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Evidence Base Medicine; Part 4: Pre and Post Test Probabilities and Fagan's Nomogram

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1. Introduction

Emergency physicians face numerous questions regarding proper management of patients and selection ofthe best laboratory test or imaging every day. Knowledge on screening performance characteristics of the diagnostic tools used in this department plays an important role in finding the answers to these questions. We assessed these characteristics in the previous parts of educational article series in Emergency journal (1-3). In the present manuscript, we will describe how to use these screening characteristics for selecting the right diagnostic tools. Overall, in managing a patient in emergency department (ED), commonly the most probable cause of the problem is considered and diagnostic and treatment measures are based on that. There are various sources for determining the initial probability of a cause, called pre-test probability in this article. Usually, the examiner's experience, prevalence of the disease at the time of patient presentation, and clinical decision rules are the 3 most important and major sources in determining pre-test probability. Pre-test probability is either high enough to guarantee the initiation of treatment, or low enough to disprove the presence of the disease. A problem arises when this probability is average and one or more diagnostic tools are required for confirmation. Therefore, our aim when selecting a suitable test, is practically converting anaverage pre-test probability to a higher post-test probability that guarantees initiation of treatment or intervention. The most important characteristic among screening performance characteristics of a test used for this purpose is likelihood ratio. Theoretically, post-test probability is calculated by multiplying pre-test probability and likelihood ratio. Yet practically, it is not that simple, because probability cannot be divided and multiplied by nature. Therefore, first we should convert probability to a dividable and multipliable measure called odds. In the present article, we will discuss how to convert probability to odds and vice versa, and calculate post-test probability.

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2. Definition

2.1. Probability

It is a measurement tool for expression of likeliness. It is quantified from 0 to 1 and tells us that how certainly the event will occur (4, 5).

2.2. Odds

It is defined as "the ratio of the probability of an event happening to that of it not happening" . Odds is quantified from zero to infinity (4, 6).

2.3. Pre-test probability

It is defined as the probability of the screened person having the disease (7).

2.4. Pre-test odds

Pre-test probability/ [1 - Pre-test probability]

2.5. Post-test probability

It is the probability of the patient having a disease after obtaining the test results (7).

2.6. Example 1

If the prevalence of disease X among a certain population is 25%, the pre-test probability of this disease will be 0.25. From this, we can calculate the pre-test odds as follows:

* Pre-test probability = 0.25

* Pre-test odds = 0.25/ (1-0.25) = 0.25/ 0.75 = 0.33 We should know the likelihood ratio of the test selected for rule in/out of probable disease.

* Post-test odds = Pre-test odds × Likelihood ratio If the likelihood ratio of this test was 10, the post-test odds can be calculated as follows:

* Post-test odds = 0.33 × 10 = 3.3 After calculation of post-test odds, using the same equation, we should convert it to post-test probability.

* Post-test probability = Post-test odds / [Post-test odds + 1]

* Post-test probability = 3.3 / (3.3 + 1) = 0.76 This means that, if the result of the assumed test was positive for this patient, probability of disease rises from 0.25 to 0.76, which may guarantee initiation of treatment.

2.7. Example 2

The likelihood ratio of ultrasonography in detection of traumatic lens dislocation was estimated to be 49.5 in a study by Haghighi et al. (8). Considering 15% prevalence of lens dislocation in an example population, please calculate post-test probability of lens dislocation in patients with unilateral blindness following direct eye trauma and positive finding in ultrasonography for lens dislocation.

* Pre-test probability of lens dislocation = 0.15

* Pre-test odds = 0.15 / (1-0.15) = 0.15 / 0.85 = 0.18

* Post-test odds = 0.18 × 49.5 = 8.91

* Post-test probability = 8.91 / (8.91 + 1) = 0.90

This means that, ultrasonography is a good choice for rule in of lens dislocation in traumatic patients, because it could raise a low probability of 0.15 to 0.90.

3. An alternative way for calculating post-test probability

We can also use a shortcut for calculating post-test probability without converting probability to odds. This alternative solution is Fagan's nomogram (figure 1). It is a graphical tool used for calculating post-test probability, knowingpre-test probability and likelihood ratio (9, 10).

