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Predictivities Based ROC Curve

The conventional ROC curve considers sensitivity-specificity but not predictivities. The threshold based on this ROC would be valid across population since sensitivity-specificity are not affected by prevalence. However, the diagnostic efficiency is obtained by the predictivities and not the sensitivity-specificity. Thus, the ROC curve between positive predictivity and (1 – negative predictivity) may be more useful in a local setup as it takes prevalence into account and uses right kind of indexes.

The relationship between predictivities and sensitivity-specificity can be used is to find the criterion that is best to confirm the diagnosis (i.e., maximally increase the positive predictivity) and to exclude the disease (i.e., maximally increase the negative predictivity). For example, instead of using the criterion of at least 250 U/L of total CPK for infarction, one can think of using a threshold of 200 U/L or 300 U/L. The procedure then would be to obtain sensitivity-specificity for various thresholds. These possibly can be easily obtained from established cases of infarction and suspected cases established as healthy. Substitute these sensitivity and specificity values in formulas given below and calculate predictivities for different prevalence rates. A graph of the type given in Fig. 1 can thus be obtained.

From Bayes' rule, it can be easily shown that positive predictivity,

$$P(+) \text{ or } P(\text{D}+/\text{T}+) = \frac{P(T+/D+)P(D+)}{P(T+/D+)P(D+) + P(T+/D-)P(D-)}$$

$$= \frac{S(+)*p}{S(+)*p + [1 - S(-)]*(1-p)},$$

where p is the prevalence rate per unit, S(+) is sensitivity, S(–) is specificity, and D+ is for disease positive, D– for disease negative, T+ is for test positive and T– for test negative. Similarly, negative predictivity,

$$P(-) \text{ or } P(D-/T-) = \frac{S(-)*(1-p)}{S(-)*(1-p) + [1 - S(+)]*p}.$$

Details of sensitivity, specificity and predictivities

Sensitivity-specificity based ROC curve

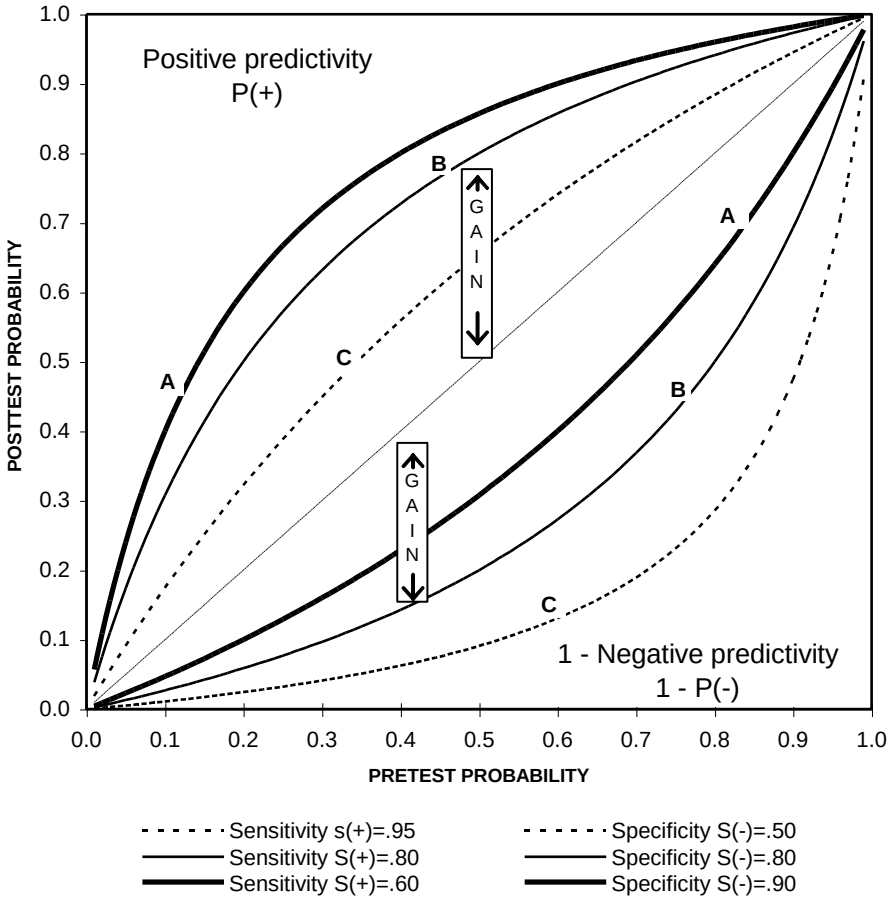

Figure 1 Illustration of the relationship between pretest and posttest probability

Figure 1 is drawn for thresholds 350, 250, and 150 U/L assuming that (sensitivity, specificity) for these thresholds respectively are (0.60, 0.90), (0.80, 0.80), and (0.95, 0.50). Shown are positive predictivity on the upper side and (1– negative predictivity) on the lower side. Thus, this is a predictivity counterpart of the ROC curve. The curves are marked as A, B and C for the three pairs of (sensitivity, specificity) levels, respectively, corresponding to the three CPK levels under consideration. When sensitivity and specificity are equal, the curves are symmetrical as illustrated by curve B in this figure. Depending on the pretest probability for the patient in hand, which could be either the known prevalence of infarction in these types of cases or subjectively estimated on the basis of history and signs and symptoms, and the CPK level present, you can immediately obtain the posttest probability (or predictivity) of the presence of infarction with such curves. If you estimate that the chance of infarction in a patient with specific signs and symptoms is 60 percent (pretest probability 0.60) and the CPK level is found to be 150 U/L, then curve C applies and the posttest probability can be read as 70 percent. This is a gain of merely 10 percent over pretest probability. If the CPK level is 350 U/L, then the curve A applies and the posttest probability is 90 percent, a handsome gain of 30 percent over the pretest probability for the presence of the disease. These gains can be utilized to find a threshold CPK level that is best in the sense of highest gain over a particular pretest probability. Now, note the following.

1. All the discussion of the sensitivity-specificity and predictivities assumes that these can be exactly obtained. In practice, these will be based on the study of a sample and

are subject to sampling error. Thus, caution should always be exercised. Similar variation is also expected in the prevalence rate. This too will be generally based on a sample. Even when a pretest probability is based on the clinician's belief concerning presence of disease after taking the history and examination into consideration, it would most likely vary from clinician to clinician. Thus, the values of sensitivity-specificity and predictivities serve only as guidelines and do not have much utility in an absolute sense. The ultimate decision, as always, rests with the attending clinician, and to give or not give credence to such indicators.

2. There is another reason for clinicians to be judicious in using sensitivity-specificity and predictivities. All these measure probabilities. And probabilities are never absolute—they yield expected results in the long run but may fail in a particular case.