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A predictive model of shoulder instability after a first-time anterior shoulder dislocation

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Introduction: Management of a first-time anterior shoulder dislocation (FTASD) involves important clinical and policy decisions. Predictive disease modeling can improve the quality of information disseminated in treatment discussions. In this paper, we describe a general-purpose, publicly available model and illustrate its potential as a tool for management of a FTASD.

Methods: A Markov decision model of the natural history of a FTASD was constructed. Outcome probabilities and effectiveness were derived from the literature or estimated by expert opinion where necessary. Outcomes were the Western Ontario Shoulder Instability index (WOSI) and the probability of a patient experiencing recurrent instability, undergoing surgical stabilization, and having a stable shoulder at 10 years. The model was both internally and externally validated. Outcomes were examined for specific cases.

Results: The model was effectively externally validated against two studies, a Swedish prospective cohort of Hovelius et al and Botonni et al's military cohort. It can produce detailed outcome predictions for individuals; eg, an 18-year-old man has a 77% risk of dislocation in year 1 and a 32% chance of having a stable shoulder in 10 years.

Conclusion: Detailed and specific information about prognosis is critical in the management of a FTASD. Disease modeling lends itself well to these needs and allows improved shared decision-making. Our model was externally validated and can predict specific outcomes. As a publically available resource, it will allow physicians to accurately predict the expected outcome of treatment based on covariates, patient demographics, and their own surgical success rates.

Level of evidence: Level II, Economic and Decision Analysis.

Keywords: Anterior shoulder dislocation; Markov modeling; instability; surgical stabilization

Anterior shoulder dislocations occur in approximately 2% of the population with 80% of dislocations occurring in younger patients.[19] Recurrent instability after a first-time anterior shoulder dislocation is common with reports in high-risk populations approaching 100%.[14,27] Self-reported outcomes suggest an unstable shoulder is significantly worse than a stable one, with regard to disease specific

In accordance with Duke University policies and procedures regarding the protection of human research subjects, we have obtained approval for this study from our Institutional Review Board. Its approval number is #3723, which approves multiple studies on Cost Effectiveness Analysis in Orthopaedic Surgery.

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health related quality of life and shoulder function.[12,22] Several studies have investigated the effect of varying treatments for a first-time dislocator such as immobilization in a sling, immobilization in external rotation, and early primary arthroscopic stabilization.[3-5,7,8,12,15,24,29] While these studies suggest early alternative intervention can decrease the rate of recurrent instability, controversy over management of a first-time anterior shoulder dislocation continues. Multiple influences on this complex treatment decision exist, and the ability to predict the interactions of these influences would be helpful for policymakers, administrators, and individual clinicians.[4,28]

Multiple clinical and policy questions arise among various treatment decisions for a first-time anterior shoulder dislocation. When considering time lost from work or sport, specific risk factors in specific populations and uncertain outcomes, which interventions provide improved health outcomes? Do the health benefits come at an acceptable cost? Is the potential budget impact for the health care organization or the public program acceptable? Are we providing adequate information to patients to facilitate informed decision-making? A substantial challenge to decision-making is the complexity of issues involved —not only the wide variety of potential interventions but also the dynamic epidemiology of a first-time anterior shoulder dislocation. Additionally, it involves risk factors for recurrent instability that differ among specific populations of patients.

Decision-making through the use of Markov modeling via Monte Carlo simulation can assist providers and their patients in making health care decisions by accounting for the progression of the disease as well as uncertainties regarding outcomes under a range of possible scenarios.[17] One strategy to avoid this inefficiency is to create a model sanctioned by a major governmental agency, professional organization, or other accountable entity. Another strategy—which we describe in this report—is to develop a general-purpose, publicly available model based on a ''natural history'' core that simulates disease progression in the absence of therapy. It is general-purpose insofar as the model is designed to address a wide variety of clinically-and policy-relevant questions, which range from predicting the risk of recurrent instability to estimating the time lost from sport or work to make an intervention acceptable for a specific patient or population. It is public use in that it is available for use and comment on request. The notion is that such a model could serve to promote a more shared decision-making process by allowing for consistent evaluation of various treatment strategies and specific populations and ongoing feedback from users who are encouraged to participate in the continuous improvement of the model in a public forum. Lastly, it will be customizable to an individual provider's patient population and treatment outcomes.

In this study, we describe such a general-purpose, publicly available model and illustrate its potential as a tool for management of a first-time anterior shoulder dislocation with an example: prediction of the natural history for specific individuals and populations.

Methods

Overview

The model was constructed to provide, for a defined population experiencing a first-time anterior shoulder dislocation, the likelihood of a variety of outcomes of potential importance to decision makers, such as number of patients experiencing recurrent instability, stabilization procedures, revision stabilizations, and stability at 10 years, as well as disease specific quality of life. It also allows for the influence of several variables such as age, gender, time lost from work, or sport from surgery (disutility of an intervention) on the outcome of a treatment intervention. It was measured against the natural history of a first-time anterior shoulder dislocation treated in a traditional sling.

To guide the development of the model, we convened a panel of health policy and sports medicine experts. The panel consisted of a senior fellow at the Center for Health Policy Research at Duke University, our institution, an American Academy of Orthopaedic Surgery health policy fellow, and a professor of orthopaedic surgery with numerous publications on shoulder instability and the first time anterior shoulder dislocation. During group meetings we elicited 2 lists: (1) patient characteristics judged to influence management by virtue of being known or strongly suspected to predict natural history, effectiveness/risk of treatment, cost, or quality of life/utility; and (2) outcomes that the model should be able to produce in order to promote informed decision-making. A comprehensive literature search was performed to identify the values for each parameter of the model. Level I and II studies were used to create the primary inputs, while lower level studies were utilized to complement or support these inputs. In addition, when model input values were not available in the literature, we solicited expert opinion.

Population

Population characteristics are defined prior to entering the recursive simulation sequence and include age and gender. Although some studies suggest other risk factors for recurrent instability exist such as activity level, level I studies show the only independent predictors of instability are age and gender;[22,23,27] however, these cohort parameters are modifiable within the model to suit an individual user's need and context. For example, it may be set to represent the characteristics of the U.S. military population, a university's athletic department, or an individual 18-year-old man. Patient activity measures, such as the Marx Activity Rating, could be used to define the population as well.[16] The default population is a general population sustaining a first-time anterior shoulder dislocation in the United Kingdom, as presented by Robinson et al.[23] This population was chosen due to the clarity of the results presented in this study. Additionally, this is the most recent prospective cohort in the published literature.

Model structure

The foundation of the model is a ''natural history'' Markov Monte Carlo simulation with a discrete cycle length of one year (TreeAge