Making sense of diagnostic test likelihood ratios

A smart mother makes often a better diagnosis than a poor doctor.
–August Bier
Professor of surgery, 1861–1949

Statistical diagnosis is a mystery to many health practitioners (1). Information is often presented as test accuracy (sensitivity and specificity). However, at the bedside, we need to know how a test result predicts the diagnosis or outcome of interest. Attempts to demystify approaches to diagnosis include the construction of 2-by-2 tables, nomograms, and such rules as SpPin (with a Specific test the Positive rules in) and SnNout (with a Sensitive test the Negative rules out). In our teachings of evidence-based medicine, we have found an easier, intuitive way to interpret the results of diagnostic studies based on 2 elements: the likelihood ratio and the pretest odds.

The likelihood ratio (LR) summarizes information about the diagnostic test by combining information about the sensitivity and specificity. It tells you how much a positive or negative result changes the likelihood that a patient would have the disease. The LR of a positive test result (+LR) is equal to sensitivity/(1–specificity), while the LR of a negative test result (–LR) is (1–sensitivity)/specificity.

Figure 1 illustrates 2 ways of calculating the chances of having a particular condition. The first uses the prevalence of a particular disease to formulate the pretest probability; the LR in the nomogram (a graphical calculator that is a useful, convenient way to perform calculations without the need to remember formulas [2]) is then used to calculate the posttest probability (3). The second way is to convert the pretest probability into pretest odds and then calculate the posttest odds. The graphical cube in Figure 1 represents the calculation done when using the nomogram. We propose that it is simpler to think of diagnostic tests just using the cube in Figure 1.

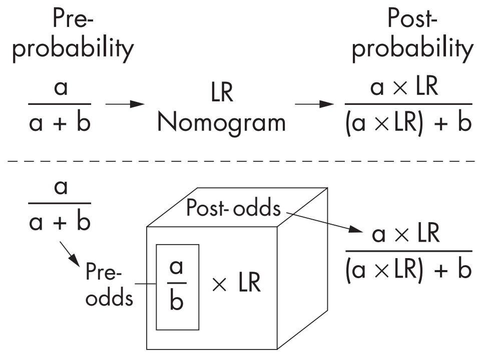

Figure 1. Incorporating diagnostic tests. a = the proportion of patients who have the target disorder; b = the proportion of patients who do not have the target disorder.

The formula in the cube shows that the pretest odds are modified by the diagnostic information summarized by the LR. The odds increase if the LR is > 1, decrease if the LR is < 1, and stay the same if the LR = 1. Therefore, an LR of 5 would increase the initial odds by a factor of 5, while an LR of 0.5 would decrease the odds by half. Table 1 shows the steps for making sense of a diagnostic test.

Table 1. Steps for interpreting diagnostic tests*

Steps	Description	Calculation
1	Think in terms of pretest odds (as fractions)	a/b
2	Multiply the top half of the fraction by the likelihood ratio (LR)	a × LR/b
3 (optional)	Transform back to posttest probabilities from posttest odds	a × LR/(a × LR) + b

*The trick here is that, if we think in odds, all we need to do is multiply the numerator by the LR.

Consider this method in the prediction of coronary artery disease (CAD) using data from a systematic review on the bedside diagnosis of CAD (4) in Table 2.

Table 2. Diagnosis of coronary artery disease (CAD)

Findings	Number of studies (*n*)	Pooled likelihood ratios (LRs)	
		+LR (95% CI)	–LR (CI)
Typical angina	8 (11 544)	5.8 (4.2 to 7.8)	–
Serum cholesterol > 300 mg/dL	2 (1585)	4.0 (2.5 to 6.3)	–
Previous myocardial infarction	7 (8216)	3.8 (2.1 to 6.8)	0.6 (0.2 to 0.6)

The information presented in Table 2 shows the +LR (how much the odds of the disease increase when a test is positive) and the –LR (how much the odds of the disease decrease when a test is negative). The largest +LR is for typical angina, hence, the conclusion and commentary for this article published in *Evidence-Based Medicine*:

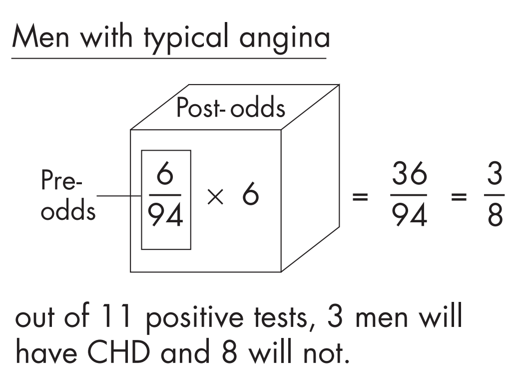

Figure 2. Posttest odds for men who have typical angina.

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"The message is simple but scientifically supported: classifying the patient's chest pain by careful questioning is the most important tool for diagnosing CAD" (5). To quantify this statement, we used data from the 2003 Health Survey in England (6). The prevalence of CAD from this survey is 6.4% (rounded to 6%) in men and 4.2% (rounded to 4%) in women. Using the largest +LR of 5.8 (rounded to 6), we can obtain the posttest odds for both men (Figure 2) and women (Figure 3) who have typical angina.

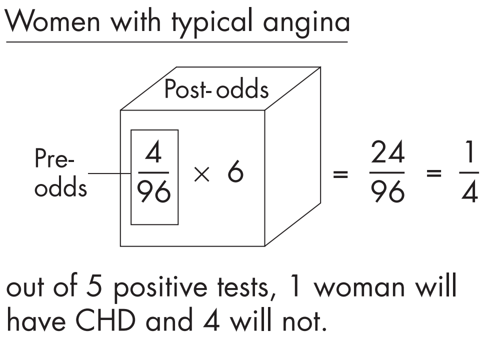

Figure 3. Posttest odds for women who have typical angina.

When using the LR to perform the calculations, we have rounded up or down to the nearest whole number, allowing for simplification of the calculations. Finally, we could also round up the fractions to enhance interpretation (i.e., 36/94 becomes 4/10). This step is similar to the rounding up of numbers needed to treat, facilitating both calculation and interpretation. Although we have performed these approximations, the result is still valid because our final odds fall within the 95% confidence interval given for the LR. Some clinicians will be more comfortable using probabilities instead of odds. Using the formulas presented in Figure 1, the posttest probabilities in the example of men with typical angina would be 36/(94+36) = 36/130 (about 30%).

It is possible to use > 1 diagnostic test. If ≥ 2 tests were independent, then these could be combined, multiplying by all the LRs of the different tests. However, this approach could potentially give the wrong result if the tests are not independent (which is not easy to test for) and therefore should be used carefully (7).

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