What Is a Real Nomogram?

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The current resurgence in the use of nomograms as diagnostic and prognostic tools has legitimate roots in their effectiveness in facilitating communication between the doctor and patient. By returning to a more classical approach to nomography, graphical insights can further enlighten the patient beyond what can be achieved with current methods, while at the same time simplifying the process. We propose a going-forward extension that addresses the issue of further use of computing technology to continue to enhance understanding.
Semin Oncol 37:23-26. © 2010 Published by Elsevier Inc.

WHY NOMOGRAMS

A critical issue at the doctor–patient interface is the difference between the doctor "getting an answer" and the doctor explaining it to the patient, both for diagnosis and subsequent treatment alternatives. The distillation of large amounts of historic data can help in predicting the probable outcome for a patient, based on his test results; that part of the problem—getting the answer—is "calculation." However, in order to make an informed decision, the patient must be comfortable that he understands the situation. It is the communication of the information that becomes important, and the problem is one of "presentation." We concern ourselves here with that problem exclusively.

Informed-consent decisions are always stressful and emotional for the patient, and it is hard for him to be objective. A problem arises because different patients have different ways of understanding, just as individuals have different learning modes. In particular, there is a large class of patients who respond well to graphical presentation, and this is where nomography has played a role in recent years. However, there has recently been controversy around the subject, and it is this controversy that we address.

TERMINOLOGY

Nomography is a technique that has been plagued by difficulties in terminology since its inception over 100 years ago. People have argued whether they should be called "nomographs" or "nomograms," and the result is that the two terms are perfectly interchangeable today. We will use the term *nomogram* exclusively. The medical research community has used a specific kind of nomogram, which we refer to as "medical nomograms." The more general case consists of "classical nomograms," and we will clearly demonstrate the differences. Alternatively, there are nongraphical approaches that we call "computerized form fill-out," in which the doctor and patient input test results into a computer and receive a numerical answer. Some of the controversy surrounding "nomograms" derives from confusion surrounding these terms, and one of our objectives here is to clear up that confusion.

CONCEPTUAL COMPUTATIONAL FRAMEWORK

Our objective is to distill large amounts of data so that subsequent computations can be done quickly and with as much precision and accuracy as the underlying data permits. Imagine the case of three tests: T_1, T_2, and T_3. A given patient may score S_1, S_2, and S_3, respectively. However, the three tests might not be equally important, with arbitrary weights W_1, W_2, and W_3 for the three tests. If we knew the weights, we could make a prediction of an outcome by computing the weighted score

$$O = W_1S_1 + W_2S_2 + W_3S_3 \quad (1)$$

Now imagine that we have a dataset with thousands of sets of score triplets matched with their outcomes, O. We can perform a statistical analysis on this dataset to determine a set of W's that allows us to estimate the outcome for the next patient based on his triplet of scores.

This approach obviously generalizes from 3 to n. The test scores can be "continuous" in the sense that the scores can vary continuously—such as prostate-

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0270-9295/10/$ - see front matter

doi:10.1053/j.seminoncol.2009.12.003

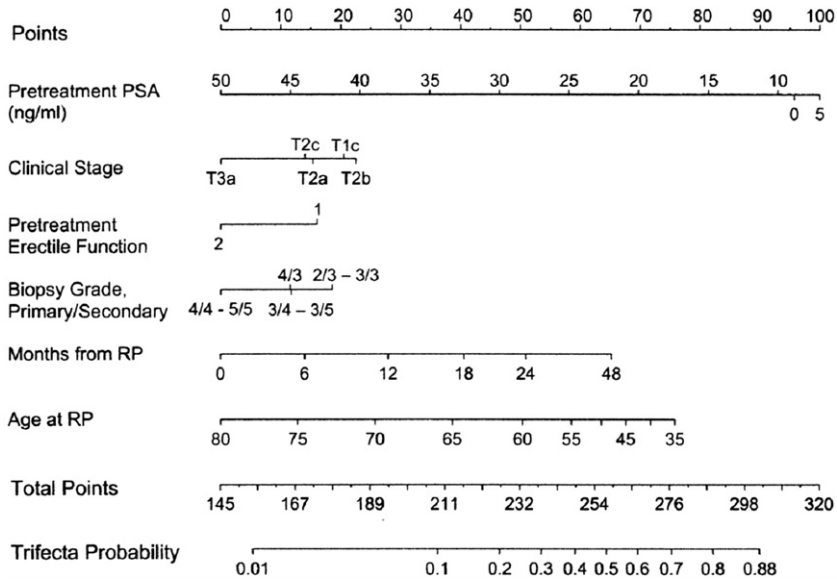

Figure 1. An example of a medical nomogram. This "Trifecta Nomogram" estimates the probability of a positive outcome as a function of six different parameters.[1]

specific antigen (PSA) readings—or they can be discrete—a condition being either present or absent. In all cases, a weight is determined for each variable. The weighted score method has been proven superior to alternate approaches; for example, separating the various cases into subpopulations leads to less discrimination for all the subpopulations.

