Predicting surgical satisfaction using artificial neural networks

Anand I. Rughani, M.D.,1 Travis M. Dumont, M.D.,2 and Bruce I. Tramer, M.D.3

1Department of Neurosurgery, Maine Medical Center, Portland, Maine; 2Department of Neurosurgery, University of Arizona, Tucson, Arizona; and 3Division of Neurosurgery, The University of Vermont, Burlington, Vermont

In this issue of the Journal of Neurosurgery: Spine, the clinical article titled “Use of artificial neural networks to predict surgical satisfaction in patients with lumbar spinal canal stenosis” by Azimi and colleagues1 represents the first application of an artificial neural network (ANN) in predicting outcomes from spinal surgery. Although ANNs have been used in the biomechanical assessments of spine disease, to date the literature lacks any examples of the clinical applications of ANNs in patients with spine disease. The authors undertook this initiative by identifying 168 patients who had undergone surgery for lumbar stenosis and who had completed a series of preoperative grading instruments. Along with age, sex, and symptom duration, scores on these instruments were collectively taken as the inputs for the ANN. The network was trained on half of the patients by pairing the inputs with known outputs. When a novel cohort of patients was then used to test the model, it statistically outperformed a standard logistic regression (LR) model in terms of accuracy in predicting surgical satisfaction.

Notably, the authors incorporated only preoperative data points in an effort to predict long-term outcome. One could reasonably expect that the most important factors in predicting this include biomechanical and surgical factors such as sagittal balance, the number of levels decompressed, and whether or not the interspinous ligaments are preserved during decompression, just to name a few. Accurate prediction of longer-term outcomes would probably need such variables incorporated. It would not only be simple to model an end point such as whether or not a patient receives a spinal fusion, but this would have practical implications if such a model were ever to be used in clinical practice.

One of the popular criticisms of ANN modeling is that the variables exist as a “black box,” with the exact relationships and interaction between them remaining somewhat abstract. Although this is true, what can still be gleaned easily from the model is which of the variables is most salient in predicting outcome. A simple visual representation of the model in the authors’ Fig. 3 readily reveals that the stenosis ratio has the greatest impact in predicting patient satisfaction.

We remain quite a distance from seeing the use of ANNs in practice. To date there are well under a dozen examples of ANN models applied to neurosurgical diseases. The few examples that exist, however, illustrate the power of this form of modeling over traditional linear models, and also over clinical intuition alone. To date ANNs have been shown to outperform LR models at predicting 1-year survival in patients with brain metastases,4 have been shown to be more accurate than LR models at predicting in-hospital survival in patients with traumatic brain injury,6 more accurate than either LR models or clinicians in predicting in-hospital survival from traumatic brain injury,7 more accurate than LR models in predicting survival from intracerebral hemorrhage,8 and more accurate at predicting which patients with subarachnoid hemorrhage are likely to suffer from cerebral vasospasm.2 That the demonstrated accomplishments of ANNs in neurosurgery can be listed so briefly hints at their unexplored potential. It is worth emphasizing that the authors used a commercially available software package to generate their ANN model. This nicely highlights the ease with which such models can be developed.

As clinical decision making becomes increasingly complex, clinical decision support tools will perhaps play an increasingly useful role in clinical practice. At the present time, however, such clinical informatics remain widely underdeveloped and underutilized, especially in the realm of neurosurgical diseases. To this end, the authors have contributed a simple proof of concept of the application of ANNs to neurosurgical decision making.

Disclosure

The authors report no conflict of interest.

References

Editorial


Response

Parisa Azimi, M.D.,¹ and Edward C. Benzel, M.D.²

¹Functional Neurosurgery Research Center of Shohada Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran; and ²Department of Neurosurgery, Cleveland Clinic Foundation, Cleveland, Ohio

We thank Drs. Rughani, Dumont, and Tranmer for their comments. We agree with them that there are probably other factors, including biomechanical and surgical factors, that can influence the success of the ANN model. We plan to continue to examine these additional variables in a prospective, multicenter fashion. Ultimately this should lead to an even finer prediction of outcome.

For example, one of the disadvantages of ANNs is that their output or results are heavily influenced by the somewhat arbitrary determination of the connection weightings. These weightings are not commonly associated with obvious and accurate objective values. However, a receiver operating characteristic–area under curve analysis provides a useful measure of discrimination and predictive value determination for ANN and LR models, and of parameters. Another issue is that ANNs do not produce a simple, transportable solution to a problem; rather, they are complex. However, given today’s portable computing technology, this issue should not be as much of a barrier as it has been. The structure and details of an ANN that do not require further training can be saved and used as a predictive software tool on a laptop computer.

To streamline and optimize ANN software assimilation into clinical practice by using standard toolboxes such as Matlab or other user-friendly programs, it is recommended that an international center be considered for the collection of real-world outcomes. Additional prognostic factors could then be used as input variables, thus radically increasing the number of patient inputs into the ANN models. This, then, could be used to develop and modify each model as a universally available tool. Hence, we encourage other researchers to share their data in such endeavors when made available. In addition, for example, some of the medical applications of ANN tools and related techniques are presented in Web services applications (http://www.phil.gu.se/ann/annworld.html; http://neuroxl.com/applications/medicine/neural-networks-in-medicine/index.htm).

Finally, ANNs will never replace human expert decision makers, but they can assist in screening and in double-checking the routine decision-making process. Perhaps more important, though, is the fact that ANNs can be used to identify variables that experts do not “see,” thus even further enhancing the diagnostic acumen of the already expert decision maker.

Reference


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