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CORR Insights®: Can We Estimate Short- and Intermediate-term Survival in Patients Undergoing Surgery for Metastatic Bone Disease?

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Where Are We Now?

The development of novel targeted drugs, a renewed focus in immunotherapy, and improved symptom management have extended the life expectancy for a number of cancers [14]. Advancements in the systemic management of metastatic carcinoma can transform cancer into a chronic condition for some patients [1]. However, as life expectancies increase, we may see more patients with carcinomas who develop skeletal metastases, pathologic fractures, and spinal compression [4, 5, 15].

Orthopaedic surgeons, therefore, are becoming more involved in the management of patients with metastatic carcinoma. We must help determine when and how patients with fractures and impending fractures should be treated, and whether a patient with a skeletal metastasis might benefit from surgery. These responsibilities require an understanding of the individual patient's life expectancy, as clinical decision-making will be based on these estimations.

In the current study, Forsberg and colleagues updated their free, online predictive model, PATHfx (www.pathfx.org), which uses clinical and physiologic variables to produce the probability of survival at 3 and 12 months after orthopaedic surgery [12]. The updated model is now capable of estimating survival at 1 month and 6 months, improving the ability to determine the likelihood of an individual's life expectancy. This information is important because a physician may defer surgery in a patient with only a 25% chance of living 1 month. A patient who is likely (perhaps 70% chance) to survive 6 months, may benefit from longer-term durable fixation such as an endoprosthesis rather than internal fixation [3, 11, 13].

Their model is based on Bayesian belief network analysis, a form of artificial intelligence that can account

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for missing data based on probabilities [8, 17]. The Bayesian predictive model can manage big data, which is becoming more central to the medical field [6].

But one of the variables used in the updated PATHfx model is "surgeon's estimate of survival"—in essence, human intelligence. The surgeon determines the likelihood of an individual patient's survival based on predictive factors such as extent of metastatic disease, type of carcinoma (ie, lung vs. breast vs. liver), patient comorbidities, patient age, and Eastern Co-operative Oncology Group performance status.

Where Do We Need To Go?

While similar to the Bayesian model, the updated PATHfx model is applied in the clinical setting. What we don't know is: Which one is more accurate?

For instance, if a surgeon uses clinical and laboratory information to decide on his/her own that a patient is likely (about 75% chance) to live at least 6 months, but the Bayesian model predicts that the patient has less than a 25% chance of living at 6 months, the discrepancy will create a conflict in the clinical decision-making process. The area under the curve (AUC) in the PATHfx model is 0.76 for both 1- and 6-month models, which means that its ability to discriminate between "alive" and "dead" at a certain time is halfway between a simple guess (0.5) and perfect (1.0) [2]. Therefore, without a close-to-perfect AUC, it is conceivable that the model will fail to accurately predict survival in some cases. As such, we still do not know if "human intelligence" is less accurate than "artificial intelligence."

All of the patients who contributed data to the calibration and validation of the PATHfx model underwent surgical management. Therefore, it is unlikely that this group represents all patients with metastatic bone disease, as they were selected for invasive management. In fact, the majority of data available that assists us in predicting survival and functional in this patient population arises from surgical patients [16]. What we need are datasets that include both surgical and nonsurgical patients in order to capture the metastatic bone disease population as a whole.

How Do We Get There?

Teams of physicians including medical oncologists, radiation oncologists, palliative care specialists, and surgeons, treat patients with metastatic bone disease. As such, any prospective evaluation of these patients (not only those that are chosen for surgery) would require multidisciplinary collaboration on a massive scale. Indeed, multidisciplinary clinics for metastatic bone disease have been described and are integral at some cancer centers [7, 9, 10]. At presentation, we do not know on a case-by-case basis whether or not each individual patient who presents to these clinics will undergo surgery. However, their clinical information and eventual survival data would be critical for developing survival models with external validity, meaning models that apply to all such patients, not those who eventually undergo surgery. These are the datasets that would capture the metastatic bone disease population on a more representative scale.

It would be compelling to determine whether "human intelligence" still surpasses "artificial intelligence." A prospective study performed at a multidisciplinary clinic could answer that question by having all patients with metastatic bone disease enter their data into a model like PATHfx. All patients with metastatic bone disease would then be assessed in the clinical setting for expected survival. Although Bayesian models can provide an estimate of discriminatory ability even in the presence of missing data, prospective studies of a broader patient population would provide considerably more robust datasets that are likely to build concise predictive models.

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However, it remains conceivable that this type of study may determine that the predictive models are less useful than traditional clinical acumen developed over years of training and practice. We could answer this fascinating question with a large and collaborative study of this design.

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