4. Interpretation of Fagan's Nomogram

In this nomogram the left axis represents the pre-test probability, middle axis represents likelihood ratio, and the right axis showspost-test probability. Initially, we find and mark pre-test probability and likelihood ratio values on the left and middle axes, respectively. Then astraight line is drawn from the two marked points along to therightaxis. The point at which the line crosses the left axis is the value of post-test probability.

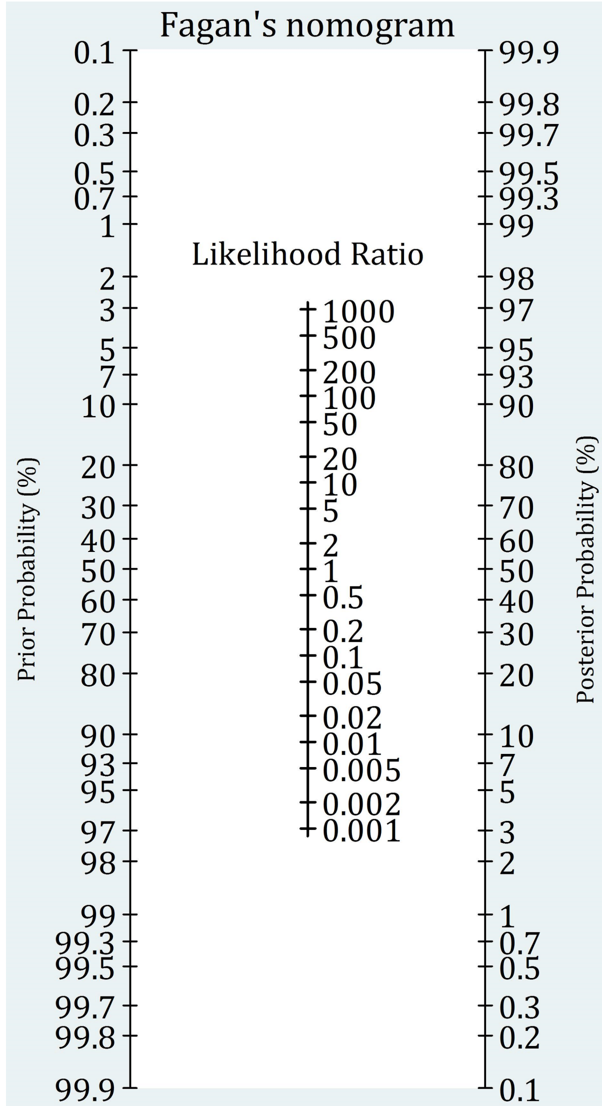

Figure 1: Fagan's nomogram.

4.1. Example 3

Assume that the prevalence of a certain disease is 25% and the positive and negative likelihood ratios of the chosen testare5 and 0.4, respectively. As shown in figure 2, post-test probability will be 62.5 and 11.7 as revealed by Fagan's nomogram. For confirmation, we will calculate the post-test probability through the equations discussed before in this article:

* Pre-test probability = 25% = 0.25

* Pre-test odds = 0.25/ (1-0.25) = 0.25/ 0.75 = 0.33

* Post-test odds = 0.33 × 5 = 1.65 (for positive likelihood ratio) 0.33 × 0.4 = 0.132(for negative likelihood ratio)

* Post-test probability = 1.65 / (1.65 + 1) = 0.625 = 62.5% 0.132 / (0.132 + 1) = 0.117 = 11.7%