A MEDICAL NOMOGRAM

Figure 1 is a medical nomogram for the computation of a prognosis for prostate cancer patients who have undergone a radical prostatectomy. The objective is to determine the "Trifecta Probability"—the probability that the patient will be free of recurrence, regain continence, and regain sexual function. The authors first rigorously define what they mean for each of these criteria. They then take 6 different factors—PSA, clinical stage, erectile function, biopsy grade, months from the radical prostatectomy (RP), and age at RP—and use these indicators to compute the probability. The method is straightforward: for each factor, one navigates up the chart to attain the number of points corresponding to the patient's score for that test; this corresponds to the WS in equation [1]. Once the six scores have been found, a total is obtained; the size and layout of the individual scales has automatically taken the weighting into account. Finally, one navigates down from the Total Points scale to discover the Trifecta Probability, what we called "the outcome" in equation [1].

This medical nomogram is in essence a distillation of the case histories of 1,577 men, and the weights determined represent a best fit to all the data pertinent to that cohort. The presentation is compact and easy to understand. The computation can be done fairly quickly. The precision and accuracy are sufficient for all practical cases. Because it is a hard-copy document, it can be photocopied and distributed, and even used as a worksheet when the doctor is explaining the situation to the patient. This general approach has become the de facto standard in medical nomography, not because any "standards board" decided so, but more because the vast majority of researchers working in the field adopted this technique, and because many, many practitioners found the product useful.

In late 2008, Dr David Grimes published an article attempting to refute the entire practice of using nomograms.[2] His argument was twofold: he contended, first, and most important, that the nomograms illustrated above were *not* in fact nomograms, and, second, that the usefulness of the technique had passed and nomograms should be relegated to the dustbin of history. Let us address these two issues one at a time.

CLASSICAL NOMOGRAMS

Dr Grimes makes a good point. Strictly speaking, a nomogram enables graphical computation. What is "artificial" in medical nomograms is the need to "graphically" look up points for each factor, then sum them, and then do the "reverse graphical lookup" on the total to achieve the result. A classical nomogram is completely graphical in its execution. However, it is possible to transform the medical nomogram into a classical nomogram. In Figure 2 we present a classical nomogram that encapsulates the exact same data as that of Figure 1. The scales are laid out differently, and the usage is documented on the nomogram itself. The dotted lines are a sample problem. One starts at the left

