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ORIGINAL ARTICLE

The indication area of a diagnostic test. Part I—discounting gain and loss in diagnostic certainty

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Abstract

Objectives: Test performance is conventionally expressed by gain in diagnostic certainty. We propose net diagnostic gain and indication area as more appropriate measures of test performance; then, the loss in certainty due to misclassification and the information of ''no test'' would be performed are taken into account.

Study Design and Setting: A decision analytical model was developed in which two alternative strategies were compared: testing and no testing. Correct diagnostic test results received a positive value; undesired test results received a negative value. Within the ''no test'' scenario, it was assumed that physicians are more prone to treat as the probability of disease is higher.

Results: Discounting gain and loss in diagnostic certainty results in a concave function of the prior. The indication area is the range of priors with a net diagnostic gain; testing is deleterious beyond this range. The net diagnostic gain reaches a maximum at a specific prior. A freely available Web site-based calculator was developed for easy calculation of the indication area and the maximum diagnostic gain for each combination of sensitivity and specificity.

Conclusion: Medical testing is not indicated when the prior disease probabilities are low (as to screening for a condition) or high (for diagnostic confirmation). Published by Elsevier Inc.

Keywords: Sensitivity; Specificity; Prevalence; Indication area; Maximum diagnostic gain; Diagnostic test

1. Introduction

''When to do a test and when to withhold a test?'' is a recurring dilemma in medical practice. The aim of a diagnostic test was to increase diagnostic certainty at a minimum of diagnostic loss due to misclassification. Many patients, and even many medical professionals, assume that a good diagnostic test will always increase diagnostic certainty about the presence of disease. It is insufficiently recognized that every test, even a very good one, can decrease diagnostic certainty and may have a higher risk of causing harm to a patient than of improving health, particularly at very low and very high priors of disease, Knottnerus and van Weel (2002, p 10) [1] recognized that for each test, there must be threshold priors beyond which the loss in diagnostic information through misclassification outweighs the diagnostic gain by correct disease classification:

> ''A test is generally not useful if the prior probability is either very low or very high. Not only will the result rarely influence patient management, but the risk of, respectively, a false positive or a false negative result is relatively high. In other words, there is an ''indication area'' for the test between these extremes of prior probability. Evaluation of diagnostics should therefore address the issue of whether the test could be particularly useful for certain categories of prior probability.''

A second problem occurs with predictive values, which only provide retrospective information, that is, after the test has been done and the result is known. In clinical practice, however, it is usually more relevant to appraise the added value of testing before the test is done to guide further action.

The detrimental effect of medical testing can be illustrated by two extreme examples for which it is obvious that

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What is new?

Key findings

- The performance of a diagnostic test is conventionally expressed by gain in diagnostic certainty. We developed ''net diagnostic gain'' and ''indication area'' as measures of test performance which may better take into account the loss in certainty due to misclassification and the information if ''no test'' is performed. These measures may be more helpful in guiding decisions when to perform or when to withhold a test.

What this adds to what was known?

- A method is presented for calculation of the indication area: a range of prior probabilities of disease wherein use of a diagnostic test results in a net gain in diagnostic certainty when compared with refraining from testing.
- Another alternative diagnostic parameter is the diagnostic maximum which indicates the maximum net gain in diagnostic certainty that can be achieved with a diagnostic test with given sensitivity and specificity.
- The freely available Web site-based calculator enables easy calculation and graphical presentation of the indication area as well as the maximum net diagnostic gain which a test can deliver.

What is the implication and what should change now?

- The value of a diagnostic test lies in its net diagnostic gain compared with ''no test.'' We developed a method to evaluate a test in terms of the net diagnostic gain.

testing is not just futile, but even harmful. A third example demonstrates the appropriate use of a diagnostic test.

1.1. Example 1—low prior

Screening for breast cancer is unnecessary in men. The obvious reason is that the risk of breast cancer is extremely low in men, although not zero. But screening will result in an unacceptable number of false positive (FP) results. Then, the question is: Above what prior is the probability of getting a correct diagnosis higher than the chance of a diagnostic misclassification?

1.2. Example 2—high prior

An elderly patient with fever, shortness of breath, and coughing visits his general practitioner. Is a confirmative chest radiograph needed for the decision to start antibiotic treatment? As discussed by Graffelman et al. [2], the prior risk of a serious bacterial infection causing the symptoms is too high, as would be the risk of missing a serious infection (FP) on chest radiography. But then, below what prior is the probability of getting a correct diagnosis higher than the chance of a diagnostic misclassification?

1.3. Example 3—intermediate prior

A 27-year-old recently married woman with a usually regular menstruation has missed her menses for 3 days. Is an over-the-counter (OTC) pregnancy test useful to establish whether she is pregnant? [3].

The first two examples illustrate that medical testing is not informative and even detrimental when the prior is extremely low or extremely high. The third example shows that, even in a population with a reasonably high prior probability of a medical condition, the net gain in diagnostic certainty and the indication area of a test strongly depend on what we already know about the prior in a specific patient.

In the larger realm of test literature, it is hardly realized that the diagnostic process before testing, that is, medical history and physical examination, is already a test, in itself. Medical history and physical examination make a considerable contribution to the physician's assessment of the prior, a risk assessment on which a physician will decide to do a test or not and on which a physician has to act or not if no further test is available. All we know about the decision to act is that it depends on vaguely specified priors. Pauker and Kassirer [4] used a ''threshold approach'' to calculate the two boundary priors of an indication area. They assumed that physicians always ''wait and see'' when the prior is low and always act when the prior is high [4]. This may hold for the two near extreme prior probabilities of 0% and 100%. However, for most clinical real-life situations, a physician's decision to act or wait and see is a clinical judgment under uncertainty that requires various cognitive decision strategies, of which we, for the time being, only know two things for sure. First, physicians are more inclined to ''act without testing'' with increasing priors and, second, not all physicians use the same decision strategy or heuristic.

In the present study, we expand on the ''threshold approach'' by Pauker and Kassirer [4], acknowledging diagnostic loss and decision strategies if no test is done. A formal method is presented to (1) calculate for each test the lower and higher thresholds of priors between which the gain of testing is higher than the diagnostic loss and (2) to calculate at what prior the maximum net gain in certainty (here called the diagnostic max) is obtained from the test.

To facilitate bedside evaluation of a diagnostic test, we developed a freely available Web site-based calculator for easy calculation of the indication area and the diagnostic max for each combination of sensitivity and specificity.