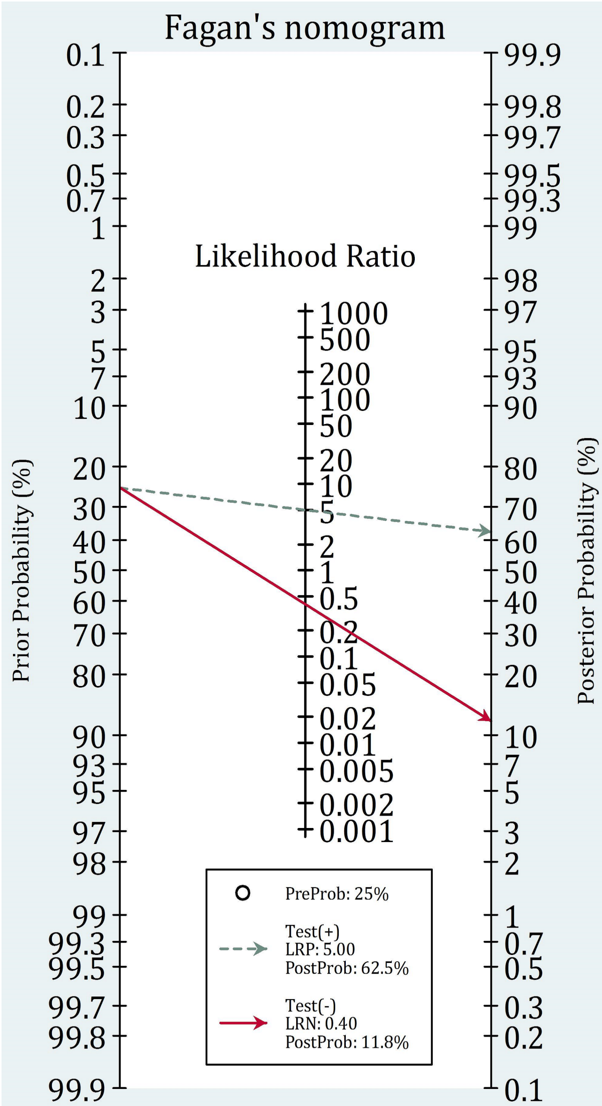

Figure 2: Fagan's nomogram of example 3.

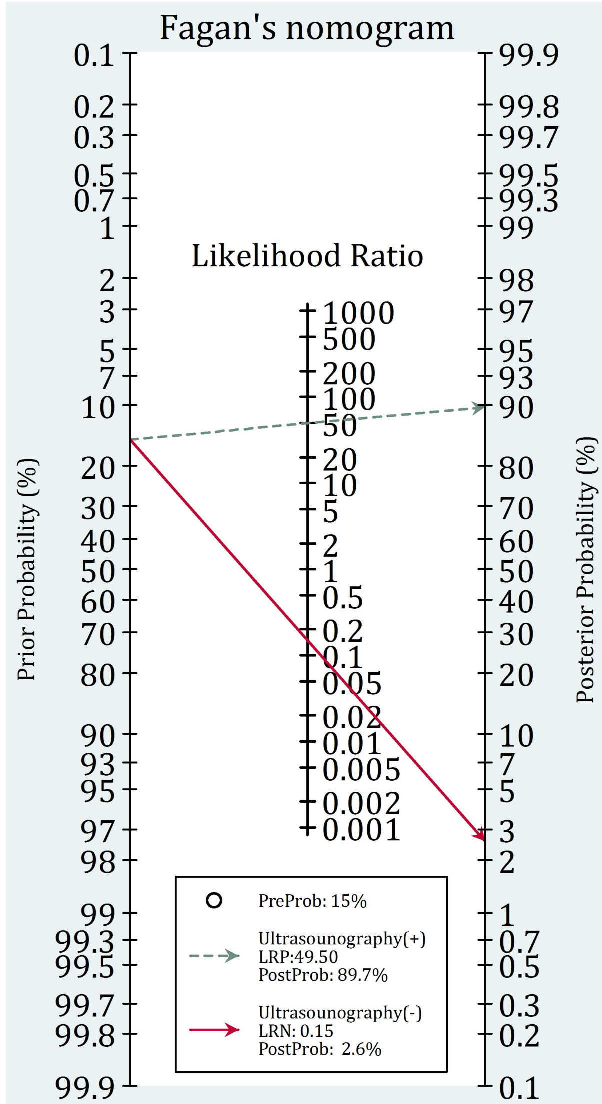

Figure 3: Fagan's nomogram of example 4.

4.2. Example 4

Let's estimate the post-test probability of example 2 using Fagan's nomogram, figure 3.

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