Deacon's Challenge No. 5 Answer

In a cancer clinic where the prevalence of ovarian malignancy is 40%, a tumour marker has a specificity of 88% and a sensitivity of 92%. Calculate the predictive value of a positive test result.

If this test was used as a screening tool in all patients attending a general gynaecological clinic with a cancer prevalence of 0.4%, what would be the predictive value of a positive test in this population?

(MRCPath, November 2000)

It is possible to do each part of this problem in a single step. However it is easier (and with less risk of making an error) to break it down into several stages:

The predictive value of a positive test, PV(+), is the proportion (usually expressed as a percentage) of the positive results which are due to the presence of disease:

$$PV(+) = \frac{TP \times 100}{TP + FP} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

where TP = true positives and FP = false positives.

The first step is to find values for TP and FP from the information given.

The sensitivity of a test is the percentage of individuals with the disease that are correctly identified by the test:

$$\text{Sensitivity (\%)} = \frac{TP \times 100}{TP + FN} \qquad (FN = \text{false negatives})$$

The incidence of true positives in the total population tested will be the product of sensitivity (92%) and prevalence (40%):

$$TP = \frac{92 \times 40}{100} = 36.8\%$$

Similarly the specificity of a test is the percentage of individuals without the disease which are correctly identified by the test:

$$\text{Specificity(\%)} = \frac{TN \times 100}{TN + FP} \qquad (TN = \text{true negatives})$$

The incidence of true negatives in the total population tested will be the product of specificity (88%) and the prevalence of disease-free individuals (100% minus 40% = 60%):

$$TN = \frac{88 \times 60}{100} = 52.8\%$$

The proportion of disease-free individuals will be the sum of the true negatives and false positives:

$$60\% = TN + FP$$

Substitute TN = 52.8% and solve for FP:

$$FP = 60 - 52.8 = 7.2\%$$

Substitute TP = 36.8% and FP = 7.25% into equation (i) to obtain the predictive value of a positive test for the cancer clinic population:

$$PV(+) = \frac{36.8 \times 100}{36.8 + 7.2} = 83.6\%$$

This process can be repeated for the gynaecological clinic population in which the prevalence of cancer is only 0.4%. Note that sensitivity and specificity are unaffected by prevalence and their values remain the same.

$$TP = \frac{92 \times 0.4}{100} = 0.368\%$$

The incidence of cancer-free individuals is now much higher at 99.6% (i.e. 100% minus 0.4%), therefore;

$$TN = \frac{88 \times 99.6}{100} = 87.65\%$$

and since $TN + FP = 99.6\%$ then $FP = 99.6 - 87.65 = 11.95\%$

Therefore the predictive value of a positive test in the gynaecological clinic can be obtained by substituting TP = 0.368 and FP = 11.95% into equation (i):

$$PV(+) = \frac{0.368 \times 100}{0.368 + 11.95} = 3\%$$

Question No. 6

Calculate the amount in grams of lactic acid which must be added to 2.0 gms of sodium hydroxide to give 1 litre of a solution with a pH of 4.0 (the pKa of lactic acid is 3.86 and the atomic weight of sodium 23).

(MRCPath November 1989)