ursodiol. Recommendations call for ultrasonography every six months while on therapy, a confirmatory sonogram one to three months after the gallstones appear to have dissolved, and liver chemistry tests on four occasions during the first year of treatment. The analysis includes costs for one ultrasound examination, one oral cholecystogram, and one biochemical profile. The possibility that gallbladder cancer might occur during follow-up of the ursodiol-treated patients (but not in those undergoing surgery) is considered to be negligible in this analysis. However, patients with gallstones have a 1% incidence of gallbladder cancer within 20 years of diagnosis, a rate of the same order of magnitude as that assumed for mortality from elective surgery. While some assumptions seemingly favor ursodiol treatment, the estimated probability of biliary complications due to undissolved stones may be too high, thereby inappropriately inflating ursodiol's potential risks.

The dose of a medication required in clinical practice obviously affects its cost to the patient. Weinstein et al. assume that two 300-mg capsules are sufficient for every patient. However, ursodiol dosing is based on body weight, and patients weighing 200 pounds or more require 900 mg daily, raising the estimated annual cost of the drug by 50%, or $639. Gallstone patients typically are above ideal weight and frequently require higher doses of ursodiol, thereby narrowing or eliminating the apparent cost benefit for elderly patients who are obese.

Virtually every complex decision analysis can be challenged on its assumptions, for the probabilities employed are notoriously difficult to ascertain. How can the conscientious journal reader keep from being misled? Careful attention to the sensitivity analysis presented with the primary results is essential. If clinical conclusions change within the boundaries of the sensitivity analysis, the alternative strategies may not result in substantially different outcomes. Finally, readers should take note of cost-effectiveness analyses undertaken by those who might use the findings to market new drugs or devices. Caveat emptor! Beware the creature from the black box! — ANDREW K. DIEHL, MD, MSc, Division of General Medicine, Department of Medicine, University of Texas Health Science Center at San Antonio, San Antonio, TX 78284-7879

REFERENCES


Decision Analysis, the Journal of General Internal Medicine, and the General Internist

TWO ARTICLES on clinical decision analysis appear in this issue. Publication of these articles reflects two editorial board principles: first, the Journal should serve as a central forum for academic work in general internal medicine; and second, it should provide useful information for practicing physicians.

Sometimes these two principles appear to conflict. A glance at the Gayed and Kern paper, with its heavy use of mathematical equations and its hieroglyphic-filled appendix, would intimidate most general internists. Of what use are articles such as these for practicing physicians? The answer, in 1990, is "not much." Such work, however, should be critiqued, not for its immediate clinical usefulness, but for its worth as a building block in an important edifice in academic internal medicine—clinical decision making.

Academic internal medicine has enjoyed a long fascination with clinical decision making and clinical epidemiology. Labeled "basic sciences for clinical medicine" by their practitioners, decision analysis and clinical epidemiology have textbooks, societies, focused journals, and even an ongoing series of articles in the Journal of the American Medical Association. Unfortunately, the masters of decision analysis tend to forget about the bedside clinician. Clinicians can easily smother in the morass of algo-
They must remember, however, that clinical decision algorithms, flow diagrams, graphs, tables, curves, formulas, and technical jargon associated with decision analysis.\(^6\) They must remember, however, that clinical decision theory and analysis, no matter how esoteric they become, still focus on a core intellectual act of the practicing clinician: interpretation of clinical data.\(^7\) These diagnostic data include the results of a specific blood test or nuclear medicine procedure, as well as the continuous flow of data from clinical chemistry, radiology, pathology, microbiology, hematology, and other diagnostic laboratories. Diagnostic data also include the immense quantity of clinical information that emerges during history taking and physical examination.