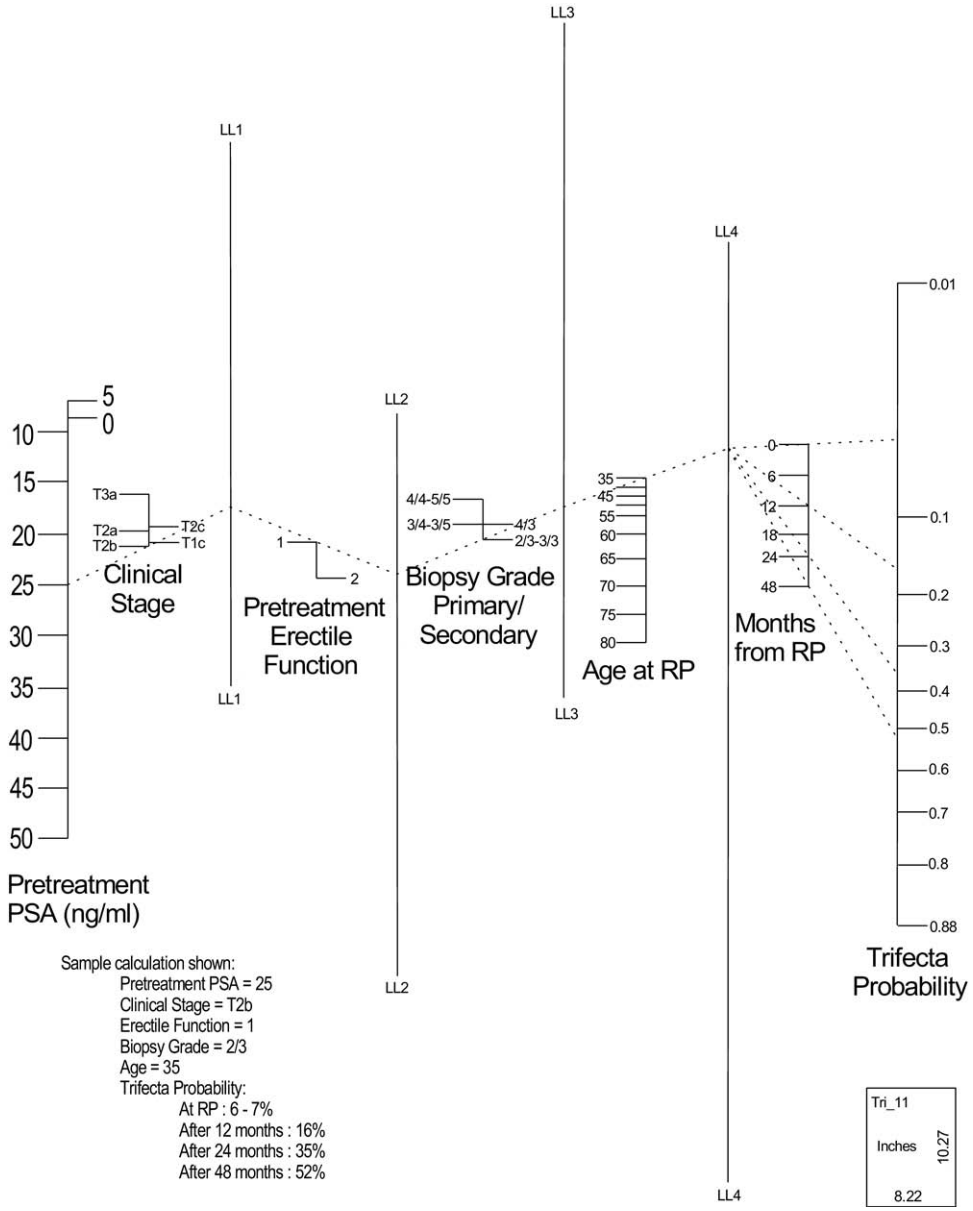

Figure 2. The Trifecta Nomogram recast. This classical version incorporates an example (dotted lines).

with a straight edge and moves across the page one scale at a time. Note that we have slightly rearranged the order of the scales so that the category "Months from RP" is last, allowing one to reuse all computations to that point and then to compute the final probability as a function of that variable in the last step.

Although we need the point values (or weights) to construct the nomogram, there is no need for the user to compute points, add, and then convert back. The art of nomography relieves us of that burden. The user still has to draw straight lines in Figure 2 (as was required in Figure 1), but the points calculation—a potential source of user error—is now done geometrically and is hidden from the user. The practical advantage to Figure 1 is that computer software exists to produce it. While excellent software exists to automate the production of classical nomograms (eg, www.pynomo.org), it presently takes a competent nomographer several hours to translate Figure 1 into Figure 2.

COMPUTERIZED FORM FILL-OUT

Could the presentation process be computerized? Certainly. A spreadsheet could easily be constructed, or, in some cases, a simple form fill-out could be used to get the answer automatically (eg, www.nomograms.org). This website likely derives its name from its data sources—medical nomograms; however, there are no nomograms of any kind on the site. The advantage of the form fill-out approach is that it uses the same basic

information (weights) to do its calculations. The disadvantages are twofold. First, it requires access to a computer of some sort, but its Web-based interface makes this problem of diminishing importance over time. Second, and more important, it creates a "Black Box" effect, wherein a bunch of numbers are fed into a computer, which then mysteriously produces another number. Our experience is that nomograms, because of their graphic nature, provide more transparency and are therefore more comforting when one is explaining a complex situation to the patient.

COMPARISON OF CURRENT APPROACHES

Dr Grimes believes that, in this day and age, all of these computations should be exclusively done on a personal computer, personal digital assistant, or smartphone, which ironically should make him a fan of www.nomograms.org. We respectfully beg to differ.

All of the computerized approaches suffer from the Black Box effect. On the other hand, the classical nomogram displays the process visually; one can see, for example, that certain factors are less important because their scales are shorter compared to others. It is also possible to draw "what ifs" on the page and, finally, to allow the patient to take the worksheet home with him so that he can explain it to others. We believe that is preferable to his telling them, "We punched the test results into the computer, and here's the answer we got." Note, too, that because of its hard-copy format, the version, and hence the set of assumptions (or weights), can be easily retrieved.

We should also remember that there are still many corners of the world where the health problems addressed by nomograms are prevalent, whereas access to computers is much less common. The low cost and ease of distribution and use of nomograms is a significant advantage in such situations.

In an age when we are begging for more transparency and better communication in every area of human activity, it seems odd to us that we would discard our old friend[3] the nomogram at this juncture.

RECOMMENDATION FOR FUTURE WORK

As time marches on, Web access will become omnipresent, so eventually the argument that not everyone has access to computing facilities will lose force. However, we still have the Black Box problem to consider. What would be optimal would be a Web-based tool that would allow us to input the data values and then produce the classical nomogram on the screen. As we varied the input values, the lines would move appropriately. As an example of this approach, see http://www.plastictechnologies.net/?wicket:bookmarkablePage=:com.pti.website.pages.company.Nomograph. Implementing this style would give us all the benefits of a classical nomogram while providing easy Web access. Finally, one could print out the various nomograms desired, thereby retaining the advantages of hard copy.

CONCLUSION

With one simple reformulation, all medical nomograms based on multifactor point summation can be transformed into classical "straight edge" format. The nomogram provides a graphical explanation of a prediction process and can be used where computers cannot. The best future direction is one that combines computerization with classical nomograms.

REFERENCES

1. Eastham J, Scardino P, Kattan M. Predicting an optimal outcome after radical prostatectomy: the "Trifecta" nomogram. J Urol. 2008;179:2210–1.
2. Grimes D. The nomogram epidemic: resurgence of a medical relic. Ann Intern Med. 2008;149:273–5.
3. Hankins TL. Blood, dirt and nomograms. Hist Sci Soc. 1999;90:50–80.