Editorial

Spinal deformity and pediatric intramedullary spinal cord tumors

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In this issue of the *Journal of Neurosurgery: Pediatrics*, Yao et al. present the results of a retrospective cohort study of 161 consecutive patients treated for intramedullary spinal cord tumors (IMSCFs) between 1980 and 1994 by Dr. Fred Epstein at New York University. The authors evaluated the prevalence and incidence of spinal deformity in these patients, ages 6 months to 21 years, and performed statistical analyses of multiple factors that might be associated with its development or progression. In a multivariate logistic regression model, factors associated with an increased likelihood of spinal fusion during the recorded follow-up period included an age less than 13 years, symptoms lasting for more than 1 month, preoperative scoliosis, tumor involvement of the thoracolumbar region, presence of a syrinx, and the total number of surgical procedures. None of these findings is particularly surprising by itself, but the uncertainty about causality and the relevance to current practices based on the study design and analysis merit exploration.

Although retrospective, noncomparative cohort studies can provide confirmatory evidence of previously noted associations or can generate hypotheses for future prospective investigations, few valid inferences can be drawn from them. The results presented by Yao et al. should therefore be understood as statistical associations and not causal relationships. Their study suffers from the additional unfortunate limitation that the treating surgeon is no longer alive and therefore could not help to interpret the written record or provide potentially valuable information that may not have been recorded. Indeed, none of the authors or their institutions were directly involved in the care of these patients. Finally, it is regrettable and puzzling that more recently treated patients of Dr. Epstein’s or the senior author (G.I.J.) were not included in the study to ensure that the results reflected contemporary practices, such as earlier diagnosis with magnetic resonance imaging and routine performance of laminoplasty.

The patients were not evaluated or treated for spinal deformity by Dr. Epstein and his colleagues, which may explain the lack of detailed information necessary to understand the deformities, interpret the data, and improve the care of young patients with IMSCFs. “Spinal deformity” is not a homogeneous diagnosis with a single clear cause, and there are at least three plausible explanations for the spinal defects that occurred in the patients in their study. First, idiopathic scoliotic deformities unrelated to the tumor or the surgery may have developed in some patients. In others, kyphotic deformities may have arisen due to the laminectomy procedure(s) performed to treat the IMSCF. Finally, neuromuscular curves related to the patient’s neurological impairment may have developed in some, particularly those with a Grade IV or V overall condition according to the modified McCormick Scale. Data such as the configuration and magnitude of the deformity, its apical and end levels, the location of the tumor, and the levels of the laminectomies would perhaps further our understanding of the origins of these deformities.

Univariate and multivariate regression analysis techniques are powerful tools to study statistical associations between independent and dependent variables, but the results are potentially sensitive to the operationalization of the inputs and the way the models are built. Including too many variables in a model, or overparameterization, can be problematic, as can including multiple variables that are proxies for the same underlying construct. In their study, it is concerning that several of the variables put into the multivariate model (symptom duration < 1 month, astrocytoma pathological features, local recurrence, and perhaps radiotherapy and the number of operations) may all be linked to malignant tumor behavior. The inclusion of all of these potentially related factors into one multivariate model can yield unstable results.

The selections of the outcome of interest and the operationalization of the independent variables have important implications for the interpretation of this study. The depen-
dent variable in the logistic regression model is whether the patient underwent fusion surgery for spinal deformity. This factor has the convenience of being an objective binary outcome likely to have been recorded in the patient charts. However, it may not correlate perfectly with the presence of a clinically significant or progressive spinal deformity. Spinal surgeons might have different thresholds for recommending spinal fusion surgery in this population, and all patients and their families will not uniformly decide to proceed with surgery in similar situations. The selected outcome measures therefore may not accurately represent the actual outcome of interest.

Although it is logical to expect that age at the time of surgery would be inversely associated with the odds of a spinal deformity developing, as shown in previous studies, these authors’ finding that 13 years was a significant cutoff warrants scrutiny. It is not clear how this cutoff was determined and whether it was selected before or after examining the data. Chronological age as it relates to spinal deformity is a surrogate for skeletal age, which in turn is an estimator of the child’s remaining growth potential and whether or not the child has entered the period of peak height velocity, or the growth spurt. The age at the onset of puberty, and therefore at peak height velocity, can vary substantially among children. Although not traditionally examined by neurosurgeons, markers of skeletal age, such as the Risser sign and the pattern of ossification of the metacarpals and phalanges, are used by spinal deformity surgeons to estimate the growth potential of a child and thus the likelihood of significant deformity progression before skeletal maturity. Unfortunately, these potentially more informative data are not provided and may not have been available to the investigators.

The authors’ conclusion that “aggressive resection at the first operation and deformity correction at the time of presentation can limit the morbidity of spinal deformity” in these patients is problematic. The positive correlation between the number of tumor resections and the odds of undergoing fusion surgery for spinal deformity has at least two potential explanations with different implications for case management. The first possibility, implicitly endorsed by the authors, is that the extent of resection is an independent variable that reduces the likelihood of developing spinal deformity by minimizing disruption of the spine’s structural integrity or by reducing neurological morbidity or both. A second explanation is that the extent of resection depends on tumor biology or location and that subtotal resection and repeated operations are proxy markers of aggressive tumors for which gross-total resection is not safely possible. Evidence in favor of the latter explanation, according to an earlier report on the same patient series, is the greater likelihood of “orthopedic spinal stabilization” in patients with high-grade lesions. If tumor biology determines the likelihood of achieving a gross-total resection at the first operation, then the development of deformity and its attendant morbidity are related to the natural history of the disease and are unlikely to be altered by changing current surgical strategies.

Results of the Yao et al. study also do not support prophylactic surgery for deformity correction. Based purely on the presence or absence of dependent variables in the regression model, it is impossible to estimate the probability of the development of a symptomatic or progressive spinal deformity requiring treatment in any individual child. Subsequent studies in which a grading scale based on this regression analysis was used to predict the occurrence of a spinal defect in the same cohort as well as a comparison of the proportions of nonconcurrent patients treated with laminoplasty or laminectomy that later had a spinal deformity both suffer from significant potential bias. The evaluation and treatment of spinal defects in these patients should continue to be individualized, based on rational principles of spinal deformity treatment and on factors such as the patient’s functional status, prognosis, deformity size and configuration, and symptoms.

Moving forward, there are limited lessons we can learn from this historical study. At select centers the balkanization of spinal care common during the study period is receding as multidisciplinary centers are established or neurosurgeons are trained to evaluate, monitor, and treat all types of spinal deformity. For example, at our center pediatric patients with IMSCTs are evaluated clinically and radiographically for spinal deformity on presentation, and their skeletal maturity is initially assessed. These patients are followed up postoperatively with serial clinical examinations and, if indicated, radiographic studies including long cassette, regional, and flexibility x-ray films. Deformities, whether present before or after surgery, are treated based on a constellation of factors including the patient’s skeletal age and growth potential, location and extent of the defect, neurological function of the patient, and symptoms referable to the deformity, if any. Prophylactic deformity correction and instrumented fusion are not routinely performed to avoid unnecessary or inappropriate procedures in this challenging patient population.

Complex spinal problems such as an IMSCT in a young patient with significant remaining growth potential deserve a sophisticated approach and studies appropriately designed, conducted, and analyzed to address clinically important questions. In such a patient, these questions include the following: What is the probability that a deformity will develop? What is the likelihood that treatment of the deformity, including surgery, will be necessary? Given the child’s remaining growth potential, should a growing construct be considered prior to definitive fusion? Retrospective noncomparative studies of patients treated more than two decades ago are not sufficiently rigorous to provide the data we need to answer these questions and to give our patients the best possible care.

References