See the corresponding article in this issue, pp 321–330.

J Neurosurg Pediatrics 2:320, 2008

Editorial

Closer but not there yet: models in child injury research

ANN-CHRISTINE DUHAIME, M.D.,[1] AND CARTER P. DODGE, M.D.[2]

[1]Children's Hospital at Dartmouth and Departments of Surgery (Neurosurgery) and Pediatrics; and [2]Department of Anesthesia, Dartmouth Hitchcock Medical Center, Hanover, New Hampshire

Medicine is full of examples of things we measure as proxies for things we can't measure directly because of unacceptable risk or cost, limitations in technology, or ethical constraints. End-tidal CO_2 is a reasonably good proxy for alveolar CO_2, unless you have, say, an air embolus. In that case, a second proxy, arterial PCO_2, may give you close enough information to effectively guide clinical care. Other proxy measurements are further removed from the actual target of interest. Anesthesiologists wishing to avoid recall in their patients may use a combination of measurement of the percent of end-tidal anesthetic agent concentration, patient vital signs, physiological changes such as sweating, and computer processed electroencephalography to approximate the risk of recall during a given procedure, but none of these proxy measures directly measure likelihood of recall. An indirect, or proxy, measurement has value in proportion to its ability to predict the presence or likelihood of the target event, and most such measurements have inherent limitations.

Mathematical models for prediction also appear frequently in medicine. Pharmacokinetic modeling predicts optimal drug dosing, generally with excellent but not perfect results. Mathematical modeling for hydrocephalus has become more sophisticated and takes into account an increasing number of factors but, as yet, has not resulted in perfect treatments for this condition.

In their paper in this issue, Coats and Margulies continue a long line of efforts to use anthropomorphic models to answer some of the fundamental questions about loading conditions and prediction of injury in human infants. This paper has a narrow focus: to use a more refined model of a 6-week-old human infant, with skull and neck properties that more closely replicate those physical features in actual infants, to measure the impact forces and angular decelerations in 3 dimensions from occiput-first drops from low heights onto various surfaces. These "worst-case scenario" data will be incorporated into existing mathematical models that are then validated against witnessed low-height falls analyzed in actual children. In this way the mathematical model can be refined continuously to improve its ability to predict the injuries resulting from documented clinical cases. In this instance, the specific injury type targeted is the prediction of skull fracture.

Models, whether in anesthesia, pharmacology, or surgery, are not static. They are constantly refined, tested against other proxy measurements of what is difficult or impossible to measure directly and, hopefully, improved so that they get increasingly closer to a reliable prediction of complex biological phenomena. Although the experience of many clinicians with anthropomorphic models is limited to their training in cardiopulmonary resuscitation or some lay familiarity with crash test dummies, this modeling scheme is used widely in many biomedical applications. In this specific instance, the authors fully acknowledge, and are actively engaged in, the steps necessary to get from anthropomorphic models used for measurement of loading conditions, to an understanding of specific tissue and location injury thresholds, to mathematical modeling, to model validation against a large series of well-documented witnessed events in human children. Only when this circuit is complete does this approach have a chance of correctly "working backwards" from a history of an event to a prediction of the probability that the witnessed injuries would be likely to arise from a reported mechanism.

For those who have been waiting for a model of an infant that correctly predicts all injuries, the wait isn't over yet. For those who believe that modeling as an approach is fundamentally flawed, a look at how much proxy measurement and modeling in practice that we use and accept daily may be helpful to put models in perspective. In child injury, we're not there yet. But for those who are interested, this paper gives a glimpse into the steps that get us closer.

Disclosure

The first author of this editorial has collaborated extensively with the authors of this paper and sat on the dissertation committee for some of the work presented in this manuscript.

Response

BRITTANY COATS, PH.D., AND SUSAN S. MARGULIES, PH.D.

University of Pennsylvania, Philadelphia, Pennsylvania

Similar to other methodologies used in abusive head trauma research, biomechanical investigation is not without its limitations, but biomechanical pediatric head injury research does offer objective data that, when combined with clinical experience and validated with real-world scenarios, enhances the understanding of traumatic head injury. The comments of Drs. Duhaime and Dodge highlight these major points and serve as a positive addition for the readership. In summary, our paper represents one of several components necessary to determine the likelihood of head injuries from low-height falls. As we complete the remaining pieces of the puzzle, an evidence-based portrait will emerge detailing mechanisms of traumatic head injuries in infants. *(DOI: 10.3171/PED.2008.2.11.320)*