A major contribution of decision analysis has been to emphasize the importance of the clinical interview and the physical examination—an enthusiasm shared with the most hoary clinician.\(^8\) Clinicians are considered "decision analysts" in formal decision theory.\(^9\) The thinking patterns of clinical decision making have been thoroughly dissected, if not totally explained.\(^9\)-\(^11\) In decision theory the chief complaint of the patient evokes in the mind of the clinician (and usually within seconds) a list of possible diagnoses. In decision-making the clinical interview is referred to as "cue acquisition," thinking about diagnoses as "hypothesis activation," and the possible diagnoses as "alternative hypotheses."\(^10\),\(^12\)

An obese 40-year-old woman with vague epigastric and substernal chest discomfort, for example, provokes thoughts of indigestion, gallbladder disease, peptic ulcer disease, and pulmonary and cardiac problems. The clinician, based upon experience and knowledge, would subconsciously assign different likelihoods to these possibilities. If the clinician considered "coronary artery disease" while listening to the chief complaint, he or she would probably assign it a low probability. The clinician knows that the "prevalence" of symptomatic coronary artery disease in obese 40-year-old women who walk in the office door is low. If the patient then elaborated her complaints to say that the pain was crushing in nature, substernal in location, and radiated up her neck and down her arm, the clinician would immediately adjust the possible diagnoses and probabilities.

Research in clinical problem solving suggests that the central strategy clinicians use is "feature-matching" or "family resemblance."\(^9\)-\(^12\) They attempt to match the features of the patient's problems with their prior knowledge of the diagnoses they consider possible. The acquisition of additional information such as elevated ST-segments on the electrocardiogram, elevated cardiac enzyme levels, and the development of Q-waves results in a "final diagnosis" with a high degree of probability and confidence.

Clinicians are constantly assigning "probabilities" to the diagnostic possibilities they entertain.\(^12\)-\(^15\) The term "prevalence," used in epidemiology to refer to the proportion of the population with a specific disease, is often applied to part of the microprocess of clinical decision making. A clinician considers the "prevalence" of pulmonary embolism in the "population" of all 40-year-old women with pleuritic chest pain and shortness of breath who present to the emergency department. Once the clinician obtains a room-air arterial blood gas analysis, a particular patient enters a new population—that of 40-year-old women with pleuritic chest pain and a room-air Po\(_2\) of 65 mmHg. The clinician's estimate of the "prevalence" of pulmonary embolism in this "population" changes dramatically. If the clinician orders a ventilation–perfusion scan, the estimate of the "prevalence" of pulmonary embolism in this patient becomes the "pretest probability."

Decision theory combines the diagnostic thought processes of the clinician with strategies and tactics for interpreting diagnostic data. In this example, the diagnostic data will be the results of the lung scan. Decision analysis and clinical epidemiology have done a superb job of teasing out the parameters of diagnostic test evaluation.\(^7\) Much of the terminology, such as sensitivity, specificity, and predictive value, has become familiar. Other terms, such as posttest probability, receiver operating characteristic curves, and likelihood ratios, are applied to more complicated considerations. The persistent clinician, however, remains focused upon the patient and wants to know the results of the lung scan. Is it positive or negative? With mounting frustration, the clinician learns that before the lung scan will be performed (at least in the setting described by Becker et al.) the radiologist wants to know the clinician's estimate of the "pretest probability" of a pulmonary embolism. Why this persistent focus in decision analysis upon prevalence, otherwise known as pretest probability?

With the answer must come mention of the Reverend Thomas Bayes. Decision analysts, as a breed, find it impossible to engage in even the most casual conversation with a general internist without mentioning "Bayes theorem."\(^13\),\(^16\) This moderately simple mathematical equation helps deal with a major problem in the interpretation of diagnostic tests—the effects of prevalence on the positive predictive value of a test. The sensitivity and specificity of a test remain constant in any clinical population. The positive and negative predictive values of that test, however, change markedly, depending on the prevalence of the "disease" in the population. A positive test result will have different meaning in a population with a high prevalence (i.e., a high pretest probability) of a disease than it will in a population with a low prevalence. The key point is that the clinicians should vary their interpretation of a positive or negative test result based upon their estimate of the prior probability (prevalence) of the disease.

Radiologists have long been aware that the results