Modeling the Management of a Flexor Sheath Ganglion

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Abstract

Introduction In a published cost analysis of the management of flexor sheath ganglia, it was found that two attempts at aspiration, followed by surgical removal for those who failed, was the least costly alternative. We used this report as a template to create a model of the management that could be used in decision analysis.

Method Using the published cohort study as a guide, a decision tree and Markov model of the management of flexor sheath ganglia were created.

Results When compared to the results of a large cohort of patients reported in the literature, we accurately modeled the management of flexor sheath ganglia using both approaches.

Discussion Creating a model of the management of a disease provides the opportunity to understand and explore questions efficiently and inexpensively. Many disorders of the upper extremity have commonality in their management, making the modeling approach attractive and potentially very valuable. This simple example illustrates two common methods used and is important because it builds confidence in the method by accurately modeling actual clinical experience.

Keywords Decision analysis · Decision tree · Flexor sheath ganglion · Markov model

Introduction

In a recent publication in the *Journal of Hand Surgery*, Bittner, Kang, and Stern [1] reported a cost analysis of the management of flexor tendon sheath ganglions. The authors reported that two attempts at aspiration, followed by excision if needed, is the most cost-effective way to manage these cysts. This analysis was performed using a cohort of 175 patients.

Decision analysis is a formal method to analyze a decision and identify the best choice in the face of uncertainty. One important aspect of decision analysis is to create a realistic model of the health care decision that is being analyzed. If the model is too simple, it will not reflect reality and will not be acceptable to the clinical community for whom it was intended. If the model is too complex, it will be difficult to portray in the literature, making it inaccessible to the reader and therefore difficult to believe. There are no rules to finding the balance between simplicity and accuracy. In spite of widespread acceptance in other disciplines, decision modeling is not widely used in upper-extremity care.

The details provided in this report by Bittner et al. from real experience provide an opportunity to compare different decision analysis modeling approaches for this clinical problem to the actual clinical experience. Our purpose is to model this specific problem and to learn some features that may be important for modeling upper-extremity problems for decision analysis and cost-effectiveness analysis. The real life experience of Bittner et al. is therefore used as a

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guide to modeling. Although created primarily for illustrative purposes, the models that are created can then be used to analyze the results of management when variations in management are hypothetically induced. For example, if the efficacy of injection was only half of that observed, would the recommended management strategy change? We evaluated this hypothetical question using the decision analysis model we created as an illustration of the potential value of these methods. Similarly, other hypothetical questions such as the value of a third injection, varying costs of office visits, injection, and surgery could be evaluated.

Two common forms of modeling a decision are with a decision tree and a Markov model. We have recently summarized the use of decision analysis in the context of upper-extremity care [2]. A decision tree is a tree-like branching structure that starts with the decision alternatives on the left and elaborates the various health care interventions and health states to the right. Expected values of each alternative are calculated by a process called folding back where the utilities and probabilities are multiplied and summed across branches. The alternative with the highest expected value is preferred. There are many advantages to a decision tree. Decision trees are relatively easy to create and to understand. Information from the literature can be applied to a tree in a straightforward manner. There is a lot of experience with trees in decision analysis. Unfortunately, decision trees have important shortcomings when time in a health state is an important feature of the decision and when events tend to repeat themselves.

A Markov model models the transitions between defined health states over periods of time called cycles. Rewards are given for each person for each cycle in each health state and summed at the end of the process. Markov models are flexible and are particularly useful when time in a state is important or when there are recurrent events. For these reasons, Markov models are useful to overcome the shortcomings of decision trees. Some of these characteristics that lend themselves to Markov models are typical of upper-extremity problems. Upper-extremity injury and pathology can often affect young adults, reducing their ability to work, so the time an individual must live with impairment or functional limitations is important. In addition, recurrent events are typical of upper-extremity problems and care. For example, if an injection improves a condition that subsequently recurs, a repeat injection might be indicated.

The purpose of this paper is to use the clinical experience and results published by Bittner et al. to create a decision tree and Markov model that accurately recreates the management of flexor sheath ganglia as an illustration of the feasibility and accuracy of this method. Our goal is not to perform a complex decision analysis to analyze this disorder nor to make recommendations for management.

Method

We carefully scrutinized the paper of Bittner et al. to extract information to create a decision model. For the tree, we modeled three decisions: surgery, one aspiration followed by surgery for failures, and two aspirations followed by surgery for the failures. For the Markov model, we defined states of health for the cyst being present after one or two aspirations and the cyst being absent. Using the information provided and the flow of care, we created both decision models using commercially available software (TreeAge Software, 1075 Main Street, Williamstown, MA 01267) to simulate the clinical experience. Cost of treatment, probabilities for resolution of the cyst, recurrence, etc. were extracted from the paper.

Explanation of Decision Tree

A simple tree was created with three branches at the decision node (Fig. 1). The “surgery” branch gave a uniformly good result with a cost of \$1,842.51 per patient. The “single aspiration” branch then divided at a chance node to “surgery” and “cure”. The aspiration and surgery had a cost of \$1,979.85 per patient, and the cure from a single injection with a probability of 0.58 had a cost of \$151.63. The cost per patient would be \$919.48. The “two aspiration” branch divided into a “second aspiration” and “cure” and the “second aspiration” again divided into “surgery” and “cure”. The cure rate of the first aspiration was 0.58, and the second aspiration was 0.55. This gave a cost per patient of \$546.90 for two aspirations followed by surgery for those not cured. In a decision tree, the costs are summed along the branch and are exhibited on the right side of the tree. Patients lost to follow-up reported by Bittner et al. include 15 of 141 after one aspiration and 4 of 9 after the second. In the tree illustrated, the “dropout” branch is included as a space holder only. This branch has no effect on the calculations performed using the tree and is not required for the typical analysis of the three alternatives.

Explanation of Markov Model

The modeling approach described is created by extracting information from the clinical care and follow up data provided by Bittner et al. Three decisions are again modeled as above. When a patient comes in with a cyst and it is aspirated, two possible outcomes are reported. The cyst can resolve, or it can persist. If the cyst persists or recurs, it can be removed surgically or can be reaspirated. Once again, it can resolve or persist. After the second aspiration, if the cyst persisted, it was removed surgically.

Visits, aspiration, and surgery are assigned a dollar charge as noted in the article. In the Markov model, these charges can be assigned at the time they are incurred.

Results

The decision tree is shown in Fig. 1. Using this simple tree, it is possible to accurately reflect the care provided to these patients. Patients lost to follow-up reported by Bittner et al., including 15 after one aspiration and 4 after the second, have no effect on the calculations performed using the tree. These numbers are shown in this tree simply to account for all the patients reported in the referenced article. Although not the purpose of this manuscript, the tree can be evaluated to show the potential influence of these patients on the management recommendation. The costs are not exactly the same as those reported in the article; however, some discrepancies can be resolved. For example, column (A) in Fig. 3 of Bittner et al.'s report can be reconciled by including the cost of the new patient exam.

The Markov model is shown in Fig. 2. For the first aspiration, the probability of cure was 0.58 and of failure, 0.42. For the second aspiration, the probability of cure is 0.55 and of failure, 0.45. The costs match the tree and once again reflect the reality of the published report.

Forty-two of 43 patients (97.7%) were cured by surgery. Since the chance for surgical correction is assumed to be the same in each of the decision alternatives, ignoring this small degree of surgical failure has minimal influence but will bias the decision models in favor of alternatives where surgery is more prominent.

The results of the tree and Markov model mirror the observed results published by Bittner et al. Both modeling methods are able to follow the clinical experience and show

that two aspirations followed by surgery for those who fail is the recommended decision alternative.

Discussion

We have modeled the clinical care for flexor sheath ganglia using a decision tree and Markov modeling approach. Both methods give results that closely match the clinical experience that has been reported in the literature for this relatively simple clinical problem. In this cost analysis, all the management alternatives eventually result in surgical removal of the ganglia, and hence the clinical results are the same. This is an important prerequisite for a cost analysis contrasting it with other forms of economic analysis in the hand surgery literature. [3]

For this relatively simple clinical problem, both a Decision Tree and a Markov model were used successfully. Two features of upper-extremity problems that lend themselves to Markov models are the need to consider the time in a state of health and the need to model recurring events. Time with a recurrent cyst was not considered in this decision. The recurring nature of the flexor cyst is well handled by the Markov model. If this condition were more complex, the tree would soon become unwieldy. For more complex upper-extremity disorders, we believe the features of the Markov modeling approach will be useful.

Moving beyond simple copying of clinical experience, the models we have created also could analyze the effect of different cure rates, repeated injections more than twice, the morbidity of injection vs surgery, and the relative importance of various components of cost. By performing a sensitivity analysis on the cure rate of the second aspiration, for example, we can determine the relative importance of the second attempt. For illustration purposes only, we change the success of the second aspiration to 50% of the first.

Figure 1 Decision tree modeling management of flexor sheath ganglia as detailed by Bittner et al. The extra branch for dropouts is a placeholder only in this tree. Two aspirations followed by surgery for the failures is the least costly option.

Figure 2 Markov model of clinical experience of Bittner et al. reflects costs for each management strategy. This tree-like branching structure is representation of the model produced by TreeAge software, a commonly used commercial Decision Analysis program. Costs are input at the time they occur.

Figure 3 Sensitivity analysis of the influence of the efficacy of aspiration on the cost of management. For this analysis, it was assumed the second aspiration had half the efficacy of the first. This is an estimate that would make repeat aspiration less favorable; however, it was still the least costly except at very low efficacy.

Figure 3 is a graph of the cost of the three management options when the cure rate of the first aspiration is systematically altered and the success of the second aspiration is changed to half of the first attempt. This is calculated using the tree shown in Fig. 1. As the cure rate from aspiration increases, the overall cost per patient decreases in both of the aspiration strategies. When the cure rate from the first aspiration drops to less than 11% and the second is 5.5%, one aspiration is cheaper than two. If the success rate from aspiration drops below 8% for the first and 4% for the second, surgical management is less expensive. This analysis shows, by one simple example, the potential usefulness of these modeling approaches.

Due to the cost and time required, many questions about the management of upper-extremity problems will never be scrutinized by randomized trials. However, using the tools of decision analysis, many important questions can be evaluated in a timely and inexpensive manner. This simple example models the care of a flexor sheath ganglion, closely matching the clinical observations of a large cohort, illustrating the accuracy of the method, and promoting trust in the methodology.

We have not performed a decision analysis to provide treatment recommendations for flexor sheath ganglia. To do this, we could use the model generated but would need to distill the literature for probabilities of the various events. Utilities would also be estimated or measured. Rather, these models were created to mimic a single paper reporting an experience with a cohort of patients. Our analysis does not add evidence for any management scheme beyond that provided by the paper of Bittner et al.

We have observed that many problems of the upper extremity have commonality in their management. Our goal is to create a generic model of upper-extremity care that can be used for a variety of disorders.

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