Institute for Clinical Excellence) appraisal committee noted that some of these economic evaluations used poor methodologies, a notable proportion used accepted and strong analytical approaches for their economic models. In some studies, disease-specific economic analyses were used, such as the incremental cost-to-diagnosis of CAD; others used clinical outcomes as end points and included cardiac-specific (ie, cost per event detected) and traditional CEA, including cost per life-year saved or cost per quality-adjusted life-year saved.

Diagnostic costs of SPECT

There are a number of diagnostic testing modalities for the assessment of suspected myocardial ischemia. These include the low-tech but low-cost exercise ECG and increase in cost up to an invasive coronary angiogram. Costs for available diagnostic tests are listed in Figure 1, which details direct costs that vary from charges or reimbursement. Costs have been estimated by using traditional "bottom-up" and "top-down" approaches and have been synthesized from statements of the American College of Cardiology (ACC) and the European Society of Cardiology.[4,6] In reviewing this evidence, it appears that SPECT imaging is a moderately priced diagnostic modality with costs lower than those for positron emission tomography (PET), magnetic resonance imaging (MRI), and invasive coronary angiography. However, SPECT costs are uniformly higher than an office visit, exercise ECG, or echocardiography. In devising cost structures, cardiac SPECT costs might be minimized in centers with higher volumes (economies of scale) and, in many centers, by sharing fixed costs across noncardiac procedures.

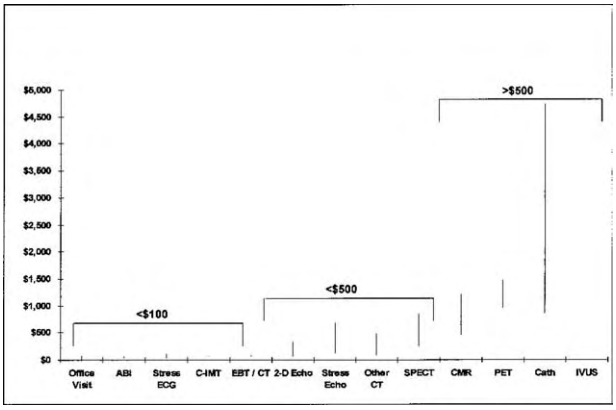

Figure 1. Comparative costs of diagnostic tests in cardiology.

Frequently, diagnostic cost differences between modalities are used as a deciding metric for test choice. However, diagnostic costs must also evaluate the economic burden throughout the episode of care; not only the upfront test costs but also any downstream or induced costs directly emanating from the procedure must be considered. For many diagnostic modalities including SPECT, this would include notably the false-positive and negative results that might define cost inefficiency for a diagnostic procedure. One method to quantify cost waste with SPECT is to examine the diagnostic accuracy statistics for insight into the common rates of false-positive and negative tests. In a recent review, the overall diagnostic sensitivity and specificity are 87% and 73% (n = 19 studies) for exercise, and 89% and 75% (n = 24 studies) for pharmacologic stress SPECT[7] (Figure 2). This means that in nearly 9 of every 10 patients with significant coronary stenosis by coronary arteriography, perfusion abnormality is noted on SPECT.

However, nearly 1 in 4 patients has a false-positive SPECT. Most often, these are due to (1) perfusion abnormalities elicited in the setting of an intermediate stenosis with endothelial dysfunction (ie, physiological true positive, but anatomically false positive) and (2) body tissue-related attenuation artifacts in women and obese patients. With regard to the latter, recent improvements have reduced this false-positive rate. These improvements include the use of attenuation correction algorithms, the use of the higher energy isotope Tc-99m rather than thallium-201 in many laboratories, and the inclusion of gated SPECT assessment of left ventricular regional function (ie, a perfusion abnormality with abnormal wall motion/thinning and reduced function has an increased likelihood of being a true positive).

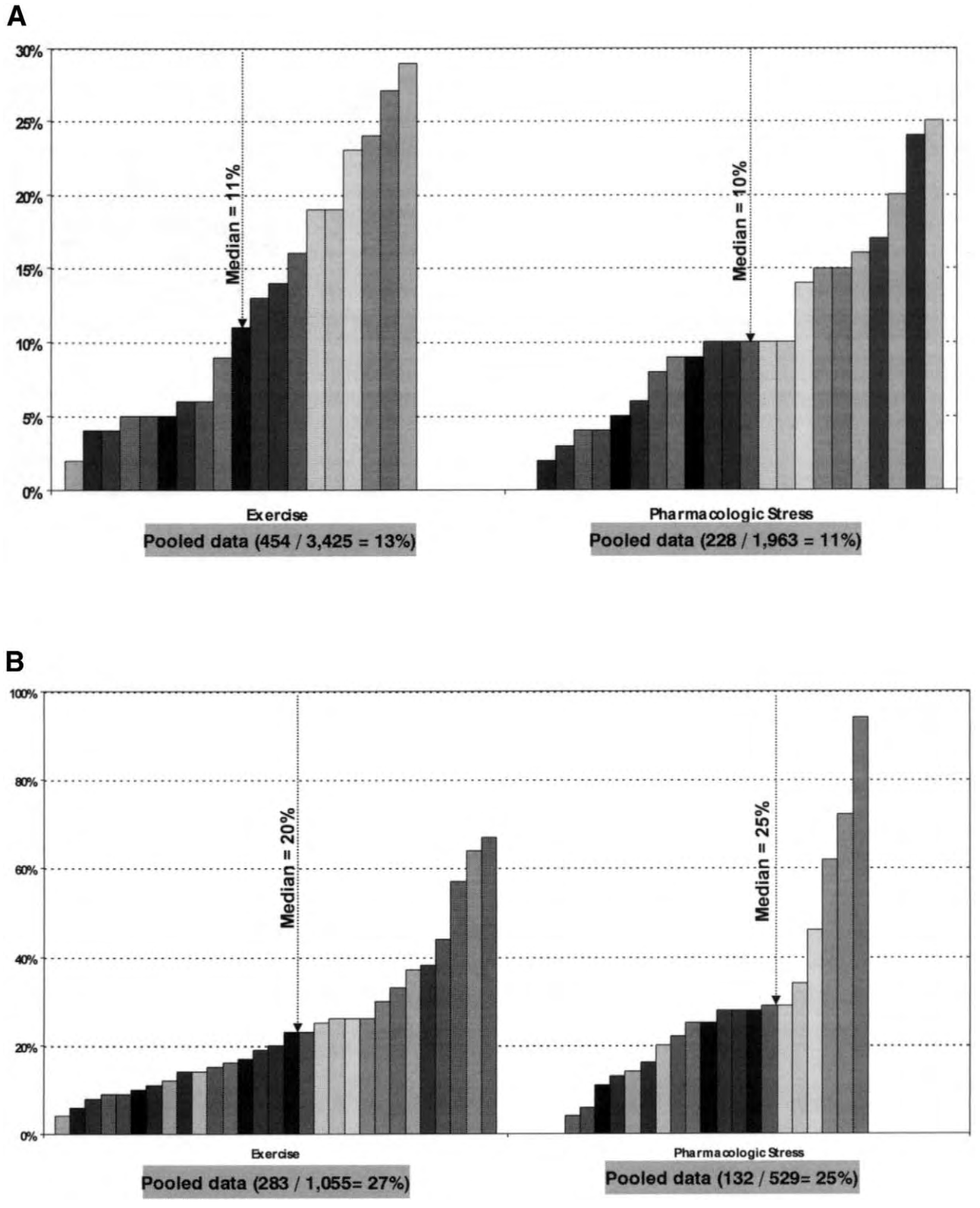

Figure 2. False-negative (**A**) and false-positive (**B**) rates for myocardial perfusion SPECT imaging by exercise (n = 19 studies), and by adenosine/dipyridamole (n = 24 studies) pharmacologic stress, with thallium, sestamibi, or tetrofosmin.

Economic principles applicable to SPECT

A number of economic principles can be garnered by reviewing the SPECT evidence. A high diagnostic sensitivity shows that costly false-negative SPECT scans (eg, downstream myocardial infarction or death in a patient with normal perfusion) are rare. From the prognostic literature, a normal myocardial perfusion SPECT is associated with annual rates of cardiac death or myocardial infarction of 0.7% (exercise) to 1.2% (pharmacologic stress).[8] This avoidance of future cardiac events in undiagnosed patients is a particular strength of this modality.

Available prognostic data lend considerable insight into the value of a positive study. From guidelines from the ACC, the AHA, and the American Society of Nuclear Cardiology (ASNC), there is a direct linear relationship between the extent and severity of perfusion abnormalities and clinical outcomes.[9,10] As the extent and severity of perfusion defects worsen, so does a patient's risk of cardiac death or myocardial infarction. From this evidence, we can also see that risk and cost have a directly proportional relationship. High-risk SPECT results are associated with high-cost care, because events have direct economic consequences. Additionally, high-risk patients also have a greater frequency of significant obstructive coronary disease and require more therapeutic intervention, leading to even greater costs of care. For the high-risk patient, this relationship of risk to expenditures is the result of diagnostic modalities and therapeutic interventions aimed at improving life expectancy and quality of life. It is the economic aim of current diagnostic strategies that higher costs of care would be justified to the degree these strategies are effective at reducing premature morbidity and mortality and, thus, are both clinically effective and cost-effective.

One additional principle can be seen in reviewing these data—the idea of allocative efficiency. Discerning the extent and severity of SPECT perfusion abnormalities (normal, mildly abnormal, and moderate to severely abnormal) is effective at classifying patients into corresponding risk groups (low, intermediate, and high), allowing one to envision a strategy of expected costs of care for each subset of patients. Thus, the estimation of risk by SPECT directs the allocation of resources to focus high-cost care to those who will receive the most benefit from such care. For the low-risk patient, low costs of care are expected for 2 to 3 years after SPECT imaging. This would entail minimal use (about 1%) of downstream coronary angiography for patients with normal stress perfusion results.[11-13] For the patient with moderate or severely abnormal SPECT results, high-cost interventional care is focused on a cohort with more advanced coronary disease and on those who have the most to gain in terms of life expectancy.

Thus, myocardial perfusion SPECT might be cost-effective, even if more costly than another diagnostic modality, because it is substantially more effective in identifying risk and improving outcomes, and more efficient in directing the allocation of resources (Figure 3). SPECT might also be more cost-effective, when compared with more expensive diagnostic modalities, because it is at least as effective at identifying diseased patients and results in equivalent (at a minimum) rates of major adverse cardiovascular events.

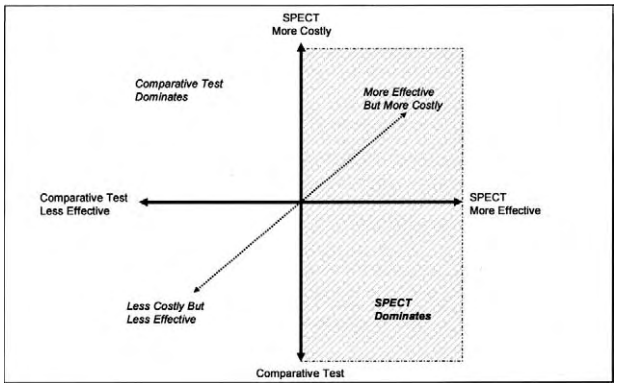

Figure 3. Compared with another modality, SPECT appears cost effective (hatched area) by being better at identifying risk than a less expensive test, *but also* by being both less expensive and more effective at identifying risk than a comparative modality.

Economic modeling evidence on SPECT by pretest risk patient subsets

Although earlier analyses,[14-18] such as those by Patterson et al[14] and Maddahi and Gambhir,[15] used decision or simulation models, more recent economic data have been derived from "real-world" effectiveness data.[19-25] These earlier models focused on the application of diagnostic accuracy statistics as drivers for evaluating economic efficiency and were built on the principles described above of minimizing cost waste through higher diagnostic sensitivity and lower false-positive rates. Although these models often rely on unrealistic assumptions, such as 100% of the patients with abnormal tests proceeding to coronary angiography, they provide some insight into developing economic efficiencies and might be the groundwork for future cost models in imaging.

The lion's share of current CEA evidence is in the routine use of myocardial perfusion SPECT as compared with exercise ECG, echocardiography, or angiography in the evaluation of chest-pain symptoms, especially for the intermediate-risk patient. In general, several reports have noted that SPECT is economically superior to exercise ECG, primarily because of its improved accuracy.[2] For stress ECG, diminished accuracy has been noted, leading to greater (unnecessary) downstream costs. In a related

report by Marwick et al,[26] a normal stress ECG often did not prevent additional diagnostic testing, which was performed based on clinical risk profiles, and resulted in an unexpected increase in the rate of coronary angiography. Thus, normal stress perfusion results are strong deterrents for additional confirmatory testing. Applying a SPECT perfusion-based strategy has been shown to result in a 23% to 41% cost savings when compared with direct coronary angiography.[19,20,25]

These results are consistent with the evidence in the NICE appraisal that the use of myocardial perfusion imaging, followed by selective coronary angiography, is cost-effective for intermediate-risk patients. Of the 10 published CEA reports cited by the NICE appraisal, 7 noted economic favorability of a SPECT-guided testing approach over stress ECG alone. By using mostly disease-specific CEA, the results ranged from a cost of $5417 per correct disease classification to $20,550 per correct cardiac event classified.[2] In 2 other reports, myocardial perfusion SPECT had an ICER of $38,000 to $40,316 per quality-adjusted life-year, values below the threshold for economic efficiency (set at less than $50,000 per life-year saved) when compared with stress ECG.[17,18]

However, for low-risk patients, a sequential testing strategy that included initial testing by stress ECG followed by SPECT and (possibly) coronary angiography if the results were positive allowed for more selective use of higher-cost tests. This has been shown to be a more cost-effective approach than direct imaging strategies.[2] This economic evidence is further supported by ACC/AHA guidelines[9,10] that recommend against the use of initial SPECT for low-risk patients.

Additionally, several reports also compared stress SPECT to coronary angiography in high-risk patients.[2] These results consistently show that, for diagnosis, direct angiography is economically favorable. In a report by Jacklin et al[27] for high-risk patients, SPECT was more costly and less effective than direct coronary angiography. The resulting ICER exceeded $100,000 for SPECT versus coronary angiography in the decision model by Garber and Solomon.[17]

It is reasonable to conclude that direct coronary angiography is cost-effective when the pretest risk of CAD is high ($>$ 75%). However, at lower levels of pretest risk, noninvasive strategies are a better use of resources than direct coronary angiography. Furthermore, a synthesis of available evidence in intermediate-risk patients shows that SPECT-based strategies are likely to economically dominate (defined as less costly and more effective) or result in economic favorability when compared with a stress ECG strategy.[2]

When stress echocardiography (a lower-cost procedure) has been compared with SPECT, exercise ECG, and angiography, several decision models have concluded that, by using a case-based analysis of a 55-year-old man with atypical angina, the ICER of echocardiography versus exercise ECG was less than $50,000 per quality-adjusted life-year saved.[19,20] Additionally, the ICER for SPECT versus ECG was similar at $54,800 per quality-adjusted life-year saved. From the report by Garber and Solomon,[17] the ICER of echocardiography vs outdated planar Tl-201 imaging was marginal at $75,000 per quality-adjusted life-year saved. Furthermore, direct angiography was not cost-effective when compared with SPECT with an ICER of $94,000 per quality-adjusted life-year saved. Garber and Solomon concluded that echocardiography, SPECT, and direct angiography were all cost-effective alternatives as compared with other diagnostic modalities and that optimal test selection should be guided by local expertise. However, questions have been raised about such analyses, because there is a significant selection bias in the populations referred for each test (with practitioners referring a lower-risk subset to stress echocardiography), and the existing direct crossover comparison database is small.

From the recent Agency for Health-Related Quality evaluation of diagnostic testing modalities, the false-positive rate was similar for echocardiography and SPECT imaging.[28] Further research should focus on decreasing the false-positive rate and creating greater economic efficiency in a SPECT diagnostic testing strategy. In a preliminary report by Lee et al,[29] the lower occurrence of false-negative tests with stress SPECT balanced the greater initial expense associated with nuclear perfusion imaging resulting in cost efficiency when compared with stress echocardiography in patients with an intermediate-risk pretest probability of CAD (ie, $\geq$ 30%).

The simulation evidence is mixed but often favorable with regard to SPECT, although models often mix planar and SPECT data. As a result, more contemporary evidence, such as that from the NICE appraisal, increasingly supports diagnostic testing strategies that use myocardial perfusion SPECT imaging.[2,17,18] A key to the transition in this evidence has been the unfolding of several large observational cohorts that have detailed the economic efficiency of SPECT.[19-25]

Observational economic evidence on SPECT

The END registry compiled a consecutive series of patients with stable angina presenting for diagnostic evaluations that included either direct coronary angiography or SPECT imaging.[20] A total of 5826 SPECT imaging patients were matched to a cohort of 5423 patients referred for direct diagnostic cardiac catheterization. Extensive statistical matching was used so that the 3-year risk of death or myocardial infarction was similar between the 2 groups; the 2 cohorts were matched according to pretest clinical risk.[30] Because the outcomes between these groups were equal, the

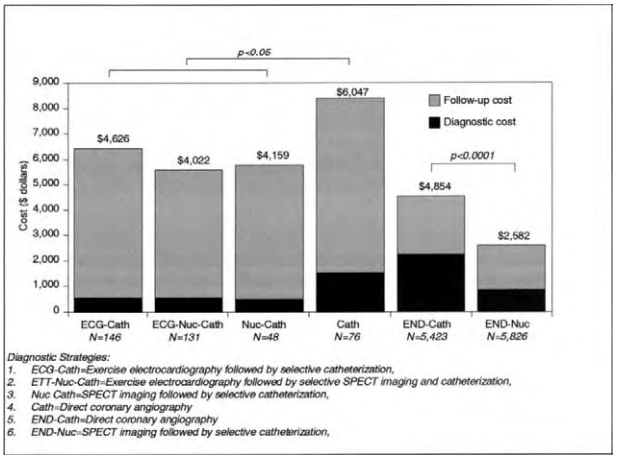

Figure 4. 2-3 Year costs for varying diagnostic strategies for intermediate risk patients with stable chest pain/angina; using data from economics of myocardial perfusion imaging in Europe (EMPIRE) and economics of noninvasive diagnosis (END) registries.

analysis focused on a cost-minimization (or savings) approach. In this cohort with stable angina, the use of myocardial perfusion SPECT resulted in a 30% to 41% cost savings when compared with direct cardiac catheterization (Figure 4). From this analysis, several factors appear to drive cost efficiency: (1) cardiac catheterization was rarely used for patients with normal stress perfusion imaging results and (2) direct coronary angiography resulted in a greater frequency of revascularization, without an added outcome benefit. Thus, from this series, direct coronary angiography resulted in substantial cost waste when compared with a SPECT approach that included selective coronary angiography for those with provocable ischemia. Similar findings were reported from the EMPIRE study of 396 patients.[25]

In a related report by Mishra et al,[21] myocardial perfusion SPECT (n = 2022) was compared with direct coronary angiography (n = 4572) and resulted in an average cost of care that was nearly half that incurred by a strategy of direct cardiac catheterization (ie, $1420 per patient lower in the SPECT group). Of the 557 patients with abnormal MPI images, only 313 (66%) underwent cardiac catheterization, suggesting that risk stratification by the extent and severity of perfusion abnormalities is cost efficient by creating selective resource consumption. Of interest, in the SPECT cohort, the ratio of catheterization to revascularization for those with significant CAD was 38%, showing that medical therapy was used in patients with modest perfusion abnormalities. By comparison, in the catheterization cohort, the catheterization to revascularization ratio was 51% for those with significant CAD ($P <$ .001). These results demonstrate that, when perfusion imaging is used as an initial diagnostic strategy, both cardiac catheterization and revascularization are used more selectively, resulting in lower costs.

Economic analysis in special populations

There is economic evidence for the use of SPECT in special populations including those evaluated with acute chest-pain symptoms in the ED,[31-39] diabetic patients,[40] and women.[41]

ED imaging of chest pain

SPECT imaging is one of many strategies used as a gatekeeper to hospitalization for acute chest pain. Of the approximately 6 million patients evaluated for chest pain in EDs in the United States, only one third will be found to have symptoms of cardiac origin.[42,43] It is estimated that nearly 3 million of these patients are hospitalized unnecessarily at an annual cost of $5 to $8 billion.[44] Additionally, 4% to 7% of patients with an acute coronary syndrome will be inappropriately sent home from the ED each year.[31-33]

Several studies have demonstrated that the use of SPECT imaging in the ED reduces costs by avoiding hospitalization in certain patient subsets without compromising patient outcome. A study by Weissman et al[33] documented changes in physicians' decision making in a group of ED chest-pain patients before and after the physicians were given the MPI data. They found that 68% of physician decisions were influenced by the SPECT imaging results, generating a potential cost savings of $786 per patient from reduced admissions for patients with low-risk SPECT findings. Radensky et al[36] used a decision model comparing use vs no use of myocardial perfusion SPECT and calculated a potential cost savings of $796 per patient in a similar clinical setting.

When SPECT imaging is introduced into a chest-pain workup, rates of hospitalization (53%-41%) and the ensuing admission diagnosis of "rule out myocardial infarction" (32%-18%) decline as recently reported by Abbott et al[39] and others.[35] They concluded that the use of SPECT imaging to guide admissions resulted in a 29%decrease in the rate of unnecessary hospitalizations and a 6% reduction in inappropriate discharges from the ED. In a similar report, Kontos et al[34] demonstrated significant cost savings, a lower angiography rate, and a shorter average length of stay for patients initially undergoing SPECT imaging when compared with a control population.

These results support the high negative predictive value for SPECT in ruling out acute myocardial infarction (99%) or future adverse cardiac event (97%).[31] Based on these data, the ACC/AHA/ASNC guidelines assign a Class IA indication to the assessment of myocardial risk in possible acute coronary syndrome patients with nondiagnostic ECGs and initial normal serum mark-

ers and enzymes, and a Class IB indication to the diagnosis of CAE in these patients.[9]

A substantial cost benefit of perfusion imaging is also evident in hospitalized patients, a finding that extends the benefits demonstrated in the ED. A prospective, randomized study by Stowers et al[37] assessed differences in hospital costs between conventional strategies and those guided by MPI. The median hospital costs per patient were $1843 lower in the perfusion imaging-guided arm than in the conventional arm. Heller et al[31] estimated savings of a similar magnitude. From an additional study by Kosnik et al[38] (69 admitted patients), however, the use of myocardial perfusion SPECT resulted in more appropriate triaging in 42% of the patients, but at an added cost of $307 per patient.

Overall, most of these small studies support the potential for significant cost savings for the use of SPECT in patients with low- to moderate-risk chest pain, nondiagnostic ECG, and/or negative biomarkers.

Diabetic patients

CAD is prevalent in diabetic patients, accounting for 50% of deaths in this population and encumbering substantial economic resources to care for these patients.[1,45] Myocardial perfusion SPECT has been demonstrated to effectively diagnose coronary disease and predict future cardiac risk in patients with diabetes.[46,47] Giri et al[40] demonstrated that the use of myocardial perfusion SPECT was highly effective at identifying at-risk diabetic and nondiabetic patients. From this END substudy, the 3-year risk-adjusted costs were decidedly higher in diabetic patients ($2705 vs $1688), in large part because of increased follow-up costs for diabetic patients. Importantly, diabetes itself accounted for only about 1% of the variance in costs. The most important drivers of cost were based on ischemic burden and the extent of CAD. Thus, from this evidence, the intensity of resource consumption might be predicted based on the results of SPECT to a greater extent than diabetes. We await additional results on the cost implications of varying SPECT imaging strategies in diabetic patients, such as that from the Bypass, Angioplasty, Revascularization Investigation in Diabetics and the Detection of Ischemia in Asymptomatic Diabetics study.[47]

Women and CAD

Because women more often have atypical symptoms, clinicians often disproportionately rely on imaging to guide further medical decision making. Several reports have noted the cost-effectiveness of myocardial perfusion SPECT in women.[2,41] Notably, in a subset analysis from the END database, the use of SPECT (n = 1263) resulted in substantial cost savings when compared with direct coronary angiography (n = 3375).[41] These findings mirrored the overall findings from the END study, noting cost saving of about 35% over 3 years of care. The composite cost was greater in the direct catheterization group when compared with SPECT while achieving equivalent patient outcomes (for the intermediate-risk woman, cost for catheterization was about $3000 vs $1700 for SPECT; $P < .01$). However, of the data reported to date, a decision model developed in the NICE appraisal showed that the ICER for SPECT in women was moderately favorable—in the $50,000 to $75,000 per life-year saved range—when compared with other diagnostic testing modalities. As a result, the NICE report concluded that evidence supported the use of SPECT imaging in women with suspected CAD. This model is consistent with a recent imaging statement from the AHA that supports cardiac imaging for diabetic and functionally impaired women.[48] We also await additional results from the ongoing What is the Optimal Method for Ischemia Evaluation in WomeN (WOMEN) study that is enrolling over 1008 women who are randomized to exercise ECG versus SPECT imaging and where CEA is a secondary end point.

CONCLUSIONS

The cost-effectiveness of MPI has been demonstrated in a number of clinical studies and various patient populations. Although some simulation models are mixed with regard to the benefit of SPECT vs echocardiography, contemporary research increasingly highlights the greater accuracy of SPECT as an important factor in reducing downstream costs when compared with exercise ECG. Large cohort studies (END, EMPIRE) are also available, comparing SPECT with other diagnostic modalities. The results consistently note significant cost savings when SPECT is used as a gatekeeper by limiting angiography to only patients with provocable ischemia. There are also data to support favorable cost models for special populations, including patients evaluated with acute chest pain in the ED, diabetic patients, and women.

The economic evidence reflects the prognostic data (clinical effectiveness) that SPECT imaging provides independent prognostic value incremental to that derived from clinical history, ECG, or angiographic variables.[49] From a recent independent appraisal, 3 studies note that a strategy of SPECT and selective coronary angiography resulted in revascularization rates of 6% to 21% compared with rates of 16% to 44% for direct coronary angiography, without a negative impact on outcomes. Thus, there is potential for significant cost savings when SPECT-guided diagnostic strategies are used.

The quality of the economic evidence regarding SPECT MPI has improved over time. However, many reports use simplistic analyses. We attempted to highlight the higher-quality reports and include more contemporary evaluations of the role of SPECT imaging in the diagnosis of suspected myocardial ischemia. We await the completion of several large controlled clinical trials that might provide further economic evidence on the role of myocardial perfusion SPECT in various populations, including those with established CAD, women, and diabetic patients